Various Interesting Otolaryngology Files


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- **Chapter 1: The Examination.**
- **Chapter 2: Introduction to Sinus Surgery.**
- **Chapter 3: Surgery of the Ethmoid and Sphenoid Sinuses.**
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SigmaMax Publishing
Surgery of the Upper Respiratory System

William W. Montgomery

Preface

This atlas of otolaryngologic surgery has been compiled for both the physician in training and the practicing specialist.

The past decade has seen otolaryngology expand to the point where many otolaryngologists have limited their surgery to one aspect of the specialty, such as otology, head and neck surgery, plastic procedures, or surgery of the paranasal sinuses. This trend, however, is only practicable in large medical centers that can be staffed by many specialists.

The modern otolaryngologist must be an accomplished surgeon, for a single operation can require the versatility and dexterity needed for handling soft tissues and bones, as well as various macro- and microsurgical procedures. The otolaryngologist must also be proficient in the diagnostic procedures associated with head and neck surgery and possess acumen in the interpretation of the results. He must have thorough knowledge of the anatomy and physiology of the upper respiratory system to enable him to deal effectively with diseases of the nose, paranasal sinuses, nasopharynx, oropharynx, laryngopharynx, cervical esophagus, and neck.

In this volume it has been my aim to provide the student and the practicing otolaryngologist with guidelines for the diagnosis and treatment of the various conditions requiring otolaryngologic surgery. To this end, covered in the volume are descriptions and illustrations pertaining to examination, diagnosis, and treatment of paranasal sinus disease, cerebrospinal fistula, facial fractures, and nasal and nasopharyngeal disorders. Because otologic operations have been dealt with extensively in a number of recently published textbooks, discussions on surgery of the ear have been limited to reconstructive surgery of the auricle, operations for acoustic neuromina, in which I am particularly interested, and carcinoma of the ear. Although I have endeavored to present the latest techniques, with the rapid advancement in the field of otolaryngologic surgery it is possible that new diagnostic procedures and methods in treatment may evolve while this book is in press. Comments by the reader concerning these as well as any criticisms will be appreciated. By such means, progress is advanced and goals are attained.

I am indebted to Dr. Alexander S. MacMillan, Jr, for the section of Chapter 1 dealing with the technique of paranasal sinus radiography, to Dr. Edgar Holmes for the excellent chapter on rhinoplasty, to Dr. James E. Gamble for his contribution on otoplasty, and to Dr. Charles W. Cummings for his assistance with the section on nasoseptal perforations.

To the surgeons of the Massachusetts Eye and Ear Infirmary and the Massachusetts General Hospital who have contributed to my learning I owe my sincere gratitude.

My thanks are due to Miss Edith Tagrin and Mr. Joshua B. Clark; the excellence of their drawings will be immediately apparent to the reader. Thanks are also extended to Mr.
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To Miss Patricia Perrier, Mrs. Judith Bond, and Miss Emily Anderson who spent tedious hours in manuscript editing and preparation I express my appreciation.

*Boston, Massachusetts*  
*William W. Montgomery*

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Mr. Johnson's interest in the needs of modern medicine, leading among other things to this present volume, is only one face of the personality of this "Tall Man." The author wishes to express his gratitude to him.

*W. W. M.*
Chapter 1: The Examination

Nose

History

Patients with disease of the nose or paranasal sinuses will complain of anterior nasal discharge, posterior nasal discharge, nasal stuffiness or obstruction, localized pain over a sinus, headache, bleeding, sneezing, and/or external swelling. The following inquiries should be made and the replies carefully recorded for each patient who comes to the physician for the first time with potential nasal or sinus disease.

1. When did the trouble start?
2. What was it like at that time?
3. How has it progressed until the present time?
4. Nasal discharge:
   a. Is it anterior or posterior?
   b. Is it unilateral or bilateral?
   c. Is it persistent or intermittent?
   d. Is the amount slight, moderate, or profuse?
   e. Is it purulent, watery, mucoid, or bloody in character?
   f. Does it have an odor or taste?
   g. Does it have an unusual color?
5. Sneezing:
   a. Amount?
   b. Frequency?
   c. During what time of the day?
   d. Is it accompanied by rhinorrhea and/or epiphora?
   e. Is it seasonal?
6. Nasal obstruction:
   a. Is the obstruction partial or complete?
   b. Is it unilateral or bilateral?
   c. Does it have any time-of-day relationship?
   d. Is it associated with environmental factors?
   e. Is it associated with the ingestion of liquids or food?
7. Olfactory system:
   a. Is there any distortion of smell?
   b. Is there partial or complete absence of smell?
   c. How long has the anosmia persisted?
   d. Is the anosmia associated with other signs or symptoms?
8. Pain:
   a. Does the pain consist of generalized headache, or is it localized to the distribution of the nose and paranasal sinuses? (Generalized headache is usually not a symptom of intranasal or sinus disease.)
   b. Is it true pain or a sensation of pressure?
   c. Is the pain associated with other symptoms, such as nasal blockage, rhinorrhea, or sneezing.
9. Has there been a history of redness or swelling in relation to the external nose and paranasal sinuses.
Local Examination

For examination of the nose, a head mirror, light source (100-watt bulb), and instrument tray containing a nasal speculum, finger cots, an atomizer, bayonet forceps, cotton strips, sterile swabs (for culture), nasal decongestants, and topical anaesthesia are essential.

After the patient has been seated directly facing the examiner, and without any extension or flexion of his head, the external nose, as well as the remainder of the face, is first carefully examined by observation and palpation. The presence of redness, swelling, or ecchymosis, or loss of structure or support is determined. The nasal speculum is inserted into the nose and directed away from the nasal septum in order to avoid unnecessary discomfort for the patient. Also overdilating the external nasal orifice is avoided, for this can cause the patient an undue amount of pain. The color of the nasal mucous membrane is observed and it is determined whether the turbinates are normal, hypertrophic, or atrophic. The nasal septum is observed carefully for deviations. Abnormalities in the nasal vestibule can be readily seen.

Next, the nose is sprayed with 0.25% Neo-synephrine, 1% ephedrine solution, or 0.51% cocaine solution and, after a few minutes, is reexamined. If the posterior aspect of the nasal cavities cannot be seen, additional spray decongestant is applied to the nasal mucous membrane. With adequate decongestant of the mucous membrane, the entire nasal cavity and superior aspect of the nasopharynx can be seen. If instrumental palpating or probing is to be carried out, or if a biopsy specimen of a lesion is to be obtained, it is best to anesthetize the mucous membrane of the nasal cavity with cotton strips impregnated with 4% cocaine or 2% Pontocaine solution. Cultures and smears are taken as soon as abnormal discharge is seen.

Physiology

A sound knowledge of nasal physiology is necessary in order to evaluate normal and abnormal findings properly. The three major functions of the nose are: (1) respiration, (2) olfaction, and (3) phonation. Only a brief review of these functions is included in this text.

Respiration. Approximately 500 cubic feet of air pass through the nasal cavities every 24 hours. The nose warms, filters, and moistens this air. In order to accomplish these functions, there must be a large surface area of moist mucous membrane. The mucous film covering the nasal mucosa must be in constant motion as it replenishes itself. There must be normal airways, a sufficient air supply from the cavernous spaces, and a constant pH for the nasal secretions. On inspiration, very little air passes through the middle and superior meatuses. The reverse is true with expiration. The ostia of the paranasal sinuses are thus not subjected to cold or dry air. The negative pressure caused by inspiration is important in the evacuation of the paranasal sinuses. There is gross filtration by the vibrissae in the nasal vestibule. The mucous film and ciliary action take care of fine particles. Lysozyme found in the mucous film destroys certain bacteria. A secondary line of defense against infection is situated in the stroma of the mucous membrane. It is made up of histiocytes which engulf and destroy bacteria. The nasal cilia are 7 microns in length and beat eight to twelve times a second, with a rapid effective stroke followed by a slower recovery stroke. The direction of sweep of these cilia is away from the ostia of the sinuses and in the direction of the nasopharynx. The action of these cilia in the anterior third of the nasal cavity is relatively slow, but rather rapid from the tip of the turbinates, posteriorly.
Olfaction. The olfactory epithelium is located in the superior aspect of the nasal cavity. The olfactory mucous membrane is yellow or brownish in color and extends down onto the septum and lateral nasal wall for a distance of 5 to 8 mm. The total olfactory area is approximately 500 sq mm. The sense of smell is sometimes referred to as "taste at a distance." Taste and smell are closely connected in the central nervous system, and it is often difficult to disassociate one from the other. Constant exposure to any odor can produce fatigue. This fatigue also interferes with new or different stimuli. The mechanism of olfactory discrimination is unknown. Reflexes from the olfactory system can produce salivation and gastric secretion. Reflexes from the nasal mucous membrane can result in sneezing, lacrimation, respiratory inhibition, or vasomotor response.

Phonation. Together with the paranasal sinuses the nose gives resonance to the sounds produced by the vocal cords.

Nerve Supply

Included in the nerve supply to the nose are the following:

1. The nasociliary nerve. This nerve arises from the ophthalmic nerve and lies in the lateral wall of the cavernous sinus. It enters the orbit through the superior orbital fissure and passes obliquely across the orbital cavity to the anterior ethmoid foramen, which lies in the medial wall of the orbit. The posterior ethmoid branch leaves the orbit by way of the posterior ethmoid foramen. The other branch of the nasociliary nerve inside the orbit is the infratrochlear nerve. The anterior and posterior ethmoid nerves leave the orbit through the ethmoid foramina and thus reenter the cranial cavity. They then pass along the cranial surface of the cribriform plate before entering the nasal cavity.

2. The anterior ethmoidal nerve. The medial or septal branch of this nerve supplies the anterior septum as far as the nares. Its lateral branch supplies the anterior portions of the middle and inferior turbinates, anterior ethmoid cells, frontal sinus, and anterior middle and inferior meatuses. Its lateral nasal nerve is a branch which passes between the nasal bone and upper lateral cartilage to supply the tip of the nose.

3. The posterior ethmoidal nerve. This nerve supplies only a small area of mucous membrane, posterior ethmoid cells, and sphenoid sinus.

4. The sphenopalatine nerve. The maxillary nerve leaves the cranial cavity by way of the foramen rotundum and enters the pterygopalatine fossa where the sphenopalatine ganglion is found. The nasal branches of the sphenopalatine ganglion enter the nasal cavity through the sphenopalatine foramen, located just behind the posterior end of the middle turbinate.

The medial postero-superior branch of the sphenopalatine nerve supplies the posterior nasal septum and continues on as the nasopalatine nerve which passes through the anterior palatine (Scarpa's) foramen to supply the hard palate. Before reaching the foramen it anastomoses with the nasal branch of the antero-superior alveolar nerve. Here the medial postero-superior branch of the sphenopalatine nerve and the nasal branch of the antero-superior alveolar nerve supply the infero-anterior surface of the inferior turbinate and the adjacent floor. After anastomosing they pass together through the intermaxillary suture
(foramina of Scarpa) to supply the hard palate behind the upper teeth. At this location they anastomose with branches of the greater palatine nerve.

The lateral postero-superior branch of the sphenopalatine nerve supplies the superior and middle turbinates (large portion) and has branches to the posterior ethmoids.

The lateral postero-inferior branch of the sphenopalatine nerve is where the sphenopalatine ganglion gives off the great or anterior palatine nerve which passes through the pterygopalatine canal within the lateral nasal wall. Here it gives off branches to the postero-inferior turbinate and posterior middle and inferior meatuses.

5. The infraorbital nerve. This nerve gives off a branch which supplies the lateral surfaces of the external nose, the ala nasi and also the lower end of the septum, by way of the external nares.

6. The antero-superior alveolar (dental) nerve. This nerve gives off a branch which pierces the lateral wall of the nose to supply the anterior portion of the inferior meatus and adjacent nasal floor.

7. The nervi terminales. The ganglion cells of these nerves, which pass through the cribriform plate, lie between the crista galli and the olfactory bulb. The nerves lie in the deepest portion of the nasal septal mucosa, over the cartilaginous portion of the septum. Their function is not known. They are thought to be both sensory and autonomic.

The parasympathetic system of the nose includes the facial nerve, intermediary nerve, greater superficial petrosal nerve, and the sphenopalatine ganglion. This system has a vasodilatory and secretory function.

The sympathetic system of the nose includes the superior cervical sympathetic ganglion, the internal carotid arteries, the deep petrosal nerve, vidian nerve, vidian canal, and sphenopalatine ganglion. Its function is vasoconstrictory.

The sensory elements of the external nose are:

1. Branches of the infraorbital nerve.

2. Branches of the infratrochlear nerve, which is a branch of the nasociliary, and thus of the ophthalmic branch of the fifth cranial nerve.

3. The lateral nasal nerve, which is branch of anterior ethmoid nerves.

The motor elements of the external nose are in the muscles supplied by the seventh nerve.

Included in the arterial supply to the nose are the following:

1. Branches of the internal carotid artery. These include the anterior ethmoid arteries with their branch of the ophthalmic arteries, and the posterior ethmoid arteries with their
branch of ophthalmic arteries. The course and distribution of the ethmoid arteries are similar to those of the nerves.

2. Branches of the internal maxillary artery. The sphenopalatine arteries pass with the nerve through the sphenopalatine foramen. The lateral branches supply most of the turbinates. The nasopalatine or septal branch courses along with the nerve.

The descending palatine artery accompanies the greater palatine nerve down into the pterygopalatine canal. Like the nerve, it sends twigs to the lower posterior part of the nasal cavity. It passes through the greater palatine foramen, sends branches to the soft palate, and runs forward as the major palatine artery. Anteriorly it passes through the incisive foramen to the septum and laterally through the foramen of Stensen to anastomose with the nasopalatine branch of the sphenopalatine artery to supply the anterior floor. The infraorbital artery has the same distribution as the nerve.

The postero-superior alveolar branch arises near the pterygopalatine fossa, courses through the alveolar foramina of the maxilla and goes on to supply the maxillary antrums.

3. The external maxillary artery. The angular branch includes the branch of the facial artery and supplies the lateral aspect of the nose, the skin of the vestibule, and the dorsum of the nose. The superior labial artery supplies the vestibular portion of the septum.

Little's (Kiesselbach's) area includes the anterior ethmoidal arteries, the nasopalatine (septal) branch of the sphenopalatine arteries, the branch of greater palatine arteries which passes from the palate through the incisive foramen, and the branch of the superior labial arteries.

**Normal Findings**

The nasal vestibule varies considerably in different individuals as to size and shape. It is bound medially and laterally by the crura of the greater alar cartilage. It is lined with fibro-elastic tissue and skin which are tightly adherent to the underlying cartilage. The anterior nasal septum and anterior tips of the middle and inferior turbinates can be seen without the use of a nasal decongestant. The line of transition from squamous to respiratory epithelium can be easily identified.

After the nasal cavity has been decongested, the four walls are easily seen unless some abnormality is present. The floor is mostly made up of the hard palate. A portion of the nasal surface of the soft palate can also be seen. The nasal septum makes up the medial wall. By palpation, the anterior cartilaginous portion can be distinguished from the bony portion, which is made up of the septal process of the palate, the vomer, and the perpendicular plate of the ethmoid bone. The mucous membrane is rather tightly adherent to the septum. Superficial blood vessels, especially those located anteriorly in Little's area, can be seen. A thickening of the mucous membrane of the septum opposite the anterior tip of the middle turbinate is known as the septal tubercle. The roof of the nasal cavity is quite difficult to view. Where the mucous membrane changes from a pinkish to a yellowish hue the olfactory epithelium begins. The most prominent structure on the lateral nasal wall is the inferior turbinate. This is a separate bone which articulates with the lacrimal, ethmoid, and palatal bones. The mucous
membrane is quite thick, for it contains numerous venous plexus in the form of cavernous erectile tissue. The inferior meatus is inferior to the inferior turbinate. For the most part it corresponds to the medial wall of the maxillary sinus. The nasolacrimal duct opens high in the anterior portion of the inferior meatus. The middle turbinate is a projection of the ethmoid bone. It obstructs a good view of the middle meatus. In some patients the middle meatus can be seen, especially when the mucous membrane of the middle turbinate is atrophic. The ethmoidal infundibulum is a crescent-shaped groove seen just anterior to an elevation known as the ethmoidal bulla. The opening into the infundibulum is known as the semilunar hiatus. The nasofrontal duct may be positioned in the superior aspect of the infundibulum. Just inferior to this are the openings of the posterior ethmoid cells. The ostium of the maxillary sinus is found inferiorly and posteriorly in the infundibulum. In some individuals a superior turbinate can be seen; usually, however, only a thickening of the mucous membrane can be identified. The superior meatus and the ostia of the posterior ethmoid cells are found in this area. Posterior to this area is the spheno-ethmoidal recess. The ostium of the sphenoid sinus is located posteriorly.

**Abnormal Findings**

**Disorders of Nasal Vestibule.** The nasal vestibule is a common site for furuncles and fissures. Most deformities of the nasal vestibule are caused by dislocation of the septal cartilage at the columella. These deformities may also be due to the variation in size and shape of the alar cartilages. This area is not an uncommon site of benign and malignant skin tumors.

**Disorders of Mucous Membrane.** The color of the mucous membrane is noted. Normally it is a deep pink, but with inflammatory processes or nasal allergy, it may be reddened or pale and of a bluish-gray color. The mucous membrane should be evaluated for the presence of hypertrophy or atrophy; also the quantity and character of nasal secretions should be carefully studied. The swollen mucous membrane associated with allergy usually has a watery discharge. When vasomotor rhinitis is suspected, it is most important to determine whether or not there is an excessive amount of mucous secretion. Hypertrophy of the turbinates and mucous membrane associated with hypersecretion of mucus is probably not due to a true vasomotor rhinitis, and therefore a good response to either a medical or a surgical regimen directed toward therapy of this type of rhinitis cannot be expected. The hypertrophy may an early phase of atrophic rhinitis. Smears should be made to determine whether or not eosinophils are present. The protein and sugar content of the secretions can be easily ascertained with a lab stick. A watery rhinorrhoea can represent a leakage of spinal fluid. It is usually best to take samples for cultures before applying vasoconstrictors; on the other hand, purulent secretions may not be obtained prior to vasoconstriction.

**Irregularities of Septum.** There is almost always some degree of septal irregularity (except, possibly, in the Bantu people of South Africa). Quite commonly there is a ridge located inferiorly on one or both sides where the septal cartilage joins the septal process of the palatal and vomer bones. As a rule these minor irregularities are symptomless; too often they are taken as a cause for nasal stuffiness which is due to other factors and an unnecessary submucous resection of the nasal septum may be performed. On occasion, ridges, spurs, or deflections of the nasal septum, which do interfere with normal nasal respiration, can be seen.
Septal spurs can, on occasion, initiate nasal neuralgia manifested by a severe, intermittent or constant, boring pain, usually in the lateral aspect of the nose, over the maxilla, but may be located in any area supplied by the second division of the fifth cranial nerve. In making the diagnosis, the spur and surrounding area should be anesthetized with a topical agent. If this is not effective in relieving the pain, the sphenopalatine ganglion should be anesthetized to determine if the pain is due to sphenopalatine neuralgia.

**Stuffiness or Obstruction.** The most common symptom of nasal disease is stuffiness or obstruction. This may be unilateral or bilateral. A deviated nasal septum is the most common cause of unilateral stuffiness or obstruction. Operation for its correction should be advised only if the symptom is distressing or the deviation causes complicating sinus disease.

Foreign bodies are not uncommonly found in the nasal cavity. They may produce a reaction which in turn leads to stuffiness or obstruction. They are encountered most commonly in children and in psychotic patients. In addition to stuffiness, they may be responsible for pain, bleeding, and a foul discharge. The diagnosis is made by palpation with a probe, after a topical anesthetic has been applied, and also by x-ray examination. Removal of intranasal foreign bodies can be quite difficult and often a general anesthetic is required.

Acute and chronic rhinitis, hay fever, and vasomotor rhinitis are the most common causes of bilateral nasal stuffiness and obstruction in adults; adenoid hypertrophy is the most common cause in children. If adenoid hypertrophy is persistent or associated with recurrent or persistent sinusitis or middle ear disease, an adenoidectomy is indicated. A deviated septum may cause bilateral nasal stuffiness, especially when the septum is deviated to one side anteriorly and to the other posteriorly. Nasal polyps, a chronic edematous inflammatory process of the nasal mucous membrane, may be responsible for bilateral obstruction. They appear as yellowish, grape-like masses and are usually associated with bilateral chronic allergic ethmoiditis. Other sinuses may also be involved.

Hematoma of the septum produces bilateral nasal obstruction. It is usually of traumatic origin, or it may follow submucous resection of the nasal septum. Abscess of the nasal septum presents as bilateral nasal obstruction with pain, redness, and swelling of the septum on both sides. Both hematoma and abscess of the nasal septum require surgical therapy.

**Benign Tumors.** Papillomas appear in the region of the nasal vestibule as viable, sessile masses. Osteomas can extend into the nasal cavity. They quite often produce external deformity as well as nasal obstruction. Juvenile angiofibromas occur posteriorly. They are more common in males than in females and rarely are seen in persons beyond 20 years of age.

**Malignant Tumors.** The most frequently occurring intranasal malignant lesions are of epithelial origin. Often their presenting symptom is unilateral nasal obstruction; therefore, an excellent course to follow is to regard unilateral nasal obstruction as due to a malignant tumor until proven otherwise. Adenocarcinoma is the next most common malignant lesion. Lymphosarcoma, melanoma, and other malignant tumors also may occur in the nose. Malignant intranasal tumors may be manifested by bilateral as well as unilateral nasal stuffiness or obstruction, by external swelling, bleeding, discharge due to secondary infection, pain, and/or epiphora.
Perforation of Nasal Septum. The nasal septum may be perforated either anteriorly or posteriorly. Although such association is uncommon today, we still must think of an anterior perforation as indicative of tuberculosis and a posterior perforation as due to syphilis. At the present time, most perforations are anterior and are the result of trauma from chronic nose picking or are due to surgical procedures. Small anterior perforations are quite troublesome, for they produce a whistling nasal respiration. These can be repaired surgically. The nasal stuffiness or obstruction associated with septal perforation is due to crusting. Epistaxis from the margin of a perforation is common, especially if the patient has not learned how to use saline irrigations and to apply petroleum jelly to the margins of the perforation.

Unilateral Partial or Complete Choanal Atresia. Unilateral choanal atresia often remains undiagnosed, even in adults. In addition to the nasal obstruction, a mucoid or purulent nasal discharge is present. The diagnosis can be made by anterior rhinoscopy, probing, or contrast radiography. Bilateral choanal atresia becomes apparent in the neonatal period. Since the newborn cannot breathe through his mouth, if he has this congenital abnormality he will die from asphyxiation unless the attending physician is alerted to the necessity of an oral airway. Diagnosis is made by attempting to pass rubber catheters from the nose into the pharynx. To confirm the diagnosis and outline the obstruction, radiopaque substances are instilled into the nasal cavity, and lateral x-ray views are obtained with the infant in the recumbent position.

Paranasal Sinuses

History

Much of the history of sinus disease is obtained during the interrogation for nasal signs and symptoms. The most common symptom of sinus disease is nasal discharge. It is, however, important to review carefully the history of discomfort or pain related to the various paranasal sinuses. Generalized headache is usually not a symptom of sinusitis. Pain from the frontal sinus can be present directly over the sinus or in the orbit. This pain appears each morning and progresses in severity until late afternoon, at which time it subsides spontaneously. Pain from the maxillary sinus can occur directly over the sinus, in the orbit, or at the upper teeth. Pain from the ethmoid sinus is usually in, or medial to, the orbit on the affected side. The pain resulting from sphenoid sinus disease is most difficult for the patient to describe. It is usually severe, persistent, and emanates from the "center of the head." A change of head position may either worsen or relieve the pain.

There are numerous orbital manifestations of sinus disease. These include orbital pain, exophthalmos, enophthalmos, lid swelling, mass in the orbit, epiphora, orbital cellulitis, and abscess (see Chapter 2).

Anatomy

The anatomy of the paranasal sinuses will be discussed in detail in the following chapters along with surgical technique. A thorough knowledge of the anatomy, with its variations, is essential for the diagnosis and treatment of sinus disease.
Technique of Examination

Examination of the sinuses should include palpation of the roof and floor of the orbits, of the ascending process of the maxillae, and of the canine fossae. Tenderness may be elicited in these areas, and masses or defects may be felt. Transillumination is of limited value but should not be excluded. Its use is limited to the diagnosis of frontal and maxillary sinus disease. For the frontal sinuses the light is placed under the medial aspect of the supraorbital rim for observation of the forehead; for the maxillary sinuses it is placed above the infraorbital rim for observation of the hard palate. The test is not of true diagnostic value, for both the frontal and maxillary sinuses vary considerably in their degree of development. A sinus filled with clear liquid will transilluminate well. The presence of a mass, thickness, or reaction in the surrounding bone will interfere with transillumination. Transillumination is most useful as a tool for following the patient's progress once a clinical or radiographic diagnosis has been made.

During infancy, the frontal and sphenoid sinuses are not clinical entities. The frontal sinus is an extension of an anterior ethmoid cell and is usually not fully developed until puberty. In approximately 5% of the population there is no frontal sinus development; in 15 to 20%, only unilateral pneumatization is found above the supraorbital rim. The sphenoid sinus at birth is a definite structure in the posterior nasal cavity. Pneumatization extends into the sphenoid bone when the child is approximately 3 years of age. Full pneumatization is reached during adolescence. The maxillary and ethmoid sinuses are present at birth and thus can be diseased during infancy. This is especially true of the ethmoid sinuses. Neither the maxillary nor the ethmoid sinuses, however, reach full development until adolescence.

Technique of Radiography

By Alexander S. Macmillan, Jr, MD.

Tabletop screen technics are very effective in paranasal sinus radiography. A stainless steel lead-backed mask, 6 inches in diameter, is placed over a 6.5 x 8.5-inch cassette for each view. An off-center mask, 4 inches in diameter, is useful for obtaining both optic foramina on one film and for stereoscopic views. Five standard projections are used: (1) PA (Caldwell), (2) erect Waters', (3) prone Waters', (4) basal, and (5) lateral.

The following accessory projections are employed when necessary to show more clearly areas that are not well defined on the standard views: (1) optic foramina, (2) dental films, (3) AP and lateral laminagrams, and (4) lateral soft-tissue films. Various film combinations can be used for special purposes: (1) upright and cross-table lateral views for fluid levels, especially in the sphenoid sinus, (2) lateral and basal views for nasopharyngeal neoplasm, and (3) PA, Waters', basal, lateral and optic foramen views plus laminagraphy to determine the extent of injury after trauma.

Tabletop screen technic is adaptable to all ages and conditions of patients because of the optimal object-film distance and short exposure time. Infants are wrapped in a sheet, mummy style, for immobilization, and the standard or accessory projections are used.
We line up our five views in the above order much as one would study the facial bones and sinuses of an anatomical skull:

(1) On the Caldwell view we look the skull 'in the eye.' This is the best view of the frontal bone and sinuses, the ethmoids, and orbits and the upper aspect of the antra. The floor of the back or apex of the orbit projects above the inferior orbital rim.

(2) The erect Waters' view is taken with the orbito-meatal line at a 45° angle to the central beam. This gives the most satisfactory view of the facial bones, especially for injuries. The orbital floor is projected below the lower rim of the orbit due to parallax.

(3) In the prone Waters' view, the skull is tilted back a little more. The prone and upright Waters' views will often permit stereoscopy.

(4) The basal view is best made in the prone position with the orbito-meatal line as close to parallel to the cassette as possible and the central beam angled slightly caudally and passing through the angle of the mandible.

(5) The (erect) lateral view is usually made with the patient facing left.

Individual variations in facial features (size, shape, etc) need not be considered in positioning the patient or in angling the beam. The orbito-meatal line, sagittal plane and other surface landmarks guarantee consistent reproducibility on subsequent examinations. The central ray is always aligned to the center of the film. The mask, slightly raised above the cassette, is a convenience in accurate positioning and provides sharp edges to the exposure area on the films. We omit the mask on the lateral view.

Some Principles of Interpretation

1. The radiologist must have the patient's history at hand when reporting the films.

2. Be specific in recording your impressions. We use the term, 'density due to ...', thereby committing us to attempt a pathologic correlation, much as Fleischner, in described a blunted costophrenic angle, says, 'It is obscured by fluid, old pleurisy, tumor, etc.'

3. Displacement of air from a sinus results in increased density. An overlapping lesion outside the sinus usually has a negligible effect on the density. Feldman demonstrated this by placing bolus material over a maxillary sinus and exposing a film. It is well recognized that only the peripheral contours of a breast shadow are seen on a chest film while an epicardial fat pad is usually as dense as the heart.

4. Mucosal thickening can be determined only when seen in true tangent, as on the antronasal wall.

5. Blood in a maxillary sinus from an orbital floor fracture does not obscure the fragments. The fragments cannot be seen because they are displaced so that their flat side faces the central beam.
6. The orbital floor and optic foramina are bilaterally symmetrical.

7. An asymptomatic primary focus of cancer is commonly found in the nasopharynx but seldom in the sinuses.

8. Maxillary retention cysts are smooth in outline and are seen on the roof, lateral wall, or floor of the sinus. Rarely does cancer present in a sinus as an isolated mass unless it is irregular and then there usually is bone destruction.

9. Bone destruction usually means malignant disease but infection and benign lesions may on occasion erode bone.

10. Cellulitis over a maxillary sinus should alert the radiologist to study the teeth carefully for a periapical abscess in the upper jaw. It is rare for maxillary sinusitis to 'break out' of its confines whereas such extension from the frontal and ethmoid sinuses is common.

**Nasopharynx**

**Anatomy**

The nasopharynx extends from the bony choanae to the inferior border of the soft palate. Looking anteriorly from the nasopharynx into the nose, the posterior border of the nasal septum dividing the two choanae is seen. The posterior tips of the middle and inferior turbinates can be identified in each choana. The lateral and posterior walls of the nasopharynx are formed by mucous membrane which covers the superior constrictor muscles.

Adenoid tissue, a mass of lymphoid tissue also known as the pharyngeal tonsil, is found on the posterior wall of the nasopharynx. It is connected with the palatine and lingual tonsils by a band of lymphoid tissue extending down the lateral pharyngeal wall. This entire lymphoid complex is known as Waldeyer's ring.

In the superior aspect of the lateral wall of the nasopharynx is a depression known as the pharyngeal recess (sinus of Morgagni or fossa of Rosenmüller). This is formed by a deficiency in the muscle insertion of the superior constrictor to the base of the skull. Below the pharyngeal recess is the eustachian tube cartilage. This is called the torus tubarius. A ridge extending downward from the torus tubarius to the lateral pharyngeal wall is often referred to as the salpingopharyngeal fold.

The anterior wall of the nasopharynx is formed by the hard and soft palate.

**Physiology**

Inspired air passes into the oropharynx from the nose by way of the nasopharynx. The mucous blanket (mentioned under the discussion of nasal physiology) passes from the nose into the oropharynx by way of the nasopharynx. The nasal mucosa, under normal conditions, produces approximately a quart of seromucinous fluid a day. When this amount is decreased by intranasal and environmental factors, the mucous blanket becomes greatly thickened. This
blanket, which is normally insensible, thus becomes sensitive by virtue of being concentrated
and is referred to as a postnasal drip.

The nasopharyngeal space, with the nasal cavities, is also concerned with the resonant
quality of the voice.

**Technique of Examination**

**Mirror Examination.** A mirror, size #0 to #00, is used to examine the nasopharynx. It is warmed by a flame, hot water, or by holding it over an electric light bulb. If no heat is available, a thick soapy solution is placed on the mirror and wiped off without rinsing. The patient should be sitting directly in front of the examiner, with his head at the same level as that of the examiner. The patient is asked to sit erect, all the way back in the chair, with his head projected slightly forward.

The examiner depresses the patient's tongue onto the floor of the patient's mouth with the left hand, making sure not to extend the tip of the tongue blade beyond the patient's mid-tongue area. Light is reflected into the pharynx with the head mirror. The examiner grasps the mirror with his right hand as he would grasp a pencil and slips it behind and to one side of the patient's uvula. The patient is requested to breath quietly and not to hold his breath. Care is taken not to touch the base of the patient's tongue. Two percent Pontocaine, or 4% cocaine, solution may be sprayed into the pharynx to control the gag reflex. The soft palate may be retracted anteriorly for a better view of the nasopharynx by placing a rubber catheter, which exits through the oropharynx, into each nostril. The catheters are stretched and clamped over a piece of rolled-up gauze placed just below the nose.

**Anterior Rhinoscopy.** The upper nasopharynx can be examined, after proper shrinkage of the nasal mucosa (with 1% ephedrine or 0.5% cocaine), by direct examination of the nose through a nasal speculum.

**Nasopharyngoscope.** The nasopharyngoscope is an instrument similar to cystoscope. It provides an excellent view of all areas of the nasopharynx.

**Palpation.** Palpation is usually reserved for examination with the patient under general anesthesia. Topical anesthesia relieves some of the discomfort of this examination.

**Direct Examination.** A tubular instrument known as the Yankauer speculum provides direct inspection of the nasopharynx by lifting the soft palate out of the way. This instrument, however, is only suitable for examination of the lower half of the nasopharynx.

**X ray.** The lateral view of the nasopharynx is used to determine the following:

1. Size of adenoids.
2. Status of eustachian tubes.
5. Patency of choanae (using radiopaque substance).
7. Ability of soft palate and transverse ridge of contracted superior constrictor (known as Passavant's ridge), at level of soft palate, to close the velopharyngeal space.

8. The boundary between the nasopharynx and the oropharynx (this x ray is taken during the act of swallowing).

The base of skull view demonstrates:

1. Presence of lesions.
2. Size of lesion.
3. Extension of disease beyond the nasopharynx (bony destruction).

**Symptoms of Nasopharyngeal Disease**

**Nasal Obstruction.** Impaired or obstructed nasal airways are not always due to intranasal disease.

Unilateral or bilateral choanal atresia may be due to bony or membranous obstruction. Bilateral atresia occurring in the neonatal period presents an emergency situation, for mouth-breathing is an acquired habit.

**Choanal Polyp.** A large polyp may extend from the middle meatus into the nasopharynx and cause obstruction.

**Benign Tumors.** Fibromas and other benign tumors (neurofibroma, hemangioma, mixed tumor, chondroma, and lipoma) may arise in the nasopharynx.

**Cancer of the Nasopharynx.** Cancer of the nasopharynx represents 2% of all malignant growths. It is most common in the Oriental population. A mass in the neck or serous otitis media due to blockage of the eustachian tube may be the first symptom.

**Cysts.** Cysts may form in the upper posterior wall of the nasopharynx at the site of evagination of embryonic structures which form the pituitary gland (Rathke's pouch).

On the lower posterior wall, a cyst may form from the sac-like depression known as the pharyngeal bursa. This area is the point of union between the anterior end of the notochord and the pharyngeal endoderm (Thornwaldt's cyst).

**Adenoid Hypertrophy.** Adenoid hypertrophy is the most common cause of nasopharyngeal obstruction.

**Bleeding.** Bleeding from the nasopharynx may have its origin in the nose. Benign and malignant tumors, varices, and atrophic mucous membrane may be the sites of hemorrhage.

**Discharge.** In addition to "postnasal drip," described under the heading "Physiology," the following may account for nasopharyngeal discharge:

1. Purulent sinusitis.
2. Nasal allergy.
3. Atrophic nasopharyngitis.
4. Infected pharyngeal bursa.
5. Acute infection of the nasopharynx.

**Cranial Nerve Paralysis.** Cranial nerve palsy may result from extension of disease from the nasopharynx. The sixth cranial nerve is the one most commonly paralyzed. Next in order are the third, fourth, and fifth cranial nerves.

**Hearing Loss and Otalgia.** Almost any disease process in the nasopharynx may obstruct the eustachian tube orifice, producing discomfort and blockage of the ear. The blockage of the eustachian tube results in a negative middle ear pressure and thus exudation of serum.
Surgery of the Upper Respiratory System

William W. Montgomery

Chapter 2: Introduction to Sinus Surgery

Indications for Surgery of the Sinuses

As a general rule, surgical treatment is indicated for those patients with chronic sinusitis who do not respond to medical therapy. The advent of biochemotherapy and of a better understanding of sinus and intranasal physiology has been instrumental in a reduction of the frequency with which sinus surgery must be undertaken.

Routine indications for sinus surgery are:

1. Intracranial extension of infections such as meningitis, subdural abscess, or brain abscess.
2. Persistent pain and/or purulent discharge which has not been responded to conservative therapy.
3. Necrosis of the sinus wall as shown by fistula formation.
4. Mucocele or pyocele formation.
5. Orbital cellulitis or retrobulbar neuritis.
6. Venous sinus thrombosis.

The objective of surgical treatment of a sinus is either to (1) provide free and easy drainage from the sinus into the nose (while at the same time not interfering with intranasal physiology); or (2) eliminate the sinus (obliteration). Before resorting to any of the radical sinus procedures it is most often preferable to perform simple intranasal operations in order to establish better drainage. Such operations as submucous resection of the nasal septum, removal of nasal polyps, resection of the anterior half of the middle turbinate, intranasal antrostomy, and intranasal ethmoidectomy are often sufficient to effect a cure.

Complications of Sinus Disease

Orbital Manifestations of Sinus Disease

The paranasal sinuses might also be referred to as the paraorbital sinuses, for the orbit is surrounded (except laterally) by these sinuses. The first indication of sinus disease is often manifested by orbital symptoms.

Orbital Pain. Generalized headache is not a usual manifestation of sinus disease, whereas pain in or above the orbit is a common symptom of this malady.

Pain in the eye may be the presenting complaint in a patient with acute maxillary sinusitis. Orbital pain is a less common complaint associated with chronic maxillary sinusitis. Benign and malignant tumors which extend through the roof of the antrum may cause orbital pain.
Acute frontal sinusitis frequently produces orbital pain. Pain elicited by palpation of the floor of the frontal sinus just posterior to the medial aspect of the supraorbital rim is indicative of such infection. Orbital pain is increased if the infection extends into the orbit, either directly through the floor of the frontal sinus or by phlebitis. Chronic frontal sinusitis and benign and malignant tumors may, if they extend into or in the direction of the orbit, also produce orbital pain.

Orbital pain is an early manifestation of acute ethmoiditis. This is, of course, increased with the onset of orbital cellulitis or abscess. Chronic ethmoiditis does not usually produce orbital pain unless the disease extends in the direction of the orbit. Benign and malignant tumors of the ethmoid may produce orbital pain.

Acute and chronic sphenoiditis produce pain which the patient describes as being behind the eye(s). Extension of disease beyond the confines of the sphenoid sinus, whether the disease be inflammatory or neoplastic, may produce severe retrobulbar pain.

**Exophthalmos.** Exophthalmos is a protrusion of the eyeball from the orbit. It is usually a manifestation of a disease other than of sinus origin.

Acute and chronic maxillary sinusitis are rarely complicated by exophthalmos unless infection has extended by means of phlebitis into the retrobulbar space. Cystic lesions of the maxillary sinus include mucocele, dentigerous cyst, dermoid cyst, and cystadenoma. Any of these lesions may expand so as to destroy the roof of the antrum and extend into the orbit, thus producing exophthalmos. The pressure exerted in the direction of the orbit may also cause a ptosis of the upper lid which is produced by a restriction of elevation of the upper lid. Epiphora may accompany this proptosis. Diplopia results from the upward displacement of the orbital contents. On occasion, the lesion may be palpated posterior to the infraorbital rim. Malignant lesions of the maxillary sinus which occur high in the sinus will cause early destruction of the roof of the antrum and extend into the orbit, producing exophthalmos. Malignant lesions which have their origins elsewhere in the antrum may also extend into the orbit. In these cases the prognosis is poor because, as a rule, the disease has also spread in other directions such as through the posterior wall of the antrum into the pharyngomaxillary fossa. A fracture of the maxilla rarely produces exophthalmos, but exophthalmos does occur, however, in association with certain tripod fractures.

Acute and chronic ethmoiditis may produce exophthalmos as a result of extension of infection through the lamina papyracea. This will be discussed under the headings "Orbital Cellulitis and Abscess" and "Cavernous Sinus Thrombosis." Tumors of the ethmoid sinuses are not common. They extend in the direction of least resistance, which is the lamina papyracea, thus causing outward and lateral displacement of the orbital contents. The most common benign lesions of the ethmoid sinus are mucoceles, osteomas, papillomas, and fibromas. Primary carcinoma of the ethmoid is unusual. A fracture of the ethmoid labyrinth and lamina papyracea may cause a degree of proptosis following nose-blowing. The subcutaneous emphysema of the lids is indicative of fracture.

Acute or chronic frontal sinusitis may extend into the orbit by way of the floor of the frontal sinus with resultant cellulitis and orbital abscess attended with proptosis. Other diseases of a frontal sinus may penetrate through the orbital roof and cause displacement of
the orbital contents in an outward and downward direction. The upper lid may be involved in an inflammatory process, or a mass may be palpated between the upper lid and the supraorbital rim. The two most common tumors of the frontal sinus causing displacement of the orbital contents are mucocele and osteoma. The progression of downward and outward displacement of the orbital contents by either of these lesions can be very slow and insidious. The displacement can also have a rapid onset if the mucocele becomes infected (pyocele) or if the osteoma becomes complicated by acute frontal sinusitis. Other benign lesions and malignant lesions of the frontal sinuses are rare, but, when present, they also may produce exophthalmos by extension through the floor of the frontal sinus.

Acute and chronic sphenoiditis, cystic (mucocele) and solid benign tumors, and primary or secondary carcinomas of the sphenoid sinus may extend into the retrobulbar area and produce exophthalmos simply by occupying space or by interfering with the venous return from the orbit. These conditions are usually also accompanied by interference with the nerves and blood vessels entering the orbit as manifested by visual defects and extraocular muscular dysfunction. There have been numerous reports of metastatic lesions of the sphenoid sinuses with orbital complications. These malignant lesions may arise in the nasal cavity, nasopharynx, other sinuses, intracranial spaces (pituitary), and distant points, such as the bowel, or kidney.

**Enophthalmos.** Enophthalmos is a recession of the eyeball into the orbit. It may result from contracture following orbital cellulitis, orbital and sinus operations, orbital injuries, and fractures of the orbital walls.

The blow-out fracture is a relatively common cause of enophthalmos. This is a fracture of the floor of the orbit with prolapse of the orbital contents into the antrum. There may be also a fracture and medial displacement of the lamina papyracea with prolapse of the orbital contents into the ethmoid labyrinth. Varying degrees of interference with ocular motility may accompany these fractures when the extraocular muscles (especially inferior rectus and inferior oblique) are trapped between the bony fragments. This situation requires immediate surgical intervention.

Two cases of enophthalmos resulting from mucocele of the maxillary antrum have been reported (Montgomery, 1964). The pathogenesis is not absolutely clear. It is assumed that the mucocele expands, destroying the roof of the antrum by pressure, and that the enophthalmos occurs with subsequent rupture and partial evacuation of the mucocele.

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that the mucocele expands, destroying the roof of the antrum by pressure, and that the enophthalmos occurs with subsequent rupture and partial evacuation of the mucocele.

**Lid Swelling.** Inflammatory edema of the eyelids may occur with acute maxillary, ethmoid, or frontal sinusitis. This edema is soft with no point of tenderness or localization such as that found in acute meibomian gland infection. Ocular motility and vision are not affected. If the inflammatory process extends into the orbit from the sinuses, this inflammatory edema may become more severe as orbital cellulitis progresses. As a general rule, the upper lid is more swollen with frontal than with ethmoid or maxillary sinusitis. Both upper and lower lids are swollen with ethmoiditis, and the lower lid may be more swollen than the upper with extension of infection from the maxillary sinus.

**Mass in the Orbit.** A mass palpated in the orbit may be the first sign of sinus disease. A mass in the region of the infraorbital rim may represent extension of disease from the maxillary sinus. The most common diseases of the antrum producing a mass behind the infraorbital rim are carcinoma, mucocele, and osteoma of the maxillary sinus. A mass medial to the inner canthus may indicate a disease in the ethmoid sinuses, the most common being carcinoma, mucocele, and osteoma. A mass behind the supraorbital rim may indicate disease extending through the floor of the frontal sinus; the lesions most commonly responsible are mucocele, pyocele, osteoma, chronic inflammatory process, recurrent or persistent disease following the Lynch frontal sinus procedure (which entails removal of the floor of the frontal sinus), and carcinoma of the frontal sinus.

**Epiphora.** A prolonged inflammatory process of the nasal mucosa is said to cause epiphora, either by stenosis of the nasal lacrimal duct or by obstruction of the orifice in the inferior meatus. It is also within the realm of possibility that an inflammatory process could extend from the ethmoid sinuses to the lacrimal sac. Epiphora may also accompany exophthalmos of sinus origin.

**Orbital Cellulitis and Abscess.** An inflammatory process may extend from any of the paranasal sinuses into the orbit by direct extension through the bony wall or by way of the venous circulation. At first there is an inflammatory edema of the lid(s). As the disease progresses, there is exophthalmos, chemosis of the conjunctiva, and progressive immobility of the eye. There also may be some interference with the vision. At this point the patient is usually quite ill and has a high fever and severe pain. X-ray of the sinuses should be taken to determine the origin of infection. Although the ethmoid sinus is most common the site of origin, the infection may stem from any of the other sinuses. Treatment should be vigorous because of the danger of extension of the infection into the intracranial spaces, producing such complications as meningitis and cavernous sinus thrombosis.

It is often difficult to determine whether or not an orbital abscess is present unless obvious fluctuation can be palpated. As a general rule, if the condition is not responding to intensive therapy, an exploratory operation should be performed in which the orbit is approached through a frontoethmoidectomy incision. The orbital periosteum is carefully elevated posteriorly, superiorly, and laterally. Since many orbital abscesses are extensions from a chronic ethmoiditis or acute exacerbation thereof, a point of breakthrough may be found in the lamina papyracea. In such cases, it is wise to perform an external ethmoidectomy.
simultaneously with exploration of the orbit and drainage of the orbital abscess. If an abscess is found, it should be drained for at least four days.

**Cavernous Sinus Thrombosis.** Cavernous sinus thrombosis can be a fatal disease, even when all modern therapeutic tools are utilized. It is sometimes difficult to differentiate between cavernous sinus thrombosis and orbital cellulitis or abscess. In addition to the signs for orbital cellulitis described above, a dilation of the retinal veins and edema of the optic disk may be found with cavernous sinus thrombosis. Intermittent rises of temperature to 104° or 105°F following a chill should make one suspicious of this complication. A blood culture and examination of the spinal fluid are indicated. The physician should be on the lookout for signs of meningitis.

**Involvement of Optic Nerve.** Approximately 15% of cases of retrobulbar neuritis are said to be caused by sinus disease. This is not surprising since the optic nerve may be in close relationship to the sphenoid, ethmoid, and maxillary sinuses, depending on their degree of pneumatization. The inflammatory process may spread directly through the sinus wall or by phlebitis. The loss of vision may be of sudden or gradual onset. The therapy consists in administration of antibiotics and specific surgery of the involved sinus. Benign and malignant tumors of the sinuses, as well as of the pituitary gland, can cause blindness or defects in the visual fields.

**Superior Orbital Fissure Syndrome.** The third, fourth, and sixth cranial nerves, the first division of the fifth cranial nerve, the ophthalmic vein, and sympathetic nerves from the cavernous plexus may become involved in disease of the sphenoid sinus. The lateral wall of this sinus, if well pneumatized, is in very close proximity to the superior orbital fissure. An acute or chronic inflammatory process may extend from the sphenoid sinus to this region. Cystic lesions, such as a mucocele or a craniopharyngioma, benign neoplasms, and primary or secondary malignant disease of the sphenoid sinus may be complicated by a superior orbital fissure syndrome. Any or all of the structures passing through the superior orbital fissure may be affected by the disease processes. The sixth cranial nerve is usually implicated first, with subsequent involvement of the third, fourth, and fifth nerves. As the disease progresses the fifth cranial nerve is affected, as manifested by pain in the eye and forehead. This is followed by exophthalmos and, finally, total ophthalmoplegia. X rays of the sinuses should include laminography of the sphenoid sinuses. Treatment consists in immediate exploration by means of the transethmoid approach to the sphenoid sinus.

**Osteomyelitis of the Frontal Bone**

**Etiology.** In the great majority of the reported cases of osteomyelitis of the frontal bone the organism recovered is the Staphylococcus aureus. The streptococcus, pneumococcus, and anaerobic streptococcus are found in a few instances. The degree of involvement depends to a certain extent upon the virulence of the organism and the resistance of immunity of the patient to the particular bacteria present.

In children the origin of osteomyelitis of the frontal bone is almost always hematogenous; in adults the disease is more likely to result from trauma during an episode of acute frontal sinusitis. The majority of the patients are under 30 years of age. The disease
is more common in females than in males and in many instances follows swimming. Chronic infection of the sinuses, especially an acute exacerbation of the infection, may predispose to osteomyelitis. Trauma in the region of the frontal sinus or an operation upon the frontal sinus frequently precedes the advent of the osteomyelitis.

**Symptoms.** The clinical course may be acute or chronic.

In the acute fulminating type, fever, headache, and edema of the upper eyelid on the affected side are present. The soft, doughy swelling (Pott's puffy tumor) or pericranial abscess is pathognomonic of osteomyelitis of the underlying bone. This type frequently follows swimming. Spread to the intracranial structures is not unusual. As a rule, however, osteomyelitis is a slowly progressive disease, even in the acute stage.

The chronic localized form of frontal bone osteomyelitis, without perforation of the internal table, is usually characterized by an insidious onset, a low-grade fever, local pain or tenderness, doughy swelling of the forehead, general malaise, and, occasionally, chills. Fistulas may form, and sequestra may separate from the bone during cyclic exacerbations.

**Diagnosis.** The diagnosis is made by means of roentgenogram combined with the signs and symptoms of fluctuating swellings, advancing edema, persistent low-grade temperature, leukocytosis, and pain and headache with cyclic exacerbation.

According to Mosher and Judd, the edema of the soft tissue of the forehead is the first sign of infection of the periosteum and the medulla of the frontal bone. This edema, in the past, was a practical guide to the extent of bone to be removed. X rays do not show positive change until necrosis is present and this is not apparent until 7 to 10 days after forehead edema appears. If antibiotics have been administered the clinical correlation just described does not hold true, for the edema of the forehead is no longer an index of the degree of osteomyelitis and, in fact, may not be present.

**Treatment.** Antibiotics, selected in accordance with bacteriologic sensitivity tests, should be given intravenously in large doses. Any localized abscess should be drained. If x rays show that the frontal sinus(es) contains pus, a trephine operation of the frontal sinus(es) should be carried out, both for inspection of the interior of the sinus(es) and to obtain purulent secretions for culture and antibiotic sensitivity tests. Usually the antibiotic of choice is penicillin. This should be administered intravenously and local therapy, such as application of heat, nasal spray, and systemic decongestants, should be instituted.

If there is not rapid reversal of the osteomyelitic process or if there is any question regarding involvement of the posterior wall of the frontal sinus, surgical intervention in the early course of therapy is indicated. If, on the other hand, the patient continues to show improvement, manifested both clinically and radiologically, the antibiotic therapy is continued for approximately 10 days.

After the osteomyelitis has been controlled by surgical drainage and antibiotic therapy, attention should then be directed more specifically to the frontal sinuses. If there is any question of persistent or chronic frontal sinusitis, a bilateral osteoplastic adipose obliteration operation should be carried out. A more conservative approach is contraindicated, for a
complication such as an extradural abscess could subsequently result. At the time of the osteoplastic operation any diseased bone is removed, and the sinus(es) is obliterated by insertion of subcutaneous abdominal adipose tissue. Antibiotic therapy is continued for at least 10 days following this operation.

The radical procedures which were most often necessary in the past for the treatment of osteomyelitis of the frontal bone are, for the most part, no longer necessary, if the proper antibiotics are administered in adequate doses. The operations advocated by Mosher and Judd are now procedures of the past.

On occasion it is necessary to remove a portion of devitalized bone. The resulting defect can be repaired by using an autogenous osseous autograft or a plastic implant. Since regeneration of bone is often a very slow process, this reconstructive procedure should not be attempted for many months following removal of the devitalized bone.

**Osteomyelitis of the Superior Maxilla**

Acute osteomyelitis of the superior maxilla is usually secondary to an infection of dental origin. In infants, it is occasionally secondary to a buccal infection. Involvement of the dental sac follows with extension of the necrotic process to the walls of the maxillary antrum, resulting in a purulent discharge into the nose and mouth. Lederer believes that the associated acute osteomyelitis is a result of the venous infection. He bases his opinion upon carefully studied serial sections from an infant in whom a nasal infection and sinusitis were found to be the primary cause of the osteomyelitis of the maxilla.

Osteomyelitis of the maxilla in nurslings and infants may occur from the first week following birth up to the ninth month. The highest incidence is during the first three weeks. The portal of entry and the manner of spreading of the primary infection may vary.

As shown by Lederer a sinusitis may produce a periostitis and osteitis with a fistulous tract formation which extends in any one of three ways: (1) to the facial surface with swelling of the soft parts of the cheek, breaking down of Bichat's pad, and abscess formation; (2) to the palatine and alveolar process with a fistula into the roof of the mouth; (3) to the zygomatic process with a necrosis of the zygomatic arch and extension into the pterygoid fossa with abscess formation. Extension along the fascial planes to the mandibular foramen may occur. An ethmoiditis may result in a periostitis, osteitis, and periorbital cellulitis which may extend in one or both of two ways: (1) thrombophlebitis of the venous channels, with extension to the cavernous sinus and the production of a thrombosis; (2) a periorbital abscess, with an occasional complicating external fistula.

**Symptoms.** The signs and symptoms are those of a sinusitis accompanied by marked swelling and chemosis of the cheek. Exophthalmos with limitation of movement of the eye may be present.

The first or septicemic stage may last for about 10 days with the formation of fistulas in the infraorbital regions, palate, and, in rare instances, into the nose. This is followed by a chronic indolent stage with persistent fistulas and sequestration of dead bone. This second
stage is not seen if antibiotics, proper drainage, and local therapy are instituted early in the course of the disease.

**Treatment.** Treatment consists of administration of large doses of specific antibiotics, surgical establishment of free drainage, and local application of heat. On occasion there is considerable loss of bone from osteomyelitis of the superior maxilla and a resultant large oroantral fistula, which can be repaired by using the various techniques outlined in Chapter 6.

**Osteomyelitis of the Sphenoid Bone**

Osteomyelitis of the sphenoid bone is quite rare. Many of the reported cases have been associated with osteomyelitis of the base of the skull or secondary to an infection of the petrous portion of the temporal bone. Eagleton attributes the rarity of infection of the base of the sphenoid to the preponderance of red cellular bone marrow found throughout life in this bone.

The organisms usually recovered are beta hemolytic streptococcus and Staphylococcus aureus. The early symptoms consist in a rather profuse postnasal discharge and a deep-seated headache either described as being in the center of the head or behind the eyes, which on occasion radiates to the temporal or occipital regions. Infection may spread laterally to the retrobulbar region, producing any of the various manifestations described in this chapter under the heading "Superior Orbital Fissure Syndrome."

Later, as the body of the sphenoid becomes more extensively invaded, symptoms of sepsis ensue, although the temperature may be low and the toxemia not marked. The retroorbital and temporal pain becomes especially severe. There may be, at this time, bacterial invasion of the meninges and blood stream. Cavernous sinus thrombosis, brain abscess, encephalitis, and intercranial hemorrhage may result.

**Treatment.** Osteomyelitis of the sphenoid bone is frequently not diagnosed until severe complications, which can be fatal, have developed. Careful x-ray examination of the sphenoid bone, including laminography, is imperative. The patient should also be followed closely by an ophthalmologist and neurologist. Treatment is essentially that of antibiotic therapy and surgical drainage.

**Intracranial Complications of Sinus Disease**

The modern otolaryngologist should be constantly on the lookout for intracranial complications of sinus disease. Most of these complications are readily apparent by their clinical manifestations. On the other hand, others have a slow, insidious onset which makes the diagnosis quite difficult.

The possible intracranial complications from disease of the nasal passages and sinuses are meningitis, extradural and subdural abscess, dural fistula, the various types of brain abscesses, and septic thrombosis of the cavernous or superior longitudinal sinus (the other venous sinuses are rarely involved in infections of the nasal sinuses). Meningitis which has its origin from sinusitis is more frequently observed than thrombosis of the venous sinuses.
Intracranial complications are more apt to result from acute infections of the sinuses than from chronic infections. These complications are more common in males than in females (4 to 1).

All infected sinuses may give rise to an intracranial complication, but an extension from a maxillary sinusitis is rare. Courville and Rosenvold state that a maxillary sinusitis of dental origin is more apt to provoke intracranial supplicative lesions than is maxillary sinusitis of any other type.

Infections from the nose or sinuses may invade the intracranial structures (1) after trauma; (2) through congenital dehiscences or nonclosure of fetal defects; (3) by a direct pathway through the sinus wall; (4) along the sheaths of the olfactory nerves; (5) by way of the communicating veins; (6) by means of septic thrombi along the diploetic veins with a retrograde thrombophlebitis or periphlebitis to the cavernous sinus; (7) by way of the angular or ethmoidal veins to the cavernous sinus; or (8) by way of the orbit. There has been some question as to the possibility of a direct extension of an infection of the sinuses to the intracranial structures by way of the lymphatic vessels.

Temporal lobe abscesses most commonly originate from infection in the temporal bone and lateral dural sinus. A temporal lobe abscess can originate from the sphenoid sinus or indirectly from the other sinuses by way of the cavernous sinus. Frontal lobe abscesses may complicate acute or chronic frontal sinusitis or tumors of the frontal sinus (such as osteoma), following surgical treatment of frontal or ethmoid sinus or trauma to the forehead.

**Frontal Sinus Pneumocele**

A pneumocele (pneumatocoele) is a collection of air, under pressure, in the tissues. The air usually escapes from a defect in the bony wall of the frontal sinus and collects adjacent to the sinus. If the defect is on the forehead, an external pneumocele results. If the defect is in the posterior wall of the frontal sinus, an internal or intracranial pneumocele is present.

A pneumocele may follow fracture, trauma, operation, congenital cleft, dehiscence, or necrosis of the bone. The latter may be due to syphilis, osteomyelitis, or sinusitis. Cases have been reported as secondary to, or associated with, an osteoma of the frontal sinus.

The sinus mucous membrane or frontal periosteum is intact over the bony defect, so that a ballooning of the mucosa or periosteum occurs; this forms an air sac when under pressure from blowing the nose, coughing, or sneezing. A pneumocele may occur in connection with a mucocele of the frontal sinus if air takes the place of the fluid contents and there is a connection from the nasal cavity to a defect in the mucocele.

In addition to the external and internal pneumoceles, a third type, characterized by an excessive dilation of the sinus (pneumosinus dilatans), may occur. Dilation of the sinus is usually associated with acromegaly or localized osteitis, or follows fractures in the region of the sinuses. Enlargement of the sinus is more apt to result if the bone changes occur before the sinuses are fully developed. Any of the sinuses may be involved on one or both sides. The exact mechanism by which the dilation occurs is not understood.
Surgery of the Upper Respiratory System

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Chapter 3: Surgery of the Ethmoid and Sphenoid Sinuses

Ethmoidectomy

Surgical Anatomy

The ethmoid bone is situated in the anterior cranium between the two orbits and the upper half of the nasal cavities. The lower two thirds of the lateral nasal wall is the medial wall of the maxillary sinus. The ethmoid bone appears to consist of crossed vertical and horizontal plates with the bony capsule of the labyrinthine cells attached to the inferior and lateral portion of the horizontal plate. The vertical plate rises slightly over the horizontal to form the crista galli, while the inferior vertical portion forms the perpendicular plate of the nasal septum. The ethmoid bone articulates anteriorly with the frontal bone, posteriorly with the sphenoid bone, and inferiorly with the quadrangular septal cartilage and perpendicular plate of the vomer bone. The horizontal plate of the ethmoid bone, adjacent to the midline, is perforated by many foramina for the passage of the olfactory nerve endings. The cribriform plate (lamina cribrosa) articulates with the frontal bone laterally and anteriorly. Posteriorly, it is in contact with the sphenoid bone.

The ethmoid cells lie between the upper third of the lateral nasal wall and the medial wall of the orbit. The number of cells varies according to the size of the cells. The attachment of the middle turbinate roughly divides the ethmoid cells into anterior and posterior groups. Thus, the ostia of the anterior ethmoid cells communicate with the middle meatus, while those of the posterior ethmoid cells communicate with the superior meatus.

The ethmoid labyrinth is pyramidal in shape; it is wider posteriorly than anteriorly and wider above than below. The anterior width of the labyrinth is 0.5 to 1 cm. The posterior width is approximately 1.5 cm. The anteroposterior dimension, or length of the labyrinth, is 4 to 5 cm. The height is 2 to 2.5 cm.

The lacrimal bone forms the lateral wall of the anterior ethmoid cells, and the os planum (lamina papyracea) forms the lateral wall of the posterior ethmoid cells. As a general rule, the outer half of the front face of the sphenoid sinus is the posterior limit of the ethmoid labyrinth.

The cribriform plate is the roof of the olfactory slit in the anterior superior nasal cavity. It is attached to the roof of the ethmoid labyrinth, which in turn joins the orbital plate of the frontal bone. The plane of the cribriform plate and roof of the ethmoid labyrinth correspond to a horizontal plane at the level of the pupils. The superior prolongation of the attachment of the middle turbinate, which forms the superolateral nasal wall, is the division between the cribriform plate and the roof of the ethmoid labyrinth.

The anterior half of the ethmoid labyrinth is made up of cells which are overlaid medially by the upper anterior part of the middle turbinate (the agger nasi cells, lacrimal cells,
infundibular cells, and cells of the ethmoid bulla). The posterior half of the ethmoid labyrinth is made up of cells which are overlaid medially by the upper extension of the attachment of the middle turbinate and the superior turbinate. The most important surgical relationships of the anterior ethmoid cells are: (1) the lacrimal bone, (2) the floor of the frontal sinus, (3) the semilunar hiatus, (4) the unciform groove, (5) the nasofrontal orifice, and (6) the ostium of the antrum. The most important relationships of the posterior ethmoid cells are: (1) the outer half of the front wall of the sphenoid sinus, (2) the posterior half of the inner wall of the orbit (lamina papyracea), and (3) the optic nerve. The thickness of bone between the optic nerve and the posterior ethmoid cells varies between 1 mm and 5 mm. On occasion, the nerve may mound into the posterior ethmoid cells.

There are common extensions of both the anterior and posterior ethmoid cells. The anterior cells may extend anteriorly, upward and outward, to the inside of the ascending process of the maxilla, making a cell series with the frontal sinus (the fronto-ethmoidal cell), and medially into the turbinate, producing a cellular turbinate. The common extensions of the posterior ethmoid cells are over, or to the side of, the sphenoid sinus posteriorly, and into the antrum and the pterygoid process inferiorly.

The arterial blood supply of the ethmoid cells is through the lateral branches of the sphenopalatine artery and the anterior and posterior ethmoid arteries. The ethmoid sinus thus receives blood from both the external and internal carotid systems. The venous drainage is by way of the ophthalmic vein or pterygoid plexus. The lymphatic vessels related to the ethmoid sinuses are few in number. Most of these pass directly to the nasal mucosa.

Intranasal Ethmoidectomy

**Indications.** Intranasal surgery of the ethmoid labyrinth is quite effective when indicated, but has been neglected by many otolaryngologists. Chronic polypoid ethmoiditis, with or without nasal polyps, is a positive indication for this type of operation. The eradication of chronic ethmoid infection is often sufficient to bring about a cure of chronic frontal and sphenoid infection. Even though the external ethmoidectomy provides a safer and a more thorough method of approaching the entire ethmoid labyrinth, a skillfully performed intranasal ethmoidectomy is perfectly adequate to bring about resolution of chronic polypoid ethmoiditis.

**Technique of Surgery.** Since the intranasal ethmoidectomy is used for the treatment of chronic polypoid ethmoid sinusitis, which almost invariably involves both ethmoid labyrinths, it is usually a bilateral procedure.

A submucous resection of the nasal septum facilitates the intranasal ethmoidectomy and is performed as a routine part of this operation by many surgeons. Each nasal cavity is packed with cotton strips impregnated with 1:1000 epinephrine solution. This assists in hemostasis and in providing a better view of the area to be operated upon. Polyps projecting into the nasal cavities are removed.

The patient is placed in a position of slight extension so that the middle meatus and anterior ethmoid region may be seen. The bulla and infundibulum can also be viewed unless the anatomic relationships have been distorted by disease. A sharp curette is used for
penetration into the anterior ethmoid labyrinth in the region of the bulla. Sharp, angulated, looped curettes are employed to remove the anterior ethmoid cells; if the bleeding is troublesome, the anterior ethmoid labyrinth is packed with epinephrine-impregnated gauze strips. The anterior ethmoid cells on the contralateral side are then removed in like manner.

The anterior one half or two thirds of the middle turbinate must be removed in order to gain access to the posterior ethmoid cells. The attachment of the middle turbinate is cut with turbinate scissors (or straight or slightly curved scissors). The turbinate is then transected, at the desired location, with a wire snare or a right-angled scissors. If bleeding is profuse, epinephrine-impregnated gauze strips are inserted for its control.

The posterior ethmoid cells lie behind the attachment of the middle turbinate. At times, the middle turbinate cannot be recognized as such, having been chewed away during repeated intranasal polypectomies. In such cases, the posterior ethmoid cells must be dissected with extreme care. On occasion, after the middle turbinate or a portion thereof has been removed, the attachment cannot be identified because of destruction by disease. In such cases, the relative position of the posterior ethmoid cells can be fairly well judged, since the anterior portion of the turbinate has just been removed. A ring curette is inserted into the posterior ethmoid cells. By gentle curettage and with a knowledge of the approximate dimensions of the area, the limits of the posterior ethmoid cells can be precisely outlined. Debris (bone, polyps, etc) is best removed with either Brownie or Takahashi forceps. Bleeding may be profuse at this point. It is well to remember that it can be controlled by repeated packing accompanied by patience. The posterior limit of the ethmoid labyrinth is the anterior wall of the sphenoid sinus. If indicated, the sphenoid sinus can be entered, diseased tissue removed, and a portion of the anterior wall resected in order to establish drainage. The close relationship of the optic canal to the lateral aspect of the posterior ethmoid cells must be clearly kept in mind during this dissection.

Packing. Bleeding is usually well controlled by the time all ethmoid cells have been removed. On the other hand, there is a somewhat significant incidence of postoperative epistaxis following intranasal ethmoidectomy. Some surgeons prefer not to use packing until bleeding becomes apparent. Others pack the ethmoid area routinely. A favorite packing is 1-inch iodoform gauze impregnated with aureomycin ointment. Approximately 24 inches of this packing are inserted into each ethmoid defect and held in place by a finger-cot packing inserted into each nasal cavity.

Postoperative Care. The finger-cot packing is removed on the first postoperative day. The ethmoid packing remains in place for from 3 to 5 days. Systemic antibiotic therapy, as prescribed by laboratory sensitivity tests, is usually instituted following intranasal ethmoidectomy.

Usually the patient can be discharged from the hospital on the fifth or sixth postoperative day. The intranasal spaces are not disturbed during the first postoperative week except for possible gentle cleansing executed with suction or forceps. A medicated oily spray may be used during the first few postoperative weeks in order to soften the crusts. It is most important that the patient be examined two weeks following this operation in order that any intranasal synechiae which may have formed will be detected and treated. When synechiae are present they are anesthetized with topical anesthesia and disrupted. A small piece of
double-faced Telfa gauze can be inserted to prevent their re-formation. The patient will experience dryness and repeated crust formation for a number of weeks following the intranasal ethmoidectomy. If he is warned of this, he will be more ready to accept the discomfort as due to the normal process of healing.

**External Ethmoidectomy**

**Indications.** External ethmoidectomy is indicated for those patients with acute ethmoiditis who do not respond to antibiotic therapy and have redness, swelling, and fluctuation over the ethmoid sinuses, as well as chronic ethmoid infection. Extension of the purulent infection into the orbital cavity with a resultant orbital abscess is also an indication for this operation. Mucocele, pyocele, and tumors of the ethmoid must be approached by way of the external role. The external ethmoidectomy also provides the route for external frontal sinus surgery (the Lynch procedure) and an approach to the sphenoid sinus and to the pituitary gland.

**Technique of Surgery.** The entire face is washed with antiseptic solution and drapes are placed from above the eyebrows to below the nose. Some surgeons prefer to cover one eye. In order to protect the cornea from injury, the upper and lower eyelids are sewn together with a single No. 5-0 silk or plastic suture placed through the tarsal plates. After infiltration with 2% procaine to which epinephrine solution has been added, a 1- to 1.5-inch curved incision is made half way between the inner canthus and the anterior aspect of the nasal dorsum. This incision is carefully extended through skin, subcutaneous tissues, and periosteum. If the angular vessels can be identified and ligated, much troublesome bleeding will be prevented. Before dealing with the periosteum, it is best to control all bleeding by either ligation or cauterization. There are a number of self-retaining retractors which have been devised to separate the incision. Most are bulky and cumbersome. Two or three chromic catgut sutures (No. 2-0), placed subcutaneously along the skin margins and weighted with heavy hemostats, usually provide excellent exposure. To protect the eyelids, a folded 4- x 4-inch sponge or eye pad is placed under these sutures as they extend laterally. The periosteum is elevated anteriorly and posteriorly over the ascending process of the maxillary bone. A square-ended periosteal elevator or chisel is best suited for this dissection until the anterior lacrimal crest is encountered. A small curved-end periosteal elevator is used to elevate the periosteum from the anterior lacrimal crest and the lacrimal sac from its fossa, and to expose the posterior lacrimal crest. By using a large, thin, rounded periosteal elevator, the periosteum is then readily elevated from the remainder of the lacrimal bone and the lamina papyracea. The anterior and posterior ethmoid vessels are encountered as the periosteum is elevated from the lamina papyracea. These vessels are cauterized and transected. It is usually not necessary to ligate them. If they are inadvertently ruptured before cauterization, bleeding is readily controlled by applying packing for a short period. It must be kept in mind that the anteroposterior ethmoid arteries are important landmarks. They are invariably found in the suture line between the frontal bone and the lamina papyracea and mark the plane of the roof of the ethmoid and cribiform plate. The lacrimal sac and orbital periosteum are retracted laterally with an orbital retractor, providing a good view of the nasal bone, ascending process of the maxilla, lacrimal bone, lamina papyracea, ethmoid vessels, and nasolacrimal foramen.

The anterior ethmoid labyrinth is entered by removing the thin lacrimal bone just behind the posterior lacrimal crest with a sharp curette. This opening is enlarged with various-
sized Kerrison bone-biting forceps. In order to obtain wide exposure of the later nasal mucous membrane wall, it is necessary to remove the lacrimal bone, a portion of the lamina papyracea, the ascending process of the maxilla, and sometimes a portion of the nasal bone. The anterior ethmoid cells are readily encountered and removed with Brownie or Takahashi forceps. The nasal mucosa is incised superiorly, anteriorly, and inferiorly as a "U" shaped flap and reflected laterally. This gives an excellent view of the anterior tip of the middle turbinate and the upper extension of its attachment which forms the lateral wall of the superior nasal cavity and the medial wall of the ethmoid labyrinth.

The attachment of the middle turbinate is severed by placing one blade of the turbinate scissors in the ethmoid labyrinth and the other in the superior nasal cavity. The posterior attachment of the middle turbinate is transected with a wire snare and the turbinate is removed. With Takahashi forceps, the upper extension of the attachment of the middle turbinate is carefully removed to the level of the roof of the anterior ethmoid cells. By so doing, the anterior aspect of the olfactory slit comes into view. Using, as guides, the unresected portion of the lamina papyracea, the roof of the ethmoid, and the upper extension of the attachment of the middle turbinate, the remainder of the ethmoid cells are readily removed with curettes and forceps. This done, the entire upper half of the nasal septum, the olfactory slit, the roof of the ethmoid, and the anterior face of the sphenoid sinus are entirely exposed.

**Packing.** The ethmoid labyrinth is packed by way of the operative field with 1-inch iodoform gauze that is impregnated with aureomycin ointment. One intranasal finger-cot pack is inserted to support the iodoform packing. A layer of Gelfoam is placed over the anterior aspect of the gauze packing in the medial wall of the orbit to prevent adherence of the packing to either the bone margins or the periosteum. The periosteum and subcutaneous layers are sutured with No. 4-0 catgut. The skin incision is sutured with No. 5-0 silk or plastic thread, either an interrupted or a subcuticular running stitch being used.

**Dressing.** A moderate-pressure dressing will prevent troublesome postoperative edema and ecchymosis about the eye. A small strip of Telfa gauze is placed over the incision. An eye pad is covered with three or four fluffed 4- x 4-inch gauze sponges. The skin of the forehead and lateral cheek is painted with tincture of benzoin. The dressing is secured in place with three 6-inch strips of 2-inch elastic adhesive. This is covered with a conforming gauze bandage. The finger-cot packing is removed 24 hours after completion of the operation; all dressings are removed 24 hours later. The iodoform packing is removed between the third and fifth postoperative day.

**Dacryocystorhinostomy**

**Anatomy**

The superior and inferior puncta are situated at the apex of the papillae. The papillae are found on the posteromedial aspect of the lids, about 4 mm lateral to the inner canthus. The puncta are about 0.3 mm in diameter and point in a posterosuperior and posteroinferior direction respectively.
The canaliculi pass from the puncta to the lacrimal sac and are about 10 mm in length. The course of the canaliculi is at first vertical (2 mm superiorly or inferiorly and then 8 mm horizontally). In most cases the canaliculi join to form the common canaliculus just before entering the lacrimal sac. The common canaliculus enters the lacrimal sac at a point 3 mm from its apex.

The lacrimal sac is about 12 mm in height and 5 mm in diameter. Its size roughly corresponds to the outline of the lacrimal fossa. The nasolacrimal duct is simply a continuation of the lacrimal sac in an inferior and slightly posterior direction. It is approximately 20 mm in length and 3 mm in diameter and empties into the anterior aspect of the inferior meatus of the nose. The most common site obstruction is in the upper portion of the duct.

**Indications for Dacryocystorhinostomy**

As a general rule, dacryocystorhinostomy is indicated in patients with chronic stenosis of the nasolacrimal duct when manifestations (epiphora, repeated infections, mucocele) are of sufficient severity to be annoying. A fistula from the lacrimal sac to the surface is certainly an indication. Age is not a contraindication, and the operation may be performed on children as well as elderly persons. On the other hand, in older individuals in poor health and with minimal infection and only moderate epiphora the operation can be deferred. Definite contraindications are the presence of acute dacryocystitis, carcinoma or tuberculosis of the lacrimal sac, or a severe chronic dacryocystitis that has repeatedly failed to respond to surgical treatment (a dacryocystectomy is indicated for the latter condition).

Many patients who are presented for consideration of dacryocystorhinostomy have had repeated probings and irrigations of the nasolacrimal system, both for diagnosis and treatment.

**Diagnosis**

Patency of the nasolacrimal system can be tested by probing and by application of fluorescein to the eye. X-ray examination is employed to determine the site of stenosis and whether or not a fistula is present, and to demonstrate the general anatomy of the system.

**Technique for Probing the Nasolacrimal System.** In order to probe the nasolacrimal ducts of infants and children, a general anesthetic is necessary. For adults, a topical agent, such as 2% Pontocaine, applied directly to the punctum with a cotton swab, may be used.

The lower lid is slightly everted and a punctum dilator is inserted, in a vertical direction, for approximately 2 mm. This will allow a #0 or #1 lacrimal probe to enter the canaliculus. The probe is passed inferiorly for 1 or 2 mm and then turned to a 90-degree horizontal medial direction. As the probe reaches the medial wall of the lacrimal sac, it will encounter the solid obstruction of the lacrimal fossa. It is again redirected so that it becomes vertical, and thus enters the nasolacrimal duct.

**Fluorescein Test.** A simple test to determine the patency of the nasolacrimal system consists in placing a drop of fluorescein in the eye. After a few minutes the mucous membrane of the floor of the nose and of the nasopharynx will have a yellow tinge if the
system is patent. A piece of cotton placed in the inferior meatus and subsequently observed under ultraviolet illumination is an even more accurate method of obtaining the endpoint in this test.

**X-ray Examination of the Nasolacrimal System.** The punctum is dilated as described for probing the nasolacrimal system. A more satisfactory outline of the lacrimal sac will be obtained if the sac is irrigated with normal saline solution and then evacuated by pressure over the sac prior to injection of contrast medium. Pantopaque, or Lipiodol, is injected into the canaliculus with a 2-cc syringe and a lacrimal cannula. Anteroposterior and lateral x rays are taken immediately.

**Technique of Dacryocystorhinostomy**

**Anesthesia.** General anesthesia is preferable for the operation unless there is some contraindication to its use.

The technique for local anesthesia is as follows:

1. Premedication, consisting of Nembutal, Demerol, and atropine, is given.

2. Intranasal packing (4% cocaine-impregnated cotton strips) is placed in the superior nasal cavity to anesthetize the mucous membrane innervated by the anterior ethmoid nerves and to reduce the size of the middle turbinate. This packing is also placed posteriorly to anesthetize the distribution of the sphenopalatine nerve.

3. With a 27-gauge needle, 2 cc of procaine with epinephrine (1:100,000) are infiltrated along the line of incision.

A needle is inserted 1 cm above the inner canthus, to a depth of 3 cm, while being kept in contact with bone medially, to anesthetize the nasociliary branch of the ophthalmic nerve (2 cc of the procaine-epinephrine solution are used).

The infraorbital foramen can usually be palpated. A needle is inserted below this level and directed upward to locate the foramen. Two cubic centimeters of solution are injected just inside the foramen to anesthetize the infraorbital nerve.

The eyelids are sutured with #5-0 plastic or silk material. One suture through the center of each tarsal plate is usually sufficient.

**Incision.** The incision for a dacryocystorhinostomy is identical to that for an external ethmoidectomy, ie, a 2- to 3-cm, vertical, slightly curved incision, half-way between the inner canthus and the midline of the nasal dorsum. Some surgeons prefer to start the incision 3 mm medial to, and 3 mm above, the inner canthus. The upper half of the incision is vertical, while the lower half curves laterally along Langer's lines. Skin hooks are used for retraction while the skin is undermined along the incision. The incision is then carried in layers through the periosteum. The subcutaneous and periosteal layers are elevated as a unit, both medially and laterally so as to expose the anterior lacrimal crest, the ascending process of the maxilla, and a portion of the nasal bone.
Troublesome vessels are either cauterized or ligated. Insulated suction tips are of value here when cautery is used. The medial palpebral ligament is avoided by careful elevation of the periosteum.

For retraction, two or three #00 chromic catgut sutures are placed through the subcutaneous and periosteal layers on each side of the incision. A square-edged periosteal elevator or chisel is the instrument of choice for the initial elevation of the periosteum. After the anterior lacrimal crest has been exposed, a small, sharp, curved-end periosteal elevator is used to elevate the periosteum away from the posterior aspect of this crest, as well as from the lacrimal fossa and the posterior lacrimal crest. A smooth orbital retractor is then inserted, reflecting the lacrimal sac laterally; the periosteum is then readily elevated from the anterior aspect of the lamina papyracea. It is important that the inferior aspect of the sac and the beginning of the nasolacrimal duct are freed and retracted laterally.

A curette is used to provide entrance into the ethmoid labyrinth just behind the posterior lacrimal crest. A few anterior ethmoid cells will be encountered and should be removed. The opening is enlarged with various-sized Kerrison forceps. In order to properly expose the mucous membrane of the upper lateral nasal wall, it is essential to make a bony fenestra at least 2 cm in diameter. To accomplish this, a small portion of the anterior aspect of the lamina papyracea, the anterior and the posterior lacrimal crests, the lacrimal fossa, and a portion of the ascending process of the maxilla and of the nasal bones must be removed. Anterior ethmoid cells in this area can be easily removed with Brownie or Takahashi forceps. The identity of the lateral wall mucous membrane is ascertained by inserting a cotton applicator stick, or periosteal elevator, intranasally and testing to determine whether or not the nasal mucosa bulges laterally.

**Mucosal Anastomosis.** There are many variations of technique for constructing mucosal flaps in order to prevent recurrent stenosis. The "I"-shaped incision, both in the nasal mucous membrane and on the medial wall of the sac, seems to be most popular.

A vertical incision is made in the center of the medial wall of the lacrimal sac with a knife (#11 blade) and scissors, along with small skin hooks or grasping forceps. Horizontal incisions are made at each end of the vertical incision, completing the "I" incision and thus fashioning an anteriorly and posteriorly based flap. A similar incision producing identical flaps is made in the lateral nasal mucous membrane wall. It is almost never necessary to remove the anterior tip of the middle turbinate.

The posterior flaps are sutured together with two or three #4-0 chromic catgut sutures. Relaxation of the traction sutures will facilitate the suturing of the anterior flaps. The subcutaneous layers are approximated with a #4-0 catgut sutures. The skin incision is closed with interrupted stitches of #5-0 suture material or a continuous subcuticular suture. The dressing is identical to that described for the external ethmoid operation. Intranasal packing is usually not necessary. The dressing is removed at the end of 24 or 48 hours, at which time the patient may be discharged from the hospital.

An alternate and somewhat simpler technique is that involving the construction of posteriorly based mucosal flaps from both the medial wall of the lacrimal sac and the lateral...
wall of the nose. The anterior margins of these flaps are easily approximated with #4-0 chromic catgut suture material on a small non-cutting curved needle.

Some surgeons prefer to remove the medial wall of the lacrimal sac and the mucous membrane of the lateral nasal wall without attempting to fashion mucosal flaps. Prior to making the vertical incision in the lacrimal sac, a lacrimal probe is inserted into the sac by way of the inferior canaliculus. This tents the medial wall of the lacrimal sac, allowing for positive identification of the sac and facilitating removal of the medial wall of the lacrimal sac. This is the ideal technique for surgeons not skilled in constructing and suturing mucosal flaps. It enjoys nearly as good results as those procedures in which lacrimal sac mucosa is sutured to nasal mucosa.

**Surgical Treatment of Malignant Exophthalmos**

Malignant exophthalmos is of endocrine origin. The exophthalmos produced by increase in the orbital contents is due mainly to an increased bulk of the extraocular muscles and orbital adipose tissue. As proptosis increases the eyelids become unable to cover the globes adequately, thus corneal ulceration may ensue. Also, with increasing proptosis, there is impairment of the venous return from the orbit, which results in chemosis and edema of the conjunctiva and eyelids. With the fullness of the eyelids, epiphora becomes a problem. Diplopia and finally ophthalmoplegia occur with progression of the disease. The circulatory embarrassment of the retina results in papilledema and, finally, a loss of vision.

**Indications for Surgical Treatment**

An indication for immediate operation is an impending loss of vision and/or ophthalmoplegia. Severe exophthalmos with complicating corneal exposure, chemosis of the conjunctiva and lids, and unsightly appearance due to increasing exophthalmos are also indications for surgical treatment.

**Techniques in Surgical Treatment**

**Naffzigger Technique.** This operation consists in creating two frontal flaps by means of which the orbital roof is exposed and removed as far back as the optic foramen. The optic foramen may be decompressed if edema of the nerve is noted during the operative procedure. The superior orbital rim is preserved in order to maintain the contour of the forehead. The nasal sinuses are not entered. The direction of expansion of the orbital contents is into the anterior cranial fossa. The dura, lateral to the frontal sinuses, and the anterior cranial fossa are exposed. It is obvious that careful study of the preoperative x-ray films is necessary in order to determine the degree of lateral extension of both the ethmoid and frontal sinuses. If the frontal sinus is entered the hazard of complicating frontal sinusitis and/or mucocele formation is increased. On occasion the Naffziger operation is impractical because of lateral extension of the frontal sinus. Sometimes, following this operation, the pulsations of the cerebral vessels are transmitted to the eye and are notable.

**Sewall's Method.** Sewall, in 1926, utilized the paranasal sinuses to decompress the orbit in the treatment of malignant exophthalmos. The Sewall decompression consists of a complete ethmoidectomy and removal of the entire floor of the frontal sinus. This operation
is less disfiguring and formidable than the Naffziger procedure. An actual, rather than potential, space is created. There is no subjective or objective evidence of pulsations of the orbit following the operation.

**Hirsch Technique.** This operation consists in removal of the orbital floor. The maxillary sinus is entered by the Caldwell-Luc approach. Its roof is removed on both sides of the infraorbital nerve. A narrow bony ridge is left in place for support of the infraorbital nerve. The periorbital fascia is incised. Orbital fat than prolapses into the maxillary sinus. A portion of this adipose tissue can be removed. A large fenestration is made in the nasoantral wall of the inferior meatus. Hirsch indicates that this operation is a simple procedure, leaving no external scar and attended with minimal danger of infection. A fairly large potential space for decompression is provided with an orbital recession of from 3 to 7 mm depending on the size of the maxillary sinus.

**Swift or Kronlein Operation.** The lateral wall of the orbit is removed by way of an incision over the lateral orbital rim. The bony defect is covered with orbital periosteum and temporalis muscle. This procedure provides limited space for decompression, although many satisfactory recessions have been secured by its use. There is an external scar and absence of the lateral orbital rim exposes the orbit to injury.

**Combined Technique (Walsh-Ogura).** In this procedure, both the floor and medial walls of the orbit are removed. The maxillary sinus is entered by way of the Caldwell-Luc incision. As much of the anterior wall of the antrum as possible is removed for exposure. The ethmoid sinuses are entered through the transantral route. As complete an ethmoidectomy as possible is carried out with removal of the lamina papyracea. Both the anterior and the posterior cells of the ethmoid sinuses are removed, exposing the anterior wall of the sphenoid sinus. The floor of the orbit is removed by using various rongeurs. The infraorbital nerve is preserved. Several anteroposterior incisions are made in the orbital periosteum. The orbital fat herniates into both the ethmoid and maxillary sinuses. A large nasoantral window is fashioned, and the gingivobuccal incision is closed.

This certainly is a more formidable operation for severe exophthalmos than those previously described. As with the Sewall operation there is a risk of post-operative emphysema, but this is not a severe complication and it can be avoided by the patient's refraining from nose blowing, sneezing, etc. When performing the combined ethmoid and antral decompression, it is probably wise for one not experienced with the transantral ethmoidectomy to use both the external ethmoidectomy and Caldwell-Luc incisions.

**Sphenoidotomy**

**Surgical Anatomy**

The sphenoid sinus is situated posterior to both the upper nasal cavity and the ethmoid labyrinth. The site of the ostium is variable according to the degree and direction of sinus pneumatization. Usually the ostium is found in the spheno-ethmoidal recess which is located above and behind the posterior aspect of the middle turbinate and just lateral to the nasal septum. The sinus may be contained entirely within the body of the sphenoid bone or may extend into the pterygoid process, rostrum of the sphenoid, greater wing of the sphenoid, or
basilar process of the occipital bone. Whereas the posterior aspect of the nasal septum is usually in the midline, the intersphenoidal septum is rarely so. On occasion, the intersphenoid septum is oblique and can even be horizontal.

The sphenoid sinus has a number of important anatomic relations with which the surgeon must be very familiar. An easily recognized superolateral ridge formed by the optic canal into the sphenoid sinus is quite often present. Other structures which may indent the lateral wall are the carotid artery and the maxillary nerve. A ridge on the floor of the sphenoid sinus may represent the vidian canal. The posterior superior wall of the sphenoid sinus is almost invariably in close contact with the sella turcica. This is especially true when the anterior and posterior clinoid processes are pneumatized.

There are a number of important structures to be found in a sagittal plane through the sella turcica. These include the cavernous, the internal carotid artery, all three divisions of the trigeminal nerve, and the third, fourth, and sixth motor nerves to the orbit. The intracranial relation of the sphenoid sinus and its association with the ethmoid sinuses must be familiar to the surgeon who is operating in the vicinity of the sphenoid sinus and sella turcica.

**Intranasal Surgery of the Sphenoid Sinus**

**Irrigation of the Sphenoid Sinus.** On occasion, irrigation of the sphenoid sinus is indicated for diagnosis and treatment of subacute and chronic sphenoid sinusitis. The sphenoid ostium can usually be seen after reducing the size of the turbinates with intranasal cotton packing impregnated with 4% cocaine solution. The mucous membrane over the anterior wall of the sphenoid sinus should also be treated with 4% cocaine solution to produce anesthesia and effect decongestion of edematous mucous membrane in the region of the sphenoid sinus ostium. The site of the ostium is variable as are the direction and degree of sinus pneumatization. The sphenoid cannula is 10 cm in length and slightly curved at its tip. It is introduced along the roof of the nasal cavity, adjacent to the nasal septum in the direction of the posterior tip of the middle turbinate, making approximately a 30-degree angle with the floor of the nose. If the sphenoid sinus cannot be viewed directly, it is located by gentle manipulation. As soon as the sinus has been entered, aspiration is used to determine the presence of fluid. The sinus is then slowly irrigated with warm saline solution.

If cannulation of the sphenoid ostium is not possible, a Hajek sphenoid hook with a Trumbel guard is introduced into the sphenoid sinus just lateral to the nasal septum at the level of the posterior tip of the middle turbinate. Hajek forceps are used to enlarge this opening. The sphenoid sinusotomy should be made as inferior on the anterior wall of the sphenoid sinus as is possible. The purpose of the intranasal sphenoidotomy is to obtain material for culture and antibiotic sensitivity tests and also to effect drainage. In addition to antibiotic therapy, the follow-up care should include use of nasal decongestants.

**External Sphenoidotomy**

**Diagnosis of Sphenoid Disease.** The one symptom typical of sphenoid disease is constant headache described as severe and located in the center of the head. The pain may radiate to the suboccipital region or penetrate deep behind the eye. Other symptoms of
Sphenoid disease are the result of its extension to surrounding structure rather than emanating from the sinus itself. The important neighbors of the sphenoid sinus are:

- Dura mater
- Pituitary gland
- Cavernous sinus
- Internal carotid artery
- Pterygoid canal
- Abducens nerve
- Optic nerve chiasma
- Oculomotor nerve
- Ophthalmic nerve
- Trochlear nerve
- Maxillary nerve
- Sphenopalatine nerve
- Ophthalmic artery

X rays should include routine sinus views plus laminograms. Usually sagittal plane laminograms are sufficient. At times it is impossible to differentiate radiologically between infection and tumor of the sphenoid sinus or to determine whether the lesion originates in the sinus or is an extension from a neighboring area.

Lesions involving the sphenoid sinus are:

- Infection, acute and chronic
- Polypoid sinusitis
- Mucocele or pyocele
- Fracture
- Aneurysm
- Cholesteatoma
- Eosinophilic granuloma
- Primary tumors:
  - Squamous cell carcinoma
  - Adenocarcinoma
  - Cylindroma
  - Giant cell tumors
  - Sarcoma
- Secondary invaders:
  - Craniopharyngioma
  - Chordoma
  - Pituitary tumor
  - Nasopharyngeal angiofibroma
  - Meningioma
  - Adamantinoma
  - Malignant lesions from the maxillary and ethmoid sinuses
  - Metastatic tumors such as adenocarcinoma and thyroid carcinoma

Exploratory sphenoidotomy is in order when there is clinical or radiological evidence of sphenoid disease which has not responded to conservative therapy. Too many lesions of the sphenoid sinus are missed. The sphenoid sinus is approached by the transethmoid route when chronic inflammatory, benign, and malignant lesions are to be treated. The malignant lesions are approached to obtain biopsy specimens and to establish adequate drainage and decompression.

**Technique of Operation.** A complete ethmoidectomy is carried out as has been described. It is essential that the posterior aspect of the lamina papyracea, anterior and posterior ethmoid foramina, roof of the ethmoid, and olfactory slit be identified.

The ostium of the sphenoid sinus is usually quite large and can be readily recognized. The front face of the sphenoid sinus is entered by using a sharp curette and the anterior wall is removed with various side-biting bone forceps. Diseased tissue is removed from the sinus. When treating chronic inflammatory disease, it is best to remove only sufficient amount of
anterior wall to provide adequate drainage. A wide-open sphenoid sinus can, on occasion, cause a very troublesome headache.

The intranasal packing and postoperative care are identical to those procedures outlined under "External Ethmoidectomy."

**Hypophysectomy**

The transsphenoid approach to the pituitary gland is attended with lower morbidity and mortality rates than is the anterior craniotomy route. It provides less chance for injury to the optic chiasm. Postoperative complications, such as seizures, extradural hematoma, brain damage, and cerebral edema, are rare. The convalescent period is usually quite short.

There are a number of routes and modifications for the transsphenoidal hypophysectomy.

**Type of Procedures**

**Trans-septal-sphenoidal Hypophysectomy.** This operation was pioneered by Oscar Hirsch in 1910. Cushing later used a sublabial modification of this route. Heck and associates were the first in this country to use the transseptal approach for the treatment of advanced carcinoma of the breast. The main objection to this route is that it provides a long narrow approach. Two instruments cannot be used simultaneously, and the dissecting microscope cannot be employed. It is, however, still employed by many surgeons, because it is a direct midline dissection.

**Transantro-ethmoidosphenoidal Hypophysectomy.** Hamberger and associates used this approach in a large series of patients with remarkable success. For most surgeons, however, this is a long oblique to the hypophyseal fossa. It also has the disadvantage of an increased hazard of postoperative infection, for the oral route in some patients traverses a potentially septic area.

**Transnasal Osteoplastic Hypophysectomy.** Macbeth and Hall have devised a unique direct midline approach using an osteoplastic skin flap based at the root of the nose. The only disadvantage of this procedure is that it leaves undesirable scarring of the nasal bridge. Those who perform this operation point out that this is not a factor when treating patients with advanced carcinoma of the breast.

**Tranethmoidosphenoidal Hypophysectomy.** This technique for hypophysectomy has been used since the turn of the century. Chiari, in 1912, described this method for the removal of a pituitary adenoma. A few of the otolaryngologists who deserve credit for improving the techniques for this approach are Bateman, James, and Nager, who have used this operation because it provides the shortest route to the hypophysis that affords a wide field, permitting easy manipulation of instruments and use of more than one instrument simultaneously. One instrument may be inserted by way of the nasal cavity and another by way of the operative field. The advent of the surgical microscope has also increased the popularity of the tranethmoidosphenoidal hypophysectomy.
The transethmoidosphenoidal approach has been used for removal of solid and cystic pituitary tumors, and hypophysectomy for palliative therapy in patients with advanced breast carcinoma, patients with diabetic retinopathy, and those with advanced prostatic carcinoma. Cystic tumors can easily be marsupialized. Solid tumors can be resected and/or decompressed. Most authors, Riskaer and Bateman, for example, report 60% to 80% transient remissions when employing hypophysectomy in treating patients having generalized metastases from carcinoma of the breast.

Hypophysectomy for metastatic carcinoma of the breast is a palliative operation. The transsphenoidal hypophysectomy is the ideal operation, for it is minimal in nature and more acceptable to a patient with terminal disease than are other procedures. Best results can be expected in those patients in the premenopausal group who have had a good response to castration and in postmenopausal patients who have responded well to estrogenic or androgenic hormone therapy.

Patients with breast carcinomatosis, who have been so weak that they could hardly turn in bed, have had dramatic results following hypophysectomy. In 65% of patients with diabetic retinopathy treated by hypophysectomy there has been improvement in vision or cessation of progression of the disease.

Preoperative Management in Transethmoidosphenoidal Hypophysectomy

A team consisting of a neurologist, ophthalmologist, endocrinologist, and surgeon is essential for the proper management of the patient during the preoperative and postoperative periods. A rhinologist who attempts a hypophysectomy without the assistance of these specialties is only inviting disaster. If neurologic and endocrinologic work-ups have not been carried out prior to the patient's admission to the hospital, the patient should be admitted several days prior to surgery so that these may be executed.

The neurologist's careful survey, in the patient with a pituitary tumor, should include radioactive scanning, pneumoencephalogram, and arteriograms. The endocrinologist determines the preoperative endocrine balance and prescribes the necessary hormones during the preoperative endocrine balance and prescribes the necessary hormones during the preoperative, operative, and postoperative periods. Patients with bony metastases from carcinoma of the breast should be thoroughly investigated for blood dyscrasia. A complete ophthalmologic examination should also be made prior to operation. A careful examination of the nasal cavities and the nasopharyngeal space is important to rule out the possibility of sepsis and other disease and also to orient the surgeon as to the exact anatomy of the nasal septum.

Preoperative X rays (Sinus Series)

Complete sinus x rays are taken to rule out the possibility of septic or other sinus disease. The lateral view will demonstrate the size and relationship of the sella turcica. This
view, however, is misleading as to the exact pneumatization of the sphenoid sinuses because of the densities cast by the greater wings of the sphenoid bone.

Lateral planograms of the sphenoid sinuses will give a detailed anatomy of these structures and also show their relationship to the sella turcica.

A submental vertical view will show the lateral extent of the sphenoid sinuses and the position of the sphenoid septum which is most often not in the midline.

**Operative Technique**

The anatomy of the sphenoid and sella turcica should be reviewed.

The objectives of this operation are: (1) to obtain a wide field so that a surgical microscope can be used to illuminate and outline the posterior wall of the sphenoid sinus properly (when this is accomplished, more than one instrument can be used simultaneously); (2) to define the midline with accuracy at all times during the procedure; (3) to control all bleeding and cerebrospinal fluid leakage at the completion of the operation.

An external ethmoidectomy is carried out. It is most important that the patient's head be secured in a supine position with the aid of sandbags. After the ethmoidectomy has been performed, incisions for construction of a septal mucosal flap are made. The purpose of the mucosal flap is to reduce the incidence of postoperative hemorrhage, cerebrospinal rhinorrhea, and meningitis.

A vertical incision is made through the mucosa of the nasal septum at a point approximately half-way between the nasal orifice and the anterior wall of the sphenoid. Since this incision determines the length of the septal mucosal flap, it may be varied according to the demands of the pneumatization of the sphenoid sinus. Mucosal incisions are then carried posteriorly from the superior and inferior end of the vertical incision. The superior incision extends along the nasal septum just inferior to the cribriform plate to the front face of the sphenoid sinus. It is carried laterally across the superior aspect of the front face of the sphenoid sinus and then inferiorly. The inferior septal incision is carried posteriorly to the front face of the sphenoid sinus in the region of the sphenoid rostrum. The mucosal flap is carefully elevated and reflected into the nasopharynx until the hypophysectomy has been completed.

The right sphenoid sinus is entered, and the entire anterior wall is removed. The bony nasal septum is usually left intact as an accurate guide to the midline. However, a small portion of the posterior nasal septum may be removed for a wider exposure without destroying the septum's usefulness as a midline guide.

The dissecting microscope is employed for the remainder of the operation. The bulge of the sella turcica can be seen on the posterior wall of the sphenoid sinus. The midline is again checked by using the posterior aspect of the nasal septum as a guide. If the anatomic relationships are doubtful, x rays may be taken with a portable machine, metallic probes or lead-shot attached to suture material being used as pointers. This step becomes increasingly necessary as the number of patients operated upon increases. A small opening is made in the
posterior wall of the sphenoid sinus (anterior wall of the sella turcica) with a curette or a rotating bur. This is enlarged by using various rongeurs. It is important to remove the entire anterior wall of the sella turcica in order to define accurately the limits of the hypophyseal fossa. Either a vertical or a cruciate incision is made in the dura; the pituitary gland or tumor thereof is then removed by using suction and various dissectors.

Following the completion of the pituitary surgery, the fossa is packed with Gelfoam saturated with thrombin solution if there is any bleeding or spinal fluid leakage. Fascia or adipose tissue may also be used to control bleeding or leakage. The septal mucosal flap is elevated from the nasopharynx and reflected into the sphenoid sinus. The flap is placed over the defect in the posterior wall of the sphenoid sinus, covered with a layer of Gelfoam, and then packed in place with iodoform gauze treated with petroleum jelly. When dealing with a cystic tumor, the septal mucosal flap is reflected into the hypophyseal fossa rather than used to cover the defect. This is done to ensure marsupialization of the cyst. The end of the iodoform gauze is placed in the nasal cavity so that it can be easily removed on the fifth postoperative day. The external ethmoid incision is closed subcutaneously with #4-0 chromic catgut; a #5-0 Dermalene is used for the subcuticular sutures. A dry external pressure dressing is applied over the eye and lateral nasal bridge.

Postoperative Treatment

Cortisone and other supportive hormonal therapy are prescribed by the endocrinologist. Hydrocortisone (100 mg on the average) is administered the evening before the operation, with the preoperative medication, during the operation, and postoperatively. The amount is variable and must be adjusted in accordance with the patient's basic hormonal balance. As a general rule, partial or complete removal of the pituitary gland is not as disturbing to the general glandular metabolism as one would suppose. Symptoms of thyroid insufficiency are not common and usually do not appear until one to three months postoperatively. One and one-half grain of thyroid extract or 0.1 and 0.2 mg of Thyroxin is administered daily when indicated.

Occasionally, estrogens or androgens are necessary following hypophysectomy. Sex hormones are withheld from cancer patients. Three hundred milligrams of Depo-testosterone are administered every month to maintain potential improved strength and well-being in male patients. In female patients, the administration of estrogens is of similar value.

The use of prophylactic antibiotic therapy is questionable. Six hundred thousand units of procaine penicillin may be administered intramuscularly twice a day. Diabetes insipidus may occur. This is easily controlled by administering vasopressin (Pitressin) in oil. The fluid intake and output chart will demonstrate the onset of diabetes insipidus. Disturbances in the metabolism of glucose will be demonstrated by sugar in the urine and abnormal quantities of sugar in the blood.

The pressure dressing over the eye and lateral nasal bridge is removed on the second postoperative day, and the patient is allowed full activity at this time. The iodoform-gauze packing and subcuticular sutures are removed on the fifth postoperative day. The patient is discharged from the hospital on the sixth or seventh postoperative day.
Postoperative Complication

Hemorrhage. The potential hazard of hemorrhage from the ethmoidal artery, sphenopalatine artery, and dural sinuses is fairly well eliminated by the use of the septal mucosal flap and the iodoform-gauze pack treated with petroleum jelly.

Cerebrospinal Fluid Rhinorrhea. Leakage of spinal fluid may occur in the immediate postoperative period or several weeks later. The patient complains of lightheadedness, headache, and soaking of his pillow and clothing from the cerebrospinal fluid rhinorrhea. This, for the most part, is self-limiting, but on occasion can be a very troublesome complication. The septal mucosal flap, used to cover the posterior wall of the sphenoid sinus, seems to eliminate this complication.

Meningitis. It would seem that meningitis would be a fairly common complication, since the hypophyseal fossa has been exposed to the upper respiratory tract. It is, however, surprisingly rare, although its occurrence has been reported in the immediate postoperative period or weeks and months later. The septal mucosal flap may be the barrier needed to prevent this complication.

Damage to the Eye. Bateman states: "It has been suspected that wide exposure of the sphenoid through an orbital incision would be likely to cause blindness because of stretching of the optical nerve. This has not been reported."

Intracranial Hemorrhage. Subarachnoid hemorrhage has on occasion been reported and has been attributed to anatomic anomalies and misdirected surgery.

Case Reports

Four case reports are presented to exemplify the advantages of the septal mucosal flap. The first two cases demonstrate complications which can occur when a defect in the posterior wall of the sphenoid sinus is not covered. The septal mucosal flap was used in the third and fourth cases and has been used in all subsequent cases to date.

Case I. A 52-year-old right-handed construction inspector was first examined on October 1, 1957. A history of intermittent right epistaxis, decreased visual acuity on the left side, and intermittent right-sided occipital headaches was obtained. The patient had noted a decrease in his sexual desires during the past year, but there had been no change in his body hair. He had also noted increasing nervousness.

The past history was negative except for a right petrosal nerve section in 1947 as treatment of tic douloureux.

X rays of the sinuses showed an old surgical defect in the right temporal fossa. The sinuses were entirely within normal limits. The sella turcica was enlarged.

Ophthalmologic examination demonstrated normal globes. The pupils were round and reacted normally to light. Extraocular motion was within normal limits. There was not nystagmus. Examination of the fundi showed no abnormality. The corneal reflexes were active.
and equal. The visual acuity in the right eye was 20/30 and in the left eye 3/200. There was a visual defect on the left involving the entire field with the exception of a portion of the upper medial field. There was an upper temporal quadrant defect on the right side.

A general neurologic examination showed all reactions to be within normal limits. On lumbar puncture the initial spinal fluid pressure was 280 mm and the final pressure, 220 mm. Spinal fluid studies demonstrated no abnormality except for a protein content of 180 mg%. The basal metabolic rate was - 14. Encephalograms demonstrated many $\alpha$ and $\beta$ frequencies at less than 50 $\mu$ and poorly defined $\tau$ and $\delta$ frequencies at 50 $\mu$ or less. Most of the activity was normal. Arteriograms were within normal limits except for evidence of an enlarged sella turcica. A pneumoencephalogram demonstrated a moderately dilated ventricular system; there was a very good delineation of a large mass occupying the sella turcica and projecting into the sphenoid sinus.

A diagnosis of pituitary tumor was established and, after consultation, radiation therapy was recommended. Biopsy study of the pituitary region was not made. Radiation therapy was begun on February 8, 1958. By February 18, a total dose of 1500 r had been administered. The patient had almost no vision in the left eye and decreasing visual activity in the right eye. His headaches had become unbearable. On February 19, a transethmoido-sphenoidal hypophysectomy was performed with the patient under general endotracheal anesthesia. The sphenoid sinus was found to be well pneumatized. The anterior wall of the sella turcica could be seen bulging into the sphenoid sinus. The tumor was removed with hypophyseal forceps and aspiration.

Postoperatively, the patient's headaches disappeared, and his visual acuity and field defect gradually improved. By February 26, his visual fields were within normal limits, and his vision was 20/20 on the right and 20/30 on the left. The final pathologic diagnosis was chromophobe pituitary adenoma. Radiation therapy was reinstituted as soon as the visual fields were normal. A total dose of 4000 r was administered.

On March 21, the patient was readmitted to the hospital after having had an upper respiratory infection for a week and severe occipital headaches, nausea, vomiting, and chills for 24 hours. His meningitis responded dramatically to high doses of penicillin, chloramphenicol (Chloromycetin), and sulfadiazine. The patient was discharged from the hospital on March 29. He has remained well since this admission and has had no endocrine disturbance.

Comment. This case demonstrates a fairly rapidly expanding pituitary chromophobe adenoma resulting in visual field defects. The additional swelling produced an ophthalmologic emergency. Removal of the tumor by the transethmoido-sphenoidal approach resulted in a dramatic improvement in the patient's vision. Meningitis occurred one month postoperatively. This might have been prevented if an adequate barrier had been established between the hypophyseal fossa and the upper respiratory tract.

Case II. A 45-year-old white-haired lady was first examined at the Massachusetts General Hospital in April of 1960. She was described as a typical acromegalic with large hands, feet, and facial features. Her voice was deep and coarse. Her complaints were limited
to intermittent headache and pain in the eyes, without visual difficulties, of several years' duration.

A thorough ophthalmologic examination revealed no ocular involvement. X rays of the skull showed a marked expansion of the sella turcica which measured 22 x 26 mm. A pneumoencephalogram demonstrated that the intrasellar tumor displaced the chiasmatic and interpeduncular cisterns superiorly. There was a slight concave indentation of the anterior portion of the third ventricle, indicating pressure from a suprasellar extension of the tumor. Cerebrospinal fluid studies showed no evidence of increased intracranial pressure. The total protein in the cerebrospinal fluid was 72 mg\%. Studies indicated a slight hypopituitarism.

Because of the size of the pituitary tumor and the suprasellar extension, it was decided to institute radiation therapy. A total of 4500 r was administered from April 22 to May 16.

The patient was readmitted to the hospital on November 15, 1960, complaining of failing vision of four months' duration. Ophthalmologic work-up showed a bitemporal hemianopia and decreased in the right eye (to 20/50). The fundi were normal.

On November 23 the patient was prepared for a transethmoidosphenoidal hypophysectomy. During anesthesia induction, intubation by either the oral or nasal route was impossible because of the presence of tremendous macroglossia. A tracheotomy was rapidly performed, and the anesthetic was administered through the incision into the trachea. The sphenoid area was explored, but the patient's general condition did not allow sufficient time for either adequate decompression or removal of the tumor. There was no postoperative improvement in the visual fields. A cerebrospinal fluid rhinorrhea persistent until December 6.

On March 20, 1961, the patient was readmitted to the hospital for a second attempt at hypophysectomy. The tracheotomy incision was reopened prior to anesthesia induction. The pituitary tumor was resected and a good decompression of the area was accomplished. A septal mucosal flap was used to cover the defect in the posterior wall of the sphenoid sinus. The postoperative course was uneventful. The visual fields gradually improved. The patient has remained well while receiving some supportive endocrine therapy.

Comment. This was our first attempt to intubate a patient with marked macroglossia. A rapidly performed tracheotomy rectified the situation. A troublesome cerebrospinal fluid rhinorrhea followed the first attempt at hypophysectomy, in which neither adequate decompression of the area nor removal of the tumor were accomplished. The operation was successfully undertaken at a later date. A septal mucosal flap was used to cover the defect in the posterior wall of the sphenoid sinus to prevent the recurrence of the cerebrospinal fluid rhinorrhea.

Case III. A 59-year-old white, obese caterer was admitted to the hospital on July 4, 1961, with the chief complaint, "I can't walk downstairs." For the past eight years, she had been struggling unsuccessfully to wear bifocals. Two years prior to this hospital admission, her family doctor found that her lateral vision was blurred. X rays of the skull were taken because the patient had severe headaches. These demonstrated an enlargement of the sella turcica. The past history was otherwise not significant.
General physical examination revealed no abnormality except for obesity and a blood pressure of 190/110. Complete neurologic examination yielded findings within normal limits.

The pressure and dynamics of the spinal fluid were normal. The spinal fluid protein content was 64 mg%. The complete blood cell count gave normal values. The electroencephalogram and the blood studies, which included those for determination of protein-bound iodine, blood urea nitrogen, fasting blood sugar, and calcium content, showed no abnormality. The X-rays of the skull demonstrated marked enlargement of the sella turcica. The posterior clinoid processes were destroyed. The pineal body was calcified and in the midline. The pneumoencephalogram demonstrated a pituitary tumor of 3.5-cm diameter. The electrocardiogram showed no abnormality.

Ophthalmologic examinations demonstrated a complete bitemporal hemianopia. The globes were white and in normal position. The extraocular motion was normal. The pupils were equal (4 mm) and reacted well to light. There was no nystagmus or red lens diplopia. The fundi were normal. The visual acuity was 20/30 in both eyes.

On July 13, a transethmoidosphenoidal hypophysectomy was performed. The sphenoid sinus was found to be normal except for an anterior convexity of the posterior wall. The substance of the tumor mass was soft and granular. The tumor was easily removed with hypophyseal forceps and suction. A posterior septal mucosal flap was used to cover the defect in the posterior wall of the sphenoid sinus.

The postoperative course was uneventful except for epistaxis of brief duration occurring on the eighth day. The patient was discharged on the twelfth postoperative day. Her headache was absent. She noted a definite improvement in her vision. Her visual fields were normal one month postoperatively. Hydrocortisone was administered for four months following the operation. The final diagnosis was chromophobe pituitary adenoma.

Case IV. A 61-year-old salesman was admitted to the Massachusetts General Hospital on November 27, 1961, with a six months' history of intermittent blurring of vision while reading, and occasional diplopia. During the two months prior to admission these symptoms increased in frequency, and the patient had the feeling that "things were closing in" on him. He also complained of bitemporal headaches which were readily relieved by taking aspirin.

On examination a definite left temporal field defect to a 3-mm white object and a similar but less apparent defect in the right temporal field were noted. There was no defect on finger confrontation. The red glass test revealed a variable diplopia. It was crossed on forward gaze, homonymous on looking to the right, and not present on looking to the left. The optic disks were normal and other cranial nerves intact. The reflexes were active and equal. The motor nerves and sensation were normal.

As demonstrated by X rays of the skull, the pituitary fossa was enlarged and the dorsum sellae and the right anterior clinoid process were eroded.

An electroencephalogram showed no abnormality. The spinal fluid protein content was 90 mg%. The pneumoencephalogram gave evidence of a suprasellar expansion of an intrasellar mass. Routine blood and endocrine studies yielded values within normal limits.
Radiation therapy (total of 4000 r) was delivered to the sellar region from December 4, 1961, to January 8, 1962.

There was no improvement in the patients' symptoms after the radiation therapy. He admitted to a mild loss of energy, decreased libido and potentia, and increasing constipation. Repeated field examinations indicated an increasing bitemporal hemianopia.

On May 29, the patient was admitted to the Massachusetts Eye and Ear Infirmary. X rays showed the sella turcica to measure 18 mm in its anteroposterior dimension and the posterior clinoid processes to be decalcified. A neuromedical and endocrine evaluation revealed no changes since the previous hospital admission other than the increasing defects in the visual fields.

On June 1, a transethmoidosphenoidal hypophysectomy was performed from the right side. The fluid center of a dark-brown tumor was aspirated. The lesion was then removed, but its capsule was left in place. The dural incision was covered with a septal mucous membrane flap. This was covered with Gelfoam and packed in place with petrolatum-impregnated iodoform gauze. Cortisone therapy was given both pre- and postoperatively. The pathologic diagnosis was "chromophobe adenoma."

Examination of the visual fields made three days postoperatively showed no improvement. The subcuticular sutures were removed on the fourth postoperative day. The patient was discharged from the hospital on June 7, 1962. His visual fields were normal on June 15.

Comment. Cases III and IV demonstrate a rapid return to normal visual fields and relief of other symptoms produced by pituitary tumors. In both of the patients the septal mucosal flap was used to cover the defect in the posterior wall of the sphenoid sinus. The postoperative courses were short and benign.
Surgery of the Upper Respiratory System

William W Montgomery

Chapter 4: Surgery of the Frontal Sinus

Frontal Sinus Anatomy

The frontal bone consists of two portions: (1) a squamous or vertical portion which forms the forehead and houses the frontal sinuses, and (2) an orbital or horizontal portion which serves as the roof of the orbital cavity and floor of the anterior cranial fossa. The nasal process of the frontal bone articulates with the two nasal bones and the ascending process of the maxilla. Along with the zygomatic bone, the frontal bone makes up the supraorbital margin. Laterally, in the temporal fossa, the frontal bone articulates with the greater wing of the sphenoid bone. Posteriorly, it articulates with the parietal bone to form the coronal suture. In the orbital cavity, the frontal bone articulates with the lacrimal, ethmoid, and sphenoid bones.

Each frontal sinus is usually somewhat pyramidal in shape and lies between the inner and outer table of the vertical portion of the frontal bone. The roof of the orbital cavity forms its base. There are usually two frontal sinuses, but there may be three or even more. If additional frontal sinuses are present, they may lie lateral or posterior to one another. Quite frequently a frontal sinus is partially subdivided by septa. These septa can be so placed as to interfere with proper drainage. The two frontal sinuses are frequently asymmetrical. In about 10% of persons, one frontal sinus does not develop above the level of the supraorbital rim. The important relations of the frontal sinus are the anterior cranial fossa and the orbit. The bony plate separating the frontal sinus from these neighbors can be quite thin and is potentially the direction for extension of disease.

Drainage from the frontal sinus into the nasal cavity is variable. In most persons the nasofrontal duct is absent and drainage takes place directly from the frontal sinus into the frontal recess of the nasal cavity. In approximately 15%, the drainage from the frontal sinuses is by way of a nasofrontal duct into the infundibulum ethmoidale. Probably the most common cause for blockage of drainage and maintenance of a chronic infection of the frontal sinus is impingement of the nasofrontal orifice in the middle meatus. This can be caused by abnormally large ethmoid cells in this region, a cystic or cellular middle turbinate, a deviated nasal septum, or a chronic edematous inflammatory process of the middle turbinate. In some persons, an anterior ethmoid cell may extend superiorly and interfere with the patency of the nasofrontal orifice or duct.

The blood supply to the frontal sinus is from the internal carotid artery by way of the supraorbital branch of the ophthalmic artery. On occasion there may be a branch of the anterior ethmoid artery supplying the frontal sinus. Externally, blood is drained from the sinus into the facial vein; posteriorly, venous drainage takes place through emissary vessels passing into the dura, and internally, by way of the orbit.
The frontal sinus is innervated by the supraorbital branch of the ophthalmic nerve. Most of the sensory nerve endings are found in the region of the nasofrontal orifice; thus an increase or decrease of intrasinus pressure can produce severe frontal pain.

**Trephination of the Frontal Sinus**

**Indications**

Most episodes of acute frontal sinusitis clear spontaneously or following local intranasal therapy (decongestant sprays), intermittent packing with 4% cocaine-impregnated cotton pledgets in the region of the middle meatus, and/or local application of heat combined with systemic treatment (antibiotics and systemic decongestants).

If pain is not present, a 10-day to 2-week period of local and systemic therapy should be prescribed. X-rays of the sinuses should be taken (upright Waters' views) at 2- to 4-week intervals until the sinuses appear normal. X-ray evidence of fluid and/or swelling of the mucosal lining of the frontal sinus is not positive indication for the trephine operation unless the patient has persistent pain.

If, on the other hand, the acute frontal sinusitis is accompanied by persistent pain in the region of the sinus and edema of the upper eyelid and there is lack of response to conservative measures, it will be necessary to obtain drainage in order to prevent complications.

In addition to its use in the treatment of acute frontal sinusitis, the trephine operation may be employed as an exploratory procedure, to determine the nature of chronic frontal-sinus disease and/or to obtain a biopsy specimen.

**Technique**

Trephination of the frontal sinus can be carried out with the patient under either local or general anesthesia. A 3/4-inch horizontal incision is made in the superomedial aspect of the orbit just below the eyebrow, through skin, subcutaneous tissue, and the periosteum over the floor of the frontal sinus. The periosteum is then elevated above and below this incision, exposing the floor of the frontal sinus. The floor, rather than the anterior wall, is penetrated, for the floor consists of laminar bone containing no marrow, whereas the bone of the anterior wall is cancellous and contains marrow. If cancellous bone becomes contaminated by the purulent secretions from the frontal sinus there is danger of complicating osteomyelitis. A curette, or, preferably, a rotating cutting bur is used to penetrate the bone and make an opening in the floor 6 to 8 mm in diameter. Material for culture is then taken.

Some idea of the status of the interior of the sinus can be obtained by direct vision and also by inspection with an instrument, such as a nasopharyngoscope, inserted into the sinus through the trephine opening. Following inspection of the sinus, a rubber or plastic drainage tube, approximately 1 inch in length, is inserted and sutured in place.

Following the release of pus, the edema of the mucous membrane in the region of the nasofrontal orifice soon subsides, and normal drainage is reestablished. Irrigation of the sinus
through the drainage tube with warm normal saline solution is of value, and should be executed at least four times a day. Specific antibiotics, prescribed according to results of sensitivity tests, may be added to the irrigation solution. In addition to local treatment the patient is given systemic antibiotics. The patency of the nasofrontal communication may be determined by inserting a dilute dye solution (methylene blue) into the sinus through the trephine tubing. If the nasofrontal orifice is patent the dye should appear in the nasal cavity almost immediately. The trephine tube is removed as soon as drainage by the natural route has been reestablished.

**Intranasal Surgery for Chronic Frontal Sinusitis**

The treatment of chronic frontal sinusitis has been a frustrating problem for the rhinologist. Antibiotics alone are often of little value but should be given during the subacute and early chronic stages, along with local and systemic nasal decongestants.

In many instances, chronic frontal sinusitis can be cured by correcting the intranasal situations which either interfere with proper drainage by way of the nasofrontal passage or initiate re-infection of the sinus. The establishment of adequate drainage with ultimate resolution of the infection can often be accomplished by an intranasal operation. A careful submucous resection of the nasal septum, removal of intranasal polyps and/or the anterior portion of the middle turbinate, and an anterior ethmoidectomy are the procedures used to reestablish this drainage. If chronic ethmoiditis seems to be the offender, a complete external ethmoidectomy is indicated.

Intranasal probing and attempted enlargement or cannulization of the nasofrontal orifice are mentioned only to be condemned. Once the virginity of the nasofrontal passage is violated, scarring and stenosis are inevitable. If conservative intranasal surgery is not successful, then radical frontal sinus surgery is indicated.

**External Surgery of the Frontal Sinus**

**Indications**

Chronic frontal sinusitis, complicated with persistent pain, external fistula, internal fistula, intracranial extension, bone necrosis, orbital complications, and/or a mucocele or pyocele, and benign and malignant tumors of the frontal sinuses are positive indications for external frontal sinus surgery.

**Various Techniques**

There are numerous external frontal sinus operations, each having many variations. Those currently popular in the USA and the anatomic changes effected by each are shown.

**Lynch Frontal Sinus Operation (1920).** In the USA, this is probably the most frequently employed procedure for the treatment of chronic frontal sinus disease. An ethmoidectomy, removal of the middle turbinate, and resection of the entire floor of the frontal sinus are included in this operation. A rubber or plastic tube is placed between the frontal sinus and the nasal cavity by way of the ethmoid labyrinth. This tube is left in place
from one to three months following the operation and, at times, requires considerable care. As a general rule, the Lynch frontal approach has been highly effective in the control of chronic frontal sinus disease; on the other hand, its failure rate is sufficient to warrant the search for a better operation. Incomplete removal of the mucous membrane of the sinus can result in mucocele and pyocele formation. A stenosis of the reconstructed nasofrontal passage may lead to recurrent chronic frontal sinusitis.

**Riedel Operation (1898).** This consists of removing the anterior wall and floor of the frontal sinus, thus offering wide exposure of the sinus. The sinus cannot be completely obliterated in many cases, especially when its anteroposterior dimensions are large. Mosher modified the Riedel operation by removing the posterior wall of the sinus also. As a general rule, the Riedel procedure is disfiguring and offers a percentage of cure no higher than that of the Lynch operation.

**Lothrop Frontal Sinus Operation (1914).** This procedure entails a unilateral or bilateral anterior ethmoidectomy and middle turbinectomy. The interfrontal septum is removed. A large opening from the frontal sinuses into the nasal cavity is made by connecting the two nasofrontal ducts and resecting a portion of the superior nasal septum. The operation may be technically difficult, but it is quite effective in a patient with bilateral frontal sinus disease and in frontal sinuses with wide anteroposterior dimensions.

**Killian Operation (1904).** This is a modification of the Riedel procedure. In the Killian operation also, an anterior ethmoidectomy and middle turbinectomy are performed. However, a bridge of bone 10 mm wide is left in place at the supraorbital rim. This functions, of course, to prevent postoperative disfigurement. This operation is attended with much less alteration of the forehead contour than is the Riedel procedure; on the other hand, the bridge prevents obliteration of the sinus. Actually, the end result of the Killian operation is quite similar to that of the Lynch operation.

**Anterior Osteoplastic Frontal Sinus Operation.** This operation, described in the late nineteenth century literature, has been revived during the past decade. In this operation an inferiorly hinged "trapdoor" of bone is fashioned from the anterior wall of the frontal sinus. This affords direct access to the entire contents of the frontal sinus and an excellent view of the nasofrontal orifice from above. The intrasinus disease can be removed with ease. Revisions of previous frontal sinus surgery can be performed. Adequate drainage from the frontal sinus to the intranasal space can be established, or the frontal sinus can be obliterated completely by the implantation of adipose tissue.

The modification of the osteoplastic adipose obliterative frontal sinus operation is basically similar to that outlined by Bergara and Itoiz and by Tato and associates. It has been very successful in the treatment of chronic frontal sinus disease. The advantages of this techniques are:

1. It is a direct approach. The entire sinus, including the orifice of the nasofrontal duct, can be seen. The intrafrontal disease can be eradicated entirely. The dissecting microscope may be employed, if necessary, to accomplish this task. A decision whether or not to obliterate the sinus can be made readily. For example, when revising a Lynch frontal
operation, the surgeon has the choice of revising the approach from above or obliterating the sinus with adipose tissue.

2. There is no resultant facial deformity following the operation. All other radical frontal sinus operations do, at least on occasion, produce orbital or forehead defects.

3. The operation is relatively atraumatic and its morbidity is low. Postoperative care is negligible. We have found follow-up care to be unnecessary other than for the purpose of clinical research.

4. The two frontal sinuses may be operated upon simultaneously.

One hundred consecutive cases of frontal sinus disease treated by the osteoplastic approach have been reviewed. They are categorized as follows:

I. Osteoma 15
   A. Uninfected 9
   B. Infected 6

II. Trauma 2

III. Foreign body 1

IV. Chronic infection 82
   (The categories below are not mutually exclusive.)
   A. Orbital displacement 15
   B. Previous surgery 41
   C. Painless swelling 5
   D. Draining fistula 7
   E. Bilateral operation 31
   F. Brain abscess 2
   G. Allergy 21

Fifteen of the 100 patients were operated upon because of an osteoma or complications thereof. Nine of these were found to have osteoma without secondary infection. Their complaints consisted of pain in the region of the orbit and over the frontal sinus and manifestations of displacement of the orbital contents. The most common direction of extension of disease was through the floor of the frontal sinus, interfrontal septum, and posterior wall, exposing the dura. In all these patients the operation consisted of simple removal of the osteoma without disturbing normal mucous membrane. The sinus was not obliterated with adipose tissue. There have been no postoperative complications.

Six of the patients with osteoma had secondary infection. Two were referred for frontal sinus operation after excision of frontal lobe abscesses.

Two patients underwent bilateral adipose obliteration of the frontal sinuses in order to create a barrier between the nose and intracranial space following trauma to the frontal region.
One patient had pain and swelling of the right frontal region which occurred shortly after neurosurgical treatment of a berry aneurysm. X-ray examination revealed increased density in the right frontal sinus and a metallic button in the frontal bone just superior to the sinus. At surgical exploration, the sinus was found to contain a large cyst in continuity with the metallic button. The sinus membrane was thickened. The dura was exposed. Diseased tissue was removed and the sinus was obliterated. The patient has remained asymptomatic for five years.

Eighty-two of the 100 patients were operated upon because of chronic frontal sinus infection. The chief complaint of the majority of these patients was forehead pain. In 50% of them the presenting symptom was swelling in the region of the eyebrow or upper lid; 13 complained of diplopia. One half of the group had a history of a previous operation upon the frontal sinus. Five patients with painless swelling in the region of the supraorbital rim had been seen first by ophthalmologists. At operation, all 5 were found to have erosion of the sinus floor and exposure of orbital periosteum, and all but one had exposure of the anterior fossa dura.

Complications among the 100 patients were not common. Five had hematomas of the forehead which became secondarily infected. Treatment consisting of drainage and antibiotics was effective and no further complications ensued. One elderly patient developed thrombophlebitis and a nonfatal pulmonary embolism. Some of the patients complained of either hypoesthesia or hyperesthesia in the distribution of the supraorbital nerves. In 3 patients the operation failed to effect a cure; in 2 of these, the Lynch frontal sinus operation had been performed previously and in the third, failure was associated with fibrous dysplasia of the frontal bone.

A number of categories were studied in the group of 82 patients who had chronic frontal sinusitis. Fifteen of the group complained of diplopia; all but two of these had orbital and frontal pain. Nine of the 15 had erosion through the floor of the frontal sinus, and the remaining 6 had inferior convexity of the floor producing displacement of the orbital contents. Three patients had erosion of the posterior wall of the frontal sinus with exposure of the dura of the anterior fossa. A pyocele or a mucocele was found in 13, chronic inflammation in one, and hypertrophic polypoid sinusitis in another.

Forty-one patients had undergone previous surgery related to the frontal sinus exclusive of other intranasal or sinus procedures. Twenty-nine of these had had a Lynch frontal sinus operation previously; 26 of the 29 had either a mucocele or a pyocele.

Five patients were first seen by an ophthalmologist and were referred to the otolaryngologist after x rays revealed frontal sinus disease. They complained of diplopia without symptoms referable to sinus disease. One of this group had had a Lynch frontal operation previously. The other 4 gave no definite history of sinus disease. All 5 of these patients had erosion of the frontal sinus floor, and one had exposure of the anterior fossa of the dura.

Seven patients had a chronic draining fistula in the region of the eyebrow or forehead. All of these had chronic inflammatory disease of both frontal sinuses. Adipose tissue was used to obliterate the sinuses in all of the group. Antibiotics, selected according to culture and
sensitivity tests, were administered pre- and postoperatively. None of the group had postoperative complications.

The bilateral osteoplastic frontal sinus operation was performed on 31 patients. As experience and confidence in the procedure grew, there was less hesitation about operating on both sides when the x rays showed bilateral disease, even though only one side presented symptoms. The bilateral operation adds very little extra time to the procedure and sometimes provides better exposure with more working room than a unilateral bone flap would allow. The morbidity of the bilateral operation is no greater than that of the unilateral. The horizontal scar across the root of the nose is rarely objectionable and is hidden by eyeglasses. The scar is obviated in females by a coronal incision behind the hairline.

In addition to the two patients previously discussed in the osteoma group, two young women, ages 16 and 29 years, underwent frontal sinus operation following neurosurgical treatment of frontal lobe abscess. Both had a bilateral operation for chronic infection with exposed dura. In the younger patient, a large area of osteomyelitic frontal bone was resected. Both patients have done well postoperatively.

Twenty-one patients have a history of varying degrees of nasal symptoms ascribed to "allergy." This proportion is about what one might expect in any average New England population. A number had had repeated polypectomies and an ethmoidectomy. The type of sinus disease encountered and the postoperative results were no different from those in nonallergic individuals. One patient, 8 years after the osteoplastic procedure, which had followed multiple unsuccessful operations, states that the operation relieved her of a life of misery and "even cured my allergy." One wonders, in some cases, whether the "allergy" causes the sinusitis or vice versa.

Experimental evidence has shown that adipose tissue seems to be the ideal implantation substance for long-term obliteration of the frontal sinus. Adipose obliteration of the feline frontal sinus has initiated the following observations and conclusions:

1. Varying amounts of adipose tissue survive. The remaining portion is replaced by fibrous tissue to complete the obliteration.

2. Time is not a factor, for both one-week and one-year experiments showed nearly 100% survival of adipose tissue, while other experiments, such as a one-month implant, showed only 50% survival of the adipose tissue.

3. Revascularization of the adipose implant from the blood supply available in the osseous sinus wall occurs during the first few days by ingrowth of blood vessels and direct blood-vessel anastomosis.

4. Traumatized adipose implants do not survive well and are for the most part replaced by fibrous tissue.

5. Adipose tissues seems to resist infection. Clinical results demonstrate that cartilaginous adipose implants have not been affected by the presence of pathogenic organisms. None of our experimental adipose implants became infected.
6. There was complete obliteration of the frontal sinus in all experiments when adipose tissue implants were used.

7. There was no regeneration of mucous membrane. It is apparent that the rapid revascularization of the implant prevents ingrowth of mucous membrane into the frontal sinus or into the nasofrontal region.

8. The evidence obtained from the experiments as well as clinical experience strongly emphasizes the fact that the removal of both the mucosal and inner cortical linings of the frontal sinus is absolutely necessary for a successful obliteration.

**Technique of Unilateral Osteoplastic Operation**

**Preoperative Preparation.** Preoperative bacteriologic cultures from the nose should be obtained for antibiotic sensitivity tests. Cultures must be made well in advance so that appropriate antibiotic therapy may be instituted prior to surgery. Pathogenic organisms are often not found in cultures of intranasal material obtained prior to operation, and therefore it is important that additional material for culture be taken from the frontal sinus at the time of the operation.

An x-ray cutout (template) is made preoperatively from the Caldwell view of the x-rays of the sinus. This is done by placing an exposed transparent x-ray film over the Caldwell view and outlining the sinuses with a glass-marking pencil. The cutout may be made slightly smaller than the actual dimensions of the sinus to ensure that the cut will lie within the sinus limits. However, with careful cutting this is not essential. The cutout is placed in sterilizing solution prior to surgery.

The abdomen should be prepared so that an adipose autograft may be obtained from the subcutaneous layer of the left abdominal wall (a right rectus incision is avoided so that the scar will not at a later date be interpreted as one resulting from an appendectomy).

**The Operation.** The forehead and face are prepared and draped in the manner appropriate for any frontal sinus procedure. The patient lies on the table in the supine position with his head slightly raised and inclined forward. The patient's eyelids are sewed together with #5-0 dermal sutures to prevent injury to the eyes during the operation. The eyebrows are not shaved.

Procaine or Xylocaine (2%), with added epinephrine, is infiltrated along the upper margin of the eyebrow, both to reduce the amount of bleeding and to supplement the general anesthetic.

In the unilateral procedure the first incision is made along the entire length of the upper margin of the eyebrow. The incision is carried through the subcutaneous tissues and the frontalis muscle to the periosteum covering the frontal bone. It is essential not to extend the incision into the periosteum in order that the blood supply to the osteoplastic flap is preserved.
With scissors and blunt dissection a plane of cleavage is easily established between the frontalis muscle and the frontal periosteum. It is important to make this exposure wide enough so that the x-ray cutout may be applied to the periosteum to outline the periosteal incision.

The periosteal incision is made around the x-ray cutout (template). This incision should include the periosteum over the supraorbital rim medially and laterally. The periosteum along the supraorbital rim between the above incisions is not disturbed so as to ensure an adequate blood supply for the osteoplastic flap. The periosteum above the incision is then elevated a few millimeters in order to obtain adequate space for a clean bone cut.

The bone incision is made along the outline of the periosteal incision with a Stryker saw blade which has been especially designed for this purpose. The saw is slightly angulated so that it is directed towards the cavity of the frontal sinus. Beveling of this bone incision accomplishes two purposes: it ensures that the incision is within the limits of the frontal sinus and it allows for accurate replacement of the osteoplastic flap. Following the outline of the periosteal incision, the bone incision is extended so as to include the supraorbital rim medially and laterally. This step is essential to provide for a fracture which hinges the osteoplastic flap across the floor of the frontal sinus, just posterior to the supraorbital rim.

A mallet and chisel are used to inspect the completeness of the bone incision. Inspection is accomplished by inserting the chisel, tapping lightly, and prying around the entire bone incision. The chisel is then placed superiorly and, with a prying maneuver, the osteoplastic flap is elevated downward and forward.

The interior of the frontal sinus can now be inspected. A sample is taken for culture. It is at this point that the surgeon makes his final decision as to the extent of the operation. If a benign tumor, such as an osteoma, is present, it is removed and no further surgery is necessary, providing the mucous membrane lining is not diseased and the nasofrontal orifice is adequate. If the mucous membrane lining of the frontal sinus is so extensively diseased that there is no possibility of its recovery, it is removed and the surgeon should proceed with an obliterator procedure. The entire inner cortical bony lining of the sinus, including that on the inner aspect of the osteoplastic flap, is removed with a rotating cutting bur. This step must be systematically and carefully accomplished. The dissecting microscope may be used if necessary. The removal of the inner cortical lining is essential both to ensure a complete removal of the mucosal sinus and to establish a blood supply to nourish the adipose autograft. The removal of mucous membrane and inner cortical lining is carried up to, but not into, the nasofrontal orifice. Revascularization of the adipose implant, during the first few postoperative days, creates a barrier between the nasofrontal orifice and the sinus cavity.

Subcutaneous adipose tissue is obtained from the left abdominal wall by way of a left rectus incision. Subcutaneous catgut sutures are used to eliminate the dead space resulting from the removal of this tissue. Blood vessels are carefully ligated to prevent formation of a hematoma. A drain should remain in place for 48 hours.

The adipose tissue autograft is then fashioned so as to fill the frontal sinus completely. The osteoplastic flap is then returned to its original position. The periosteum is sutured with
#4-0 chromic catgut. The wound is then closed spontaneously with #4-0 chromic catgut sutures and the skin with #5-0 dermal sutures.

The forehead dressing consists of Telfa gauze, placed over the incision, an eye pad, fluffed 4- x 4-inch sponges and three strips of elastoplast adhesive. An elastic bandage is placed over this dressing.

The elastic bandage is removed at the end of 24 hours. The remainder of the dressing is removed at the end of 48 hours. No further postoperative care is necessary other than administration of antibiotics, if prescribed, and removal of the skin sutures on the fifth and sixth postoperative day.

**Techniques of Bilateral Osteoplastic Operation**

**Preoperative Preparation.** X rays of the sinuses are taken within a few weeks prior to the operation in order to determine the extent of disease. It is of particular interest to nose: (1) the depth of the sinuses; (2) whether or not the anterior and posterior walls are intact; and (3) if the interfrontal septum has been perforated or destroyed by disease. A pattern (template) of the outline of the frontal sinuses is obtained from the caldwell x-ray view. The template is made by placing a transparent exposed piece of x-ray film over the Caldwell view and tracing the outline of the sinus with a glass-marking pencil. The template, of course, must be sterilized prior to surgery.

A culture of the nasal cavity should be obtained at least one week before the operation. If pathogens are found, sensitivity tests should be carried out and the proper antibiotic administered during the immediate postoperative period.

If the coronal incision is to be used the patient is given a thorough shampoo with hexachlorophene solution the evening before the operation. The abdomen is shaved and prepared for the removal of the subcutaneous abdominal adipose tissue that is to be used to obliterate the frontal sinuses.

**The Operation.** Either the eyebrow or the coronal incision can be used for the bilateral osteoplastic frontal sinus operation. The eyebrow incision should be made along the entire length of the upper margin of the eyebrow and extended horizontally over the nasal process of the frontal bone. If the coronal incision is employed the hair is saturated with undiluted hexachlorophene solution, combed back, and shaved approximately 1.5 inches behind the anterior hairline. The incision is made approximately 1 inch behind the anterior hairline. Drapes are carefully sutured in place in order to maintain a sterile field during the operative procedure. The eyelids are closed with #5-0 polyethylene or silk suture material when using the eyebrow incision. This is not necessary when the coronal incision is employed. The bilateral eyebrow flap is elevated superiorly in a plane between the frontalis muscle and the periosteum over the frontal bone. The coronal flap is elevated in the same plane and reflected inferiorly. Since bleeding is much more of a problem with the coronal incision, 1% Xylocaine or procaine solution, with added epinephrine, is infiltrated into the line of the incision. Hemostatic clips much facilitate the control of this bleeding. The coronal incision is reflected inferiorly over the face, exposing the supraobrital rims and the nasal process of the frontal bone.
The bilateral eyebrow flap is elevated superiorly, exposing the nasal process of the frontal bone. The coronal flap is reflected inferiorly over the face, exposing both supraorbital rims and the nasal process of the frontal bone.

The x-ray template is taken from the sterilizing solution, rinsed with saline solution, and placed over the frontal periosteum. The inferior aspect of the template is cut across horizontally at a level just above the cribriform plate. A notch placed in the superior aspect of the template indicate the midline or position of the interfrontal septum is quite helpful. The template is positioned so that it accurately approximates the supraorbital rims on each side. It is held in place by any sharp object, such as a needle or knife, by stabbing through the template, periosteum, and against the frontal bone. A #15 scalpel blade is used to incise the periosteum around the outline of the template. A horizontal incision is made in the periosteum over the nasal process of the frontal bone. It is important to include the periosteum over the supraorbital rims, both medially and laterally. Superiorly, the bone incision is made on a bevel so as to make certain that it enters the frontal sinus and to ensure an accurate reapproximation of the osteoplastic flap.

The osteoplastic flap is then elevated by prying with a chisel or an elevator at the superior aspect of the bone incision. As the flap reflects downward and forward there is a fracture across the floor of the frontal sinuses just behind the supraorbital rims where the bone is invariably quite thin. If the interfrontal septum is present, it will interfere with the elevation of the osteoplastic flap. This septum must be incised by inserting a chisel from above before attempting to elevate the flap.

After the osteoplastic flap has been reflected inferiorly, the interior of the sinuses is inspected. The diseased tissue and mucous membrane are removed from the frontal sinus and the superior margin of the nasofrontal orifice. The interfrontal septum is removed. A rotating cutting bur is then used to remove the remnants of mucous membrane and also the inner cortical lining of the sinuses. The inner cortical lining of the inner aspect of the osteoplastic flap should also be removed to ensure complete removal of the mucosal lining and to establish an adequate blood supply to nourish the adipose implant.

Subcutaneous adipose tissue is taken by way of either a vertical or a horizontal left rectus incision and fashioned so that it completely fills both frontal sinuses and obstructs the superior aspect of both nasofrontal ducts. It is not important to attempt placing adipose tissue into the nasofrontal ducts, for they will be sealed from the sinuses by revascularization of the adipose implant within a few days after the operation. The osteoplastic flap is returned to its original position, and the periosteum sutured with #4-0 chromic catgut. The coronal incision is sutured as a single layer, using #3-0 polyethylene sutures. A pressure dressing, to remain in place for 24 to 48 hours, is placed over both eyes and the forehead. Antibiotic therapy is continued for at least 7 days postoperatively.

**External Frontoethmoidectomy (Lynch Frontal Sinus) Operation**

The classical incision is made along the inferior margin of the eyebrow extending downward, half-way between the inner canthus and the anterior aspect of the nasal bones, well down onto the lateral aspect of the nose. This incision is extended through skin, subcutaneous tissue, and periosteum. Troublesome bleeding is usually encountered from the
angular vessels. Before proceeding further it is best to control all bleeding either by ligation or electrodessication.

The periosteum is elevated from the medial wall of the orbit, exposing the lacrimal crests and fossa. The lacrimal sac is displaced laterally, thus allowing exposure of the cribriform lacrimal bone and, more posteriorly, the lamina papyracea. The anterior ethmoidal artery is encountered during the elevation of the periosteum from the lamina papyracea. The bleeding from this vessel can be troublesome and is controlled by cautery and by packing for a short period. The posterior ethmoid artery, found further back along the suture line between the orbital plate of the frontal bone and the lamina papyracea, is similarly treated. Some surgeons prefer to ligate both the anterior and the posterior ethmoid arteries.

The periosteum is elevated from the floor of the frontal sinus. This elevation is most easily begun at the junction of the superior and medial orbital walls. The periosteal dissection is then carried laterally until the floor of the frontal sinus has been completely exposed.

The frontal sinus is approached by way of the ethmoid sinus. Entrance into the ethmoid sinus is accomplished by removing the lacrimal bone with a sharp curette; it is important not to disturb the underlying nasal mucous membrane anteriorly. The opening is enlarged with various-sized Kerrison forceps and rongeurs. The anterior ethmoidal cells are removed with Brownie or Takahashi forceps. If a mucous membrane flap is to be used, it is fashioned at this time. A superiorly based mucosal flap, 1 to 2 cm wide and 2 to 3 cm long, is made in the upper lateral nasal wall. This flap is later turned upward for epithelialization of the reconstructed nasofrontal communication.

With Kerrison forceps, bone is removed from the upper medial orbital wall to the beginning of the osseous floor of the frontal sinus. At this point the frontal sinus cavity is encountered. The entire floor of the frontal sinus is resected. The mucous membrane lining of this sinus is removed by means of periosteal elevators, curettes, and forceps. This is often quite difficult if the sinus has lateral or superior projections and this step in the procedure represents one of the shortcomings of this approach. If the mucous membrane lining is not entirely removed, a mucocele may form at a later date.

The remainder of the anterior and posterior ethmoid cells are removed as well as the lamina papyracea and as much of the middle turbinate as is necessary to establish an adequate opening into the nasal cavity. The relative position of the cribriform plate must be kept in mind at all times. Cerebrospinal fluid leakage will not be a complication if the surgeon's work has been performed carefully. Lynch marked the position of the cribriform plate by means of a probe inserted through the nostril with its tip in contact with the roof of the olfactory slit. The anterior wall of the sphenoid is encountered at the posterior limit of the ethmoid labyrinth. If indicated, the sphenoid sinus is entered with a sharp curette. This opening is enlarged with Kerrison or Hajek forceps, and the diseased tissue is removed.

The mucous membrane flap which has been fashioned from the upper lateral nasal wall is turned upward to line the medial wall of the newly formed nasofrontal opening. This is kept in place by petrolatum gauze, a "cigarette" drain, or a rubber or plastic tube. The support for this mucosal flap is removed on the sixth postoperative day.
Other supports for maintaining the patency of the reconstructed nasofrontal passage include split-thickness skin grafts or Cargile membrane-covered tubes, uncovered plastic or rubber tubing, and tantalum foil. It is necessary that these supports remain in place from 1 to 3 months following the operation.

The success of external frontoethmoidectomy is dependent upon: (1) removal of the entire bony floor of the frontal sinus; (2) removal of the entire mucous membrane lining; (3) a complete ethmoidectomy; and (4) establishing an adequate opening into the intranasal cavity. Even after these requirements have been met, there is a significant incidence of subsequent stenosis of the nasofrontal passage, recurrent sinusitis, and mucocele formation.

Fractures of the Frontal Sinus

Etiology. The most common cause of fracture of the frontal sinus today is an automobile accident in which the victim's forehead strikes against the steering wheel or dashboard. Falls and missile injuries are also relatively common causes. A fracture into the frontal sinus may also occur during a frontal craniotomy; a bur-hole disk may enter the periphery of a frontal sinus.

Diagnosis. Routine x rays of the sinuses usually demonstrate fractures of the anterior and posterior walls of the frontal sinuses and any degree of displacement that may be present. Laminograms may be necessary to more clearly outline the contour of the posterior wall of the frontal sinus. The most common deformity results from posterior displacement of the anterior wall. The nasal process of the frontal bone may be posteriorly displaced. This fracture is quite frequently associated with a cerebrospinal fluid rhinorrhea, with the fluid escaping by way of the cribriform plate. Superior displacement of the floor of the frontal sinus may be associated with a fracture of a supraorbital rim. Air in the orbit is diagnostic of fracture of the floor of the frontal sinus, while air in the anterior cranial fossa behind the frontal bone signifies fracture of the posterior wall of the sinus. A degree of enophthalmos may be found to be associated with a fracture of the posterior wall.

Complications. The most common sequela of fracture of the frontal sinus is a mucocele or pyocele. The lesion usually does not occur for several years following the fracture. As has been mentioned, cerebrospinal fluid leakage may be associated with fracture of the posterior wall of the frontal sinus or with posterior displacement of the nasal process of the frontal bone. Secondary infection may occur with a compound fracture. Delayed secondary infection may appear with a subsequent upper respiratory infection and may extend from the frontal sinus to the extradural spaces.

Treatment. A history of the circumstances of the injury is most important. Immediate unconsciousness is usually the result of a concussion or intracranial hemorrhage. On the other hand, increasing unconsciousness after the injury may be the result of cerebral edema. Unconsciousness occurring days or weeks after the injury may be due to secondary infection.

Patients with simple fractures without displacement are treated expectantly. Antibiotics are administered when there is air in the orbit, or behind the posterior wall of the frontal sinus, in order to prevent any potential infection.
The patient should have carefully executed local and neurologic examinations. Neurosurgical consultation is requested when any sign of brain damage is present.

A depressed fracture of the frontal bone should be explored whether or not it is compounded. This is done to prevent deformity, to determine the presence of a hematoma, and to detect splintering of the posterior wall with a resultant laceration of the dura of the frontal lobe which may lead to cerebrospinal fluid leakage.

The depressed fracture of the frontal bone is often compounded, and thus repair can be accomplished through the wound. If this is impossible, the area is exposed by turning down a coronal flap or by making an incision along the upper margin of the eyebrow.

A trephine opening through healthy bone is useful for both inspection of the sinus and for insertion of instruments for elevation of the bony fragments. Usually the displaced fragments can be elevated through the fracture lines. A steel hook is inserted in the fracture line and turned 90 degrees for elevation in the direction of the loose fragments. The hook is then rotated to the position of its insertion and removed. If this is not possible, a small trephine opening is made at the margin of the fracture line to allow for instrument insertion. Small or soiled fragments of bone should be removed. Hooks, elevators, and chisels are the most useful instruments for repair of depressed fragments.

A cerebrospinal fluid rhinorrhea caused by laceration of the dura of the frontal lobe is positive indication for exploration of the frontal sinus. If comminution and displacement of the anterior wall of the frontal sinus is not extensive, an osteoplastic approach is ideal for management of the spinal fluid leakage. As indicated, either a unilateral or bilateral osteoplastic flap is elevated, providing an excellent view of the entire posterior wall and the site of leakage. A portion of the posterior wall in the vicinity of the dural defect is removed, and the dura is repaired by primary suture if possible. If this method of repair is not satisfactory, the entire mucosal and inner cortical lining of the frontal sinus is removed, and the sinus is obliterated with adipose tissue. The adipose tissue is placed directly against the dural defect.

A mucocele or pyocele not uncommonly follows a fracture of the frontal sinus. It may occur several months or many years following the injury. It can be treated by using the osteoplastic adipose obliteration procedure.

If secondary infection complicates a frontal sinus fracture and extends into the extradural space, the first line of therapy should be the administration of antibiotics according to culture and sensitivity tests. Surgical intervention, such as an anterior craniotomy by a neurosurgeon or a trephination of the frontal sinus by an otolaryngologist, may be necessary. As soon as the infection is under control, the sinuses should be obliterated with adipose tissue. Usually tend days to two weeks of antibiotic therapy are required prior to the osteoplastic obliteration operation.
This chapter deals with the etiology, diagnosis, and treatment of spinal fluid leakage from the sinuses, cribriform plate, and ear.

Repair for stopping the leakage of cerebrospinal fluid into the nasal and aural spaces can be executed by extracranial operation, with lower morbidity and mortality rates than those attained by an intracranial procedure.

Cerebrospinal fluid rhinorrhea may have its origin in the frontal sinus, sphenoid sinus, ethmoid sinus, or cribiform plate. Cerebrospinal fluid otorhinorrhea may originate in the mastoid or middle ear and reach the nasal space by way of the eustachian tube. It may exit as otorrhea from the mastoid or middle ear by way of the external auditory canal.

The repair for stemming spinal fluid leakage into the frontal sinus can be made by direct suturing of the dura, grafting fascia lata, or by adipose obliteration of the frontal sinuses. The bilateral osteoplastic flap procedure is used for exposure of the defect.

Spinal fluid otorrhea or otorhinorrhea emanating from the middle or posterior fossa by way of the mastoid can be treated by obliteration, with either a local pedicled connective tissue flap or an adipose autograft. If the spinal fluid leakage is subsequent to a radical mastoidectomy, it may be necessary to use a fascia lata graft. A nasal septal mucoperichondrial pedicled flap is used to stop spinal fluid leakage through the cribiform plate, roof of the ethmoid bone, and sphenoid sinus.

**Etiology**

McCoy and Ommaya have simplified the etiologic classification into two groups: (1) traumatic (acute or delayed); and (2) nontraumatic, which would include tumors, congenital anomalies, hydrocephalus infection, and primary or spontaneous cerebrospinal fluid rhinorrhea.

Cerebrospinal fluid rhinorrhea of acute traumatic origin may be caused by a crushing injury in which the skull is fractured. This is most commonly due to a war or automobile injury. Penetrating wounds may also result in cerebrospinal fluid rhinorrhea. Most frequently the penetrating object enters by way of the orbit, ethmoid sinus, cribiform area, otic capsule, or mastoid. On occasion, spinal fluid rhinorrhea is produced by the neurosurgeon or the otolaryngologist. Leakage following neurosurgical procedures is usually through the cribiform area and the frontal sinus. It is possible for the otolaryngological surgeon to produce a cerebrospinal fluid rhinorrhea in any of the following ways: (1) by simply removing an intranasal mass which was actually an encephalocele; (2) by rasping of the nasofrontal duct; (3) during operation upon the frontal sinus; (4) during intranasal or extranasal ethmoid operation or a pituitary operation performed by the sphenoid sinus route; or (5) during...
mastoid operations, especially when using the translabyrinthine approach for removal of cerebellopontine angle tumors.

Both extracranial and intracranial tumors may produce cerebrospinal fluid rhinorrhea by erosion of the dura mater. The most common tumors causing cerebrospinal fluid leakage are frontal and ethmoid sinus osteomas. Tumors of the olfactory bulb and pituitary gland are common intracranial tumors producing spontaneous leakage. Intracranial tumors in the region of the sphenoid sinus and mastoid may also produce leakage of cerebrospinal fluid.

Congenital defects, with the formation of an encephalocele into the nasal cavity or rupture of a persistent embryonic ventricular lumen of the olfactory tract, can result in spinal fluid rhinorrhea. The discharge is spontaneous, or primary, cerebrospinal fluid rhinorrhea reaches the nasal cavity by way of a prolongation of the subarachnoid space along the filaments of the olfactory nerve. A sudden transient rise in the cerebrospinal fluid pressure, such as with sneezing or coughing, may rupture the membranes which cover a congenitally weak area in the cribriform plate.

**Diagnosis**

Unless a leakage of cerebrospinal fluid is profuse and persistent, the detection of its source is difficult. Thus, the investigation must be systematic and thorough. Leakage should be considered in patients who have had severe trauma to the face, especially in the region of the superior aspect of the nasal bones and the nasal process of the frontal bone. A patient who has had repeated episodes of meningitis should be thoroughly investigated for cerebrospinal fluid rhinorrhea and otorrhea, especially if there is a history of trauma.

Cerebrospinal fluid rhinorrhea may be intermittent. It is most often unilateral. An acceleration in the flow rate with change in position is rather characteristic. If the rate of flow is profuse the patient will swallow frequently when in a recumbent position. The fluid is clear unless there is an associated acute trauma, when it may be sanguinous. It is odorless, salty, and has a specific gravity of about 1.006.

The nasal discharge may be tested with paper strips (glucose oxidase peroxidase and O-Tolidine) for the presence of glucose. This test is not an absolute confirmation that the discharge is spinal fluid, for lacrimal secretions also contain glucose. The protein content of cerebrospinal fluid is much less than that of a nasal discharge. Some of the discharge being tested should be allowed to remain in the test tube. After standing, a sediment will be found in nasal discharge whereas spinal fluid will remain clear. The discharge should be cultured.

Leakage through the mastoid or middle ear will be attended with a conductive hearing loss and the appearance of fluid or air bubbles behind the tympanic membrane.

X rays of the skull, paranasal sinuses, and mastoid cells may reveal a fracture or air in the cranial cavity. The site of skull fractures associated with cerebrospinal fluid rhinorrhea is usually in the frontal area or in the region of the cribriform plate of the ethmoid bone. Pneumocephalus may be present. A fracture in the olfactory area may result in loss of smell. Etiologic factors, as mentioned above, may make the diagnosis obvious.
A most important method for identification and location of the source of cerebrospinal rhinorrhea or otorrhea is by intrathecal injection of either indigo carmine dye or fluorescein and subsequently detecting its presence intranasally or by otoscopy. The patient is placed in a sitting position. Packing impregnated with 4% cocaine is inserted into the nasal cavities both to produce topical anesthesia and to shrink the nasal mucosa. The cocaine packing is removed after 10 minutes. A separate pledget of cotton is inserted into (1) the sphenom-ethmoidal recess, (2) the region of the olfactory slit, and (3) the anterosuperior nasal cavity. Fluorescein (1 cc of 5% solution) is injected intrathecally with the patient remaining in the sitting position. The room is darkened and the nasal cavity is inspected at regular intervals, using an ultraviolet light source. If there is no obvious evidence of fluorescein at the end of 10 minutes, the three cotton pledgets are carefully removed and inspected for the presence of fluorescein. If no fluorescein is present, three additional pledgets are inserted and the patient is placed in a prone position with his head dependent. The cotton is again examined for the presence of fluorescein at the end of 10 minutes. The fluorescein test can be performed without fear of complications and the results are extremely gratifying.

Cerebrospinal fluid rhinorrhea coming from the middle or posterior fossa and draining into the mastoid antrum and down the eustachian tube may be intermittent even when very active, for when the patient is in the upright or supine position the spinal fluid flows directly into the pharynx. The patient may notice gushes of rhinorrhea with change in head position. The side of the leakage will vary according to the position of the head. Cerebrospinal fluid otorhinorrhea from the mastoid region is best demonstrated by Pantopaque study. Proper positioning and serial x rays, taken for at least 24 hours, may be necessary to demonstrate the point of leakage. Pantopaque will remain in the mastoid cells for many days.

Treatment

The early management of post-traumatic cerebrospinal fluid rhinorrhea and otorrhea is conservative. The patient should remain in a semi-sitting position and be given antibiotic therapy. He should avoid nose-blowing, sneezing, and straining. If the leakage persists after 6 weeks, a more aggressive method of therapy should be employed, for sooner or later most of these patients will develop a meningitis which has a very high mortality rate.

Surgical intervention is indicated in the following instances: (1) when the leakage is of more than 6 weeks' duration; (2) when the leakage is intermittent; (3) when pneumoencephalus is present; and (4) when there is a history of recurrent meningitis and cerebrospinal fluid otorrhea.

Leakage of Cerebrospinal Fluid through the Frontal Sinus

The repair occasioned by leakage of spinal fluid through the posterior wall of the frontal sinus may be made by using the exposure acquired by the anterior osteoplastic flap procedure. I have used this technique in the following cases: (1) leakage encountered when dissecting a mucocele of the frontal sinus from the anterior fossa dura; (2) leakage due to traumatic lacerations of the posterior wall of the frontal sinus and adjacent dura; and (3) leakage occurring during removal of an osteoma of the frontal sinus which extended into the anterior cranial fossa and was complicated by a frontal lobe abscess.
The frontal sinus(es) is opened by way of the anterior osteoplastic flap, by using either the eyebrow or coronal incision (see Chapter 4). It is very important, at this point, that the entire mucous membrane lining of the frontal sinus be removed. In order to ensure complete removal of the lining and to obtain an adequate blood supply for the adipose implant, the entire inner cortical lining of the frontal sinus must be removed; this is done with a rotating cutting bur. Subcutaneous adipose tissue is obtained from the abdomen, trimmed, and implanted so as to fill the sinus(es) completely. The revascularization of the adipose implant occurs during the first few days by ingrowth of vessels and direct blood vessel anastomosis. Fascia lata may also be used to repair a defect in the dura of the frontal lobe. This is placed over the site of the leak and tucked in behind the bony margins of the posterior wall of the frontal sinus.

**Leakage of Cerebrospinal Fluid through the Sphenoid Sinus**

The approach to the sphenoid sinus by the intracranial route for the repair occasioned by cerebrospinal fluid leakage through the sphenoid sinus is extremely difficult and, in some instances, impossible because of the anatomic development of this sinus. Hirsch was the first to use a septal flap for repair of spinal fluid rhinorrhea emanating from the sphenoid sinus following hypophysectomy. He removed the mucoperichondrium on one side of the posterior septum and the perpendicular plate of the ethmoid bone in order to rotate a mucoperichondrial flap from the opposite side into the sphenoid sinus. This procedure produces a large posterosuperior perforation of the septum, which is of little consequence. A septomucosal flap is employed routinely in performing hypophysectomies to prevent spinal fluid leakage as well as to create a barrier between the intradural space and the nasal cavity in order to avoid subsequent ascending infection.

A complete ethmoidectomy is carried out. A septal mucosal flap must be fashioned prior to entering the sphenoid sinus, for the mucosa covering the anterior wall of this sinus makes up the base of this flap. The length of the flap can be estimated from a study of anteroposterior and lateral laminograms of the sphenoid sinus. The position of the vertical incision determines the length of the mucosal flap (ie, the farther anterior the vertical incision, the longer the septal mucosal flap). Second incision is extended posteriorly from the superior aspect of the vertical incision, along the nasal septum adjacent to the medial aspect of the olfactory slit. This is extended to the front of the sphenoid sinus. The third incision is made parallel to the second incision along the inferior aspect of the nasal septum. The fourth incision is an extension of the second incision across the superior aspect of the anterior wall of the sphenoid sinus. Thus, the flap is based at the inferior margin of the front face of the sphenoid sinus. After the mucosal flap has been carefully elevated and reflected into the nasopharynx, the anterior wall of the sphenoid sinus is removed, by using curettes and Kerrison bone-biting forceps.

Usually it is necessary to remove the intersphenoid septum and a small portion of the posterior aspect of the nasal septum in order to provide wide exposure of the sphenoid sinus complex. The mucosal lining of the sphenoid sinuses is removed. The septal mucosal flap is placed over the point of leakage. If the dural defect is large, it may be plugged with adipose tissue or fascia lata before the septal mucosal flap is reflected in place. A single layer of Gelfoam is placed over the flap before it is packed in place with a 24-inch strip of 1-inch iodoform gauze which has been impregnated with aureomycin ointment. A finger-cot packing
is inserted into the nasal cavity. The wound closure, dressing, and postoperative care are outlined in the section on ethmoidectomy (Chapter 4).

**Leakage of Cerebrospinal Fluid through the Mastoid and Middle Ear**

Spinal fluid leakage by way of the mastoid or middle ear can be successfully stopped by the obliterative technique. If the leak enters the mastoid cells or mastoid antrum and the cellular development is not too extensive, an inferiorly pedicled tissue flap will be adequate. On the other hand, if the mastoid area is large, a pedicle flap may not be sufficient to provide an effective seal. In such cases, a free adipose autograft (obtained from the subcutaneous abdominal layer) is used. This latter technique is employed to prevent spinal fluid leakage following the translabyrinthine approach to the cerebellopontine angle. The dura surrounding the defect is widely exposed so that the flap or graft can be packed snugly against the point of leakage. The mastoid incision is tightly closed in layers without drainage. This technique offers closure of the cranial mastoid defect without damage to either the auditory or vestibular function.

If the point of leakage is the anterior aspect of the mastoid antrum or the epitympanic tegmen, a radical mastoidectomy obliteration procedure cannot be employed. The entire mastoid process and middle ear must be obliterated with adipose tissue or muscle (Rambo), thus eliminating the external auditory canal.

An alternate method for repair of cerebrospinal otorrhea is that of grafting fascia lata over the dural defect. This technique was employed in patient M. S., a 19-year-old female college student who was admitted to the Massachusetts Eye and Ear Infirmary on January 6, 1966, complaining of watery otorrhea on the right side of two weeks' duration. Two years before this admission, an endaural radical mastoidectomy had been performed because of longstanding otorrhea and the presence of cholesteatoma. In June of 1965 a mastoidectomy with obliteration and type III tympanoplasty had been undertaken. Following this procedure, there was necrosis of the muscle pedicle flap and the otorrhea continued. Two weeks before the present hospitalization, the patient was admitted for a revision of her mastoidectomy. This procedure was complicated by cerebrospinal fluid otorrhea.

On examination a herniation of tissue in the region of the tegmen mastoideum and a rather profuse spinal fluid leakage were noted. No complication central nervous system signs or symptoms were present. On January 7, 1966, with a modified Heermann incision with a temporal extension for exposure, a right temporal craniotomy was fashioned in the lower portion of the squamous bone and the temporal dura was exposed. The temporal lobe and dura which had herniated into the mastoid were elevated. These structures were supported and the site of cerebrospinal fluid leakage repaired with a fascia lata graft. Mastoid packing was used to support the graft. The packing was removed on the fourteenth postoperative day. The patient's ear has remained dry.

**Leakage of Cerebrospinal Fluid through the Cribriform Plate and Roof of Ethmoid**

Cerebrospinal fluid leakage by way of the cribriform plate or roof of the ethmoid is repaired by way of an external ethmoid incision.
It is essential to review a few points of anatomy in this region before proceeding with a description of the surgical technique.

**Surgical Anatomy.** The ethmoid labyrinth is pyramidal in shape, being wider posteriorly than anteriorly and wider above than below. The anterior width of the ethmoid is 0.5 to 1 cm. The posterior width is approximately 1.5 cm. The anteroposterior length of the labyrinth is 3 to 4 cm. The height is 2 to 2.5 cm. The medial wall of the ethmoid is made up of the upper half of the if the lateral nasal wall. This is actually an extension of the attachment of the middle turbinate, which also separates the roof of the ethmoid from the olfactory slit in the superior nasal cavity. A prolongation of the orbital plate of the frontal bone is the roof of the ethmoid labyrinth.

The lacrimal bone forms the lateral wall of the anterior ethmoid cells, and the os planum (lamina papyracea) forms the lateral wall of the posterior ethmoid cells. The anterior and posterior ethmoid foramina fairly accurately indicate the level of the roof of the ethmoid and the cribiform plate. The posterior ethmoid cells may be as close to the optic foramen as 1 mm. As a general rule, the outer half of the front face of the sphenoid sinus is the posterior limit of the ethmoid labyrinth.

The number of ethmoid cells varies between four and eight. The most important structures in the proximity of the anterior cells are the lacrimal bone, the floor of the frontal sinus, and the hiatus semilunaris; those in the proximity of the posterior cells are the posterior half of the medial wall of the orbit, the optic nerve, and the lateral half of the front wall of the sphenoid sinus. The plane of the cribiform plate approximately corresponds to: (1) the roof of the ethmoid labyrinth; (2) a horizontal line at the level of the pupils; and (3) the anterior and posterior ethmoid foramina.

**Technique of Operation.** The patient's face is prepared with antiseptic solution and draped so as to expose the lower forehead, eyes, cheeks, and nose. The eyelids are fastened together with a single #5-0 suture to prevent injury to the cornea. After infiltration with a 2% local anesthetic agent with added epinephrine, a 1-inch curved incision is made half way between the inner canthus and the anterior aspect of the nasal ridge. This incision is extended through the skin, subcutaneous tissue, and periosteum. Troublesome bleeding from the angular vessels and their numerous branches in this area is usually encountered. Before proceeding with the operation it is best to control this bleeding by either ligation or cauterization.

A number of retractors have been devised for exposure, but none of them seems as effective as two or three sutures, weighted with heavy hemostats, placed on each side of the incision. By elevating the periosteum laterally, the anterior and posterior lacrimal crests and fossae are identified. The lacrimal sac is displaced laterally, exposing the lacrimal bone, and posteriorly, exposing the lamina papyracea. The anterior and posterior ethmoid vessels are encountered during the elevation of the periosteum from the lamina papyracea. As a rule it is necessary to divide these vessels. Should bleeding occur, it can be easily controlled by cautery or by a short period of packing with gauze saturated with epinephrine solution. The ethmoid labyrinth is entered by perforating the thin lacrimal bone just posterior to the posterior lacrimal crest with a sharp curette. This opening is enlarged with various-sized Kerrison forceps. The anterior ethmoid cells are then removed by using ethmoid curettes and Brownie and Takahashi forceps.
An instrument such as the periosteal elevator is passed intranasally along the nasal septum and then above the middle turbinate, causing the mucous membrane of the lateral nasal wall to bulge into the field. This membrane is then incised, affording the operator a view of the middle turbinate. Turbinate scissors are used to sever the attachment of the middle turbinate; the turbinate is removed with a wire snare. Using the attachment of the middle turbinate as a guide, the posterior ethmoid cells are removed. The upper prolongation of the attachment is then removed. The olfactory slit (cribriform plate) thus becomes continuous with the roof of the ethmoid.

The dural defect is usually easily found with the aid of a surgical microscope. The thin bony roof of the ethmoid labyrinth and cribriform plate is carefully removed until the surrounding dura is exposed. After this has been accomplished, a pedicled mucosal flap is obtained from the nasal septum.

Detection of the site of leakage is facilitated by the injection of 1 cc of 5% fluorescein intrathecally prior to the operation. On occasion the dural defect is sufficiently large to reduce the spinal fluid pressure either intermittently or constantly. In such cases it may not be possible to identify the site of leakage, even when fluorescein dye has been injected intrathecally. It is therefore important to measure the spinal fluid pressure preoperatively, prior to the intrathecal injection of fluorescein. If the spinal fluid pressure is low or no pressure is registered, Hartman's solution* is used to elevate the pressure during the operation. A #20 spinal needle is inserted in the lumbar region (the patient is placed in the sitting position, if necessary) and a spinal catheter is inserted. Two cubic centimeters of 5% fluorescein are added to freshly mixed Hartman's solution and the mixture is infused through the spinal catheter.

(* Hartman's solution comes in a two-unit package. The first package contains potassium, sodium, calcium and magnesium chloride and a small amount of hydrochloric acid. The second contains sodium carbonate and phenol red dye. When the two are mixed, a salmon-pink solution having a pH of from 7.2 to 7.5 results.)

The Hartman's solution is allowed to flow intrathecally after the area of suspected leakage is exposed. The spinal fluid pressure is determined intermittently by means of a manometer attached to the infusion tubing. The orange-yellow spinal fluid will become obvious as soon as the pressure is raised, especially when the level of the patient's head is slightly below that of his body.

The septomucosal flap used to repair a fistula by way of the cribriform plate and roof of the ethmoid is based posteriorly. The superior incision extends along the anteroposterior dimension of the superior nasal septum at the junction of the septum and the olfactory slit. This incision is carried as far anteriorly as is possible. The lower incision is approximately 1.5 cm below, and parallel to, the superior incision. It may be necessary to obtain a somewhat wider flap if the dural dehiscence involves both the roof of the ethmoid labyrinth and the cribriform area. The anterior incision merely connects the anterior aspect of the superior and inferior mucosal incisions. As the mucosal flap is elevated, the perpendicular plate of the ethmoid bone is exposed. It is quite often necessary to remove most of the ascending process of the maxilla in this area to expose the anterosuperior nasal septum.
The septomucosal flap is rotated approximately 90 degrees so as to cover the point of leakage and adjacent dura of the olfactory and ethmoid regions. The flap is carefully packed in place with a layer of Gelfoam saturated with bacitracin solution. This is covered with 1-inch wide iodoform gauze stripping that has been impregnated with aureomycin ointment. A finger-cot packing is inserted into the nasal cavity to prevent inferior displacement of the iodoform gauze. A layer of Gelfoam is placed over the iodoform packing in the region of the external ethmoid incision to prevent the packing from adhering to the periosteum. The periosteal incision is then closed with #4-0 catgut and #5-0 silk or plastic suture material. The dressing consists of a layer of Telfa gauze over the suture line, an eye pad, gauze fluffs, and elastic adhesive. After 24 to 48 hours, the entire dressing and finger-cot packing are removed. The iodoform gauze packing; however, must be left in place until the sixth postoperative day.
Indications. In maxillary sinusitis, nasoantral irrigations are indicated only after adequate conservative management has failed to effect a cure or in order to obtain material for culture. An adequate trial of conservative therapy is the treatment of choice whether the sinusitis be acute, subacute, or chronic. The appropriate antibiotics are administered along with the use of local and systemic nasal decongestants. If this therapy is properly instituted, nasoantral irrigations are rarely indicated. If medical therapy is not successful, the surgeon should resort to more definite procedures, in an attempt to establish adequate drainage and remove diseased tissue from the sinus.

Technique of Irrigation. There are two routes for irrigating the maxillary sinus: (1) by way of the natural ostium, and (2) through the inferior meatus. The arguments against the natural route are that irreparable damage to the ciliated respiratory epithelium in the region of the natural ostium is a possibility, and anatomic variations may render this technique extremely difficult or impossible.

Most otolaryngologists prefer to irrigate the maxillary sinus by way of the inferior meatus. For this procedure, the inferior meatus is anesthetized by packing with cotton strips impregnated with 4% cocaine or 2% Pontocaine. Epinephrine (1:1000) or ephedrine (1%) may be added to the Pontocaine. These cotton strips should remain in place for approximately 15 minutes. A straight Lichtwitz needle with a Wolf thumb rest is the instrument of choice for the nasoantral puncture. This is inserted through the nasoantral wall of the inferior meatus, approximately 1 cm behind the anterior tip of the inferior turbinate, and directed toward the lateral canthus. At this point, it is most important not to traverse the sinus cavity completely and enter either the superior or lateral sinus walls. Aspirating before irrigation is essential. Either secretions or air is obtained if the tip of the needle is in the sinus cavity. If the tip is in the sinus cavity and neither secretion nor air is aspirated, then the antrum is filled with a solid material such as that due to polypoid mucositis or to a neoplasm.

The sinus is irrigated with warm normal saline solution. It is not necessary to inject air following this irrigation. There have been some reports of air embolism following injection of air into the maxillary sinus. It the irrigating solution containing the material washed out from the sinus is collected in a black basin, all purulent secretions and debris will be prominent, while the sanguineous material will be invisible and not upsetting to the patient.

Antrostomy (Intranasal Fenestration of the Nasoantral Wall)

A well-constructed nasoantral window is sufficient to cure a chronic purulent maxillary sinusitis, providing the antrum is not filled with polypoid disease and there is no bone necrosis or dental complication. Over the years it has been repeatedly demonstrated that a small nasoantral window closes rapidly and is thus ineffective. A large window is essential.
Technique. The intranasal antrostomy should be performed as an in-patient procedure so that the surgeon proceed with a radical antrum operation, if indicated, after fenestrating the nasoantral wall of the inferior meatus. Many surgeons perform a radical antrum operation routinely in preference to an intranasal antrostomy. The latter procedure effects a cure in less than 90% of patients, thus necessitating an additional hospitalization and operative procedure for those patients in whom the antrostomy fails to effect a cure.

For the intranasal antrostomy, cotton strips, impregnated with a topical anesthetic agent, are placed in the inferior meatus, medial to and above the inferior turbinate. It is best to leave these packs in place for 15 minutes, even when operating with a patient under general anesthesia, because shrinkage of the mucous membrane affords better visualization of the inferior meatus and better hemostasis that could otherwise be obtained. The topical anesthesia also supplements the general anesthesia.

The inferior turbinate is fractured medially and superiorly with a smooth-edged, flat instrument such as a large periosteal elevator or a tonsil dissector. No portion of the inferior turbinate is removed. The nasoantral wall of the inferior meatus is broken through with a punch or sharp curved hemostat. This opening is first enlarged anteriorly with a Kerrison bone-biting forceps and then posteriorly with side-biting ring forceps. The diameter of the fenestration should be 1.5 to 2 cm. It is obviously important to remove the nasoantral wall down to the level of the floor of the nasal cavity in order to facilitate drainage from the sinus. When the fenestration is of sufficient size, the sinus cavity can be inspected for disease by direct vision. If irreversible disease is found, it is best to enter the antrum by way of the canine fossa and carry out a radical antrum operation.

Usually, it is not necessary to insert packing following the antrostomy. On the other hand, if bleeding is troublesome, the window may be packed with 1-inch petrolatum-impregnated iodoform gauze. The packing is removed on the first or second postoperative day.

External Surgery of the Maxillary Sinus

The Caldwell-Luc Operation

Indications. The indications for the Caldwell-Luc procedure are (1) intractable infection; (2) failure of resolution of a chronic infection following intranasal antrostomy; (3) polypoid tissue filling the antrum; (4) antrochoanal polyp, or cystic disease of the antrum; (5) osteonecrosis; (6) suspicion of maxillary sinus neoplasm; (7) dental cysts; (8) presence of foreign bodies; (9) fractures of the maxilla; (10) the presence of an oroantral fistula.

Technique of Operation. Anesthesia. The Caldwell-Luc operation may be performed with the patient under either general or local anesthesia. If local anesthesia is employed, cotton strips impregnated with a topical anesthetic and vasoconstrictor are placed both above and below the inferior turbinate. Two per cent Xylocaine or procaine with added epinephrine is injected along the gingivobuccal sulcus in the region of the canine fossa. The injection is continued superiorly so as to include the infraorbital nerve.
**Incision.** A horizontal incision is made in the gingivobuccal sulcus well above the roots of the teeth. The incision extends from the level of the lateral incisor to the second molar and through the mucous membrane and periosteum. The periosteum over the canine fossa is then elevated to the level of the infraorbital canal. The infraorbital nerve is identified and carefully preserved. The best way to avoid injury to this nerve is to positively identify it. An atraumatic method of elevating the periosteum is to place a bit of gauze ahead of a chisel to provide blunt dissection. Gentle retraction throughout the procedure will also reduce the chance for trauma to the infraorbital nerve as well as to the other soft tissues of the cheek. Two retractors are used to elevate the periosteum. These are placed in a superior medial and superior lateral direction in order to avoid the infraorbital nerve.

**Fenestrating the Canine Fossa.** The best way to fenestrate the anterior wall of the antrum is with use of a curette or a rotating bur. If a rotating bur is not available, a square window may be made with a sharp chisel. The four sides of this window are first scored by light tapping in order to avoid fracture. A sharp gouge is another instrument that may be used to fenestrate the anterior wall. Whichever instrument is employed, a fracture must be avoided, for this may extend to, and injure, the infraorbital nerve or a tooth root.

The opening in the anterior wall is enlarged with either a bur or a Kerrison bone-cutting forceps. Troublesome bleeding may occur from the bone margin. This can be controlled by squeezing tightly with the Kerrison forceps but not hard enough to cut through the bone. It is well to enlarge the sinus opening to a size that will admit the fifth digit. The entire contents of the antrum can then be viewed.

Cysts and benign tumors can be removed with various elevators and forceps, injury to the normal mucosa being avoided. Removal of the entire mucous membrane lining of the antrum is rarely necessary. However, when the lining seems irreversibly diseased it can be easily removed by first elevating it with a curved blunt dissector and then using various elevators, curettes, and tissue forceps for removal. Dissection in the region of the roof of the antrum must be conducted with care, for the infraorbital nerve may not have a bony covering in this region.

**The Nasoantral Window.** A curved, sharp hemostat is inserted intranasally into the inferior meatus and, by gentle pressure, an opening is made in the anterior aspect of the nasoantral wall. The fenestra is enlarged in an anterior direction with Kerrison forceps and posteriorly with a side-biting forceps. This dissection is much more easily carried out by way of the Caldwell-Luc opening in contrast to the intranasal route. The nasoantral window should be at least 1.5 cm in diameter and should include intranasal mucous membrane, sinus mucosa, and the bony nasoantral wall. Many surgeons hold the opinion that the various mucosal flaps devised for formation of the nasoantral window are not only unnecessary but can, by becoming displaced, close the fenestra.

**The Denker modification** of the radical antrum operation is preferred by some surgeons. The opening in the anterior sinus wall is enlarged in a medial direction, thus removing the inferior portion of the ascending process of the maxilla. The anterior half of the lateral nasal wall inferior to the inferior turbinate is resected to serve as the nasoantral communication. The end results of the Caldwell-Luc and Denker operations are quite similar.
Before packing, the sinus cavity is carefully inspected for retained sponges. If there is no bleeding, packing is unnecessary. Petrolatum- or aureomycin ointment-impregnated 1-inch iodoform gauze packing may be inserted into the sinus by way of the nasoantral fenestra in order to control persistent bleeding. The incision in the gingivobuccal sulcus is closed with one or two catgut sutures. Some surgeons prefer not to suture this incision, stating that there is much less postoperative edema if it is not closed.

Postoperative Care. An ice pack over the cheek during the first 24 postoperative hours is essential to prevent edema, hematoma, and discomfort and should be obtained for the patient while he is still in the recovery room. The intrasinus and intranasal packing should be removed at the end of one or two postoperative days. If purulent secretions were encountered in the sinus, the postoperative administration of antibiotics is of value. The antibiotics may be altered according to culture and sensitivity tests.

Caldwell-Luc operation - technical details

The upper lip is retracted superiorly in a direction away from the infraorbital nerve. Stretching the nerve can cause anesthesia of the upper lip and side of the nose. The endotracheal tube is directed towards the contralateral angle of the mouth. The pharynx is packed both to assist with a closed system of anesthesia and to prevent blood from entering the pharynx. An incision is made about 5 mm above the gum margin. It should be slightly "U" shaped, especially when the patient wears an upper denture. The periosteum has been elevated superiorly, exposing the bony front face of the maxillary sinus, known as the canine fossa. Again, note that the retraction is in a direction away from the infraorbital nerve, which can be seen as it leaves the infraorbital foramen. Bleeding is controlled by packing with epinephrine impregnated gauze strips or by cautery. A gauze strip pushed ahead of a chisel assists with the elevation of the periosteum.

Caldwell-Luc operation - methods for entering antrum

There are several methods for entering the antrum by way of the anterior wall.

A curette can be used if the wall is thin. A cutting "rose" bur can be used both for entrance into the antrum and for removal of the antrum's anterior wall. When a sharp chisel is used, all four sides must be scored with the chisel prior to penetrating into the antrum. This is essential to prevent fracture and possible injury to the infraorbital nerve. The anterior wall of the sinus is being removed with a Kerrison forceps. Troublesome bleeding may occur from the cut edge of bone. This can be controlled by squeezing the bone edge tightly with the Kerrison forceps but not hard enough to cut through. Sufficient amount of anterior wall has now been resected, so that the diseased area can be removed effectively and a nasoantral fenestration fashioned.

Caldwell-Luc operation - construction of nasoantral window

Diseased tissue is removed from the antrum with curettes and blunt cupped forceps. If the mucosal lining of the antrum is to be removed, it is first elevated with a blunt curved dissector. Dissection should be conducted with care in the region of the roof, for the infraorbital nerve may not have a bony covering. To construct the nasoantral window, a
curved hemostat is passed into the nasal cavity along the floor and then directly lateralward beneath the inferior turbinate. The tip of the hemostat is moved from side to side in order to enlarge the opening sufficiently to admit a small Kerrison or Hajek forceps.

The nasoantral fenestration is enlarged in an anterior direction with Kerrison forceps and posteriorly with ring forceps. The bony and membranous layers are removed simultaneously, exposing the inferior turbinate. There are a number of techniques for the construction of a flap from the medial wall of the antrum to be reflected laterally. These are somewhat difficult to fashion and have a tendency to resume their anatomic position, thus closing the fenestra.

**Oroantral Fistula**

**Diagnosis.** The number of upper premolars and molars in intimate contact with the floor of the maxillary sinus is dependent upon the size of the sinus. The sinus may be separated from the roots of these teeth by a thin layer of bone, or there may be an absence of bone. On occasion the roots may extend into the maxillary sinus. An oroantral fistula may occur following the extraction of a non-diseased tooth. There are two predisposing factors to oroantral fistulas: the close proximity of premolar and molar roots to the sinus floor, and the presence of either an apical abscess or a maxillary sinusitis with poor drainage at the time of an upper molar or premolar extraction. An oroantral fistula may be secondary to a compound maxillary fracture, neoplasm of the antrum (especially after radiation therapy), or following a radical antrum operation.

The symptoms of an oroantral fistula, if of recent origin, are blood in the nasal cavity, and an escape of air from the fistulous tooth socket. Liquids taken into the mouth may escape through the nostril. If infection is present it usually is manifested within one or two days following the extraction of the tooth. Pain over the maxillary sinus and a profuse odoriferous nasal discharge are characteristic. The patient complains of foul taste. Purulent discharge can be seen exuding from the extraction site. This discharge may increase when the patient holds his nose and increases the internal pressure. The patient may have difficult in developing a negative intraoral pressure such as when drinking through a straw.

The diagnosis is made from the history, signs and symptoms, x rays of the sinuses, and probing of the fistulous tract with a small-caliber lacrimal probe.

**Indications for Surgical Procedure.** The surgical procedure is determined by:

1. The size of the fistula.
2. The presence or absence of adjacent teeth.
3. Previous unsuccessful attempts for closure.
4. Severity of the associated maxillary sinusitis.
5. Epithelialization of the fistulous tract.

On occasion an oromaxillary fistula may occur following the extraction of a non-diseased tooth. This usually heals rapidly after local repair, administration of antibiotics, and prohibiting the patient from nose-blowing. If a tooth root is broken off during extraction and found to lie within the antrum but submucosally, it is best left alone if there is no infection.
If infection is present, antibiotic therapy plus irrigation may result in resolution of the inferior and healing. Otherwise a more radical procedure is necessary both to remove the foreign body and to close the oroantral fistula.

**Repair of Fistula When Teeth Are Present.** If the fistula is small and teeth are present it is closed by using a combination of gingival and palatal incisions adjacent to the teeth. Antibiotic therapy is instituted several days before operation. The patient is prepared for operation as outlined for the Caldwell-Luc procedure. The incision is made near the gingival margin. The periosteum is elevated over the anterior wall of the maxillary sinus. The antrum is entered and a Caldwell-Luc operation is carried out, making certain that a large oroantral window is fashioned. It is most important to obtain a culture so that sensitivity tests can be performed. All granulation tissue and diseased bone are curetted from both the sinus and oral orifices of the fistula. An incision is made on the palatal side of the alveolar ridge. A counter incision is made over the hard palate; this incision may extend beyond the junction of the hard and soft palate if necessary. The bipedicled flap thus created is elevated so that it may be advanced laterally in order to obtain tension-free approximation of the flaps. The flaps are securely sutured over the fistula with mattress sutures. The antrum is firmly packed with 1-inch aureomycin-ointment impregnated iodoform gauze.

Postoperatively the patient is maintained on antibiotics. The iodoform packing is removed on the fifth postoperative day by way of the nasoantral window. If the suture material used is #3-0 silk rather than chromic catgut it is removed on the tenth postoperative day. The patient is warned against nose-blowing until healing is complete.

**Procedure in Edentulous Patient.** If the fistula is small or of moderate size, the there are no teeth present in the adjacent alveolar ridge, a gingivobuccal "U" flap is used to repair the defect. The "U" flap is elevated and a Caldwell-Luc operation is carried out. The lateral wall of the fistulous tract is completely removed from the alveolar ridge to the antrum. Adjacent bone is also removed laterally so that the "U" flap may be placed in contact with the entire surface of the trough thus created. The "U" flap is then secured in place with #3-0 chromic catgut or silk suture material.

**Procedure for Large or Persistent Oroantral Fistula.** There are numerous surgical procedures for the correction of a persistent or large oroantral fistula. Probably the simplest and the most successful method is that of providing a posteriorly based palatal flap combined with a buccal flap. It may be necessary to remove adjacent teeth if they are in close proximity to the fistula. In preparing the palatal flap it is important to be cognizant of the location of the greater palatal foramen and artery. The location of the greater palatal foramen is approximately 0.5 cm medial to the last molar tooth. The lateral wall of the fistulous tract is removed in a manner similar to that previously described. A more extensive resection of the alveolar ridge may also be necessary. The palatal flap is then advanced laterally so that it may be sutured to the gingivobuccal flap without tension.

A connective tissue flap derived from the area above the gingivobuccal flap may be reflected inferiorly into a large oroantral fistula. This is sometimes necessary in conjunction with the palatal and buccal flap to close a very large oroantral fistula.
Vidian Nerve Section for Vasomotor Rhinitis

**Indications.** Any patient with persistent bilateral nasal obstruction due to engorgement of the turbinates and nasal mucous membrane who has not responded to intensive conservative management may be a candidate for unilateral or bilateral vidian nerve section. The candidates are patients who have either had negative or nonspecific responses to skin sensitivity tests, have no complicating bacterial infection, and do not have local and blood eosinophilia. Before subjecting patients to the operation, emotional and endocrine factors as well as physical agents such as heat, cold, and local irritants should be considered as factors responsible for engorgement of the turbinates and nasal mucous membrane.

The surgeon must make a careful differentiation between the patient with rhinorrhea which is secondary to cholinergic effects of the parasympathetic fibers of the vidian nerve as opposed to the "blocked stuffy nose without rhinorrhea" which will usually not be improved after section of the vidian nerve. It should be emphasized that sectioning of the vidian nerve should be reserved only for patients in whom conservative measures have failed.

**Anatomy of the Pterygomaxillary Fossa.** The pterygomaxillary fossa is bound:

1. Anteriorly, by the infratemporal surface of the maxilla (posterior wall of the maxillary sinus).
2. Superiorly, by the undersurface of the sphenoid bone and the orbital process of the palatine bone.
3. Medially, by the perpendicular plate of the palatal bone.
4. Posteriorly, by the base of the pterygoid process and part of the anterior surface of the greater wing of the sphenoid bone.

The pterygomaxillary fossa contains the third division of the internal maxillary artery, the accompanying veins, the vidian nerve, the sphenopalatine ganglion, and the second division of the trigeminal nerve. The spaces between these structures are filled with adipose tissue.

The openings into the pterygomaxillary fossa are as follows:

1. The inferior orbital fissure is the communication between the pterygomaxillary fossa and the orbit.
2. The pterygomaxillary fissure is located laterally at the junction of the second and third division of the internal maxillary artery.
3. The sphenopalatine foramen is found close to the posterior tip of the middle turbinate. The sphenopalatine artery and nerves are distributed to the septum and the lateral wall of the nose through this foramen.
4. The foramen rotundum is readily identified in the posterior superior wall of the pterygomaxillary fossa. The second division of the trigeminal nerve enters the fossa by way of the foramen rotundum.
5. The vidian canal is a funnel-shaped opening on the posterior wall situated medial and slightly inferior to the foramen rotundum. A 7- to 10-mm wide vertical crest of bone separates the foramen rotundum from the vidian canal. The vidian canal is often difficult to
view because of its close proximity to the medial wall of the antrum (lateral wall of the nasal cavity). The vidian nerve exits from this canal to join the overlying sphenopalatine ganglion.

6. The pharyngeal canal is an opening into the lateral aspect of the roof of the choanae. The pharyngeal branches of the sphenopalatine ganglion and the pharyngeal branches of the sphenopalatine ganglion and the pharyngeal branches of the internal maxillary artery reach the nasopharynx by way of this canal.

7. The posterior palatine canal, found in the floor of the pterygomaxillary fossa, provides passage for the descending palatine nerves and the greater palatine artery.

**Anatomy of the Vidian Nerve.** The vidian nerve is made up of both sympathetic and parasympathetic fibers. The sympathetic innervation arises from the cervical ganglion of the carotid plexus. The parasympathetic innervation originates in the superior salivatory nucleus and accompanies the facial nerve to the geniculate ganglion. Here the parasympathetic fibers separate from the facial nerve to form the greater superficial petrosal nerve, which exits the temporal bone through the hiatus facialis on the anterior surface of its petrous portion. Shortly thereafter the greater superficial petrosal nerve joins the sympathetic fibers from the carotid plexus to form the vidian nerve.

The vidian nerve joins the overlying sphenopalatine ganglion shortly after its exit from the vidian canal. It proceeds to provide the parasympathetic and sympathetic nerve supply of the nasal cavities.

**Technique of Vidian Nerve Section.** The procedure may be performed with the patient under either general or local anesthesia. When local anesthesia is the choice, 2% Xylocaine with 1:100,000 epinephrine is injected into the gingivobuccal sulcus and around the infraorbital nerve.

A curved needle is inserted 2 cm into the greater palatine foramen and 2 cc of the same local anesthetic agent previously used are slowly injected into the canal and pterygomaxillary fossa.

A Caldwell-Luc incision is employed. The periosteum is elevated from the anterior wall of the antrum in the region of the canine fossa. A curette, chisel, or rotating bur is used for entry into the antrum. As much of the anterior wall of the antrum is removed as is possible without damaging the infraorbital nerve. Removal can be accomplished with Kerrison forceps, but is best done with a rotating bur. A cocaine pack is placed in the antrum for a few minutes to further anesthetize the antral mucosa and to decrease bleeding. A mucosal flap based laterally or inferiorly, is elevated from the posterior wall of the antrum. A self-retaining retractor is applied to elevate the upper lip and periosteum.

The surgical microscope, with a 300-mm lens, should be used during the remaining dissection. The thin posterior wall is broken through with a curette or small chisel. The periosteum is carefully separated from the posterior sinus wall, which, in turn, is removed with Hajek bone-cutting forceps. It is important to extend this bony dissection as far medially as is possible, for the vidian canal is often found directly posterior to the medial wall of the antrum. There are a number of small blood vessels directly underneath the periosteum covering the pterygomaxillary fossa. It is best, therefore, to use electrocoagulation when
making the cruciate incision to open this periosteum. The four flaps thus created are easily elevated, exposing the underlying adipose tissue.

Pulsations of the internal carotid artery can often be seen, giving the surgeon some indication as to the location of this artery. Adipose tissue is carefully removed with dissectors, alligator and cup forceps, and suction tips, all especially designed for this purpose. As soon as the main artery is identified, it is elevated with an artery hook so that its branches may be more readily dissected free.

The sphenopalatine ganglion is often quite difficult to see because of the overlying internal maxillary artery. The artery may also interfere with the dissection in a medial and inferior direction to the vidian canal. In such cases it is ligated and sectioned medial to the origin of the infraorbital artery. Once the sectioned artery is reflected medially, the rounded vertical bony ridge which separates the foramen rotundum from the vidian canal can be identified. The rather large, funnel-shaped vidian canal is found medial and slightly inferior to the foramen rotundum, nearly in direct line with the medial wall of the antrum.

The sphenopalatine ganglion is held forward with a right-angle hook, and the emerging vidian nerve is seen. The vidian nerve is sectioned with a small sickle knife or a small curette. Bone wax or Oxygauze is packed into the vidian foramen. I have abandoned the use of cautery in this area. The posterior antral wall mucosal flap is placed over the pterygomaxillary fossa and covered with a layer of Gelfoam. A Caldwell-Luc operation is completed.

**Postoperative Care.** The postoperative care is similar to that after a Caldwell-Luc procedure or ligation of the internal maxillary artery. Following the section of a vidian nerve, absence of lacrimation may give temporary discomfort. This is alleviated by methyl cellulose eye drops.

It should be noted that Gergely (1935) states that one-third of the cases of unilateral sectioning of the vidian nerve show bilateral improvement. This usually becomes apparent approximately two weeks after the operation, and thus a contralateral operation should be delayed for at least one month.

**Maxillectomy**

Maxillectomy is the treatment of choice for a carcinoma confined to the antrum. Unfortunately, these cases are few and far between, for carcinoma in the maxillary sinus usually extends beyond the confines of the sinus to produce signs and symptoms which bring the disease to the attention of the patient.

As a general rule, inferiorly located carcinoma of the maxillary sinus has the best chance for cure. If the lesion has broken through the anterior wall of the sinus, everything under the cutaneous cheek must be removed, and, on occasion, the skin of the cheek must be included with the resected specimen. If the carcinoma has broken through the roof of the antrum, the orbital contents must be resected with maxilla. If the tumor invades the anterior ethmoid cells, the nasal septum and entire ethmoid labyrinth, including the roof of the labyrinth and the cribriform plate, must be removed. Tumors which extend through the
posterior wall of the antrum into the posterior ethmoid cells, sphenoid sinus, or apex of the orbit have a poor prognosis even with preoperative or postoperative radiation therapy. If the carcinoma extends into the frontal sinus, the frontal bone in this area should be resected.

If the disease extends beyond the confines of the antrum and the site of extension can be accurately outlined, preoperative radiation therapy should be instituted. The advantage here is that a larger dose of radiation can be given with less chance of tumor spread by the surgical procedure, and there will be fewer postoperative complications. Postoperative radiation therapy is given when the site of extension is discovered at the time of the operation. In such cases, a radiotherapist can administer the radiation more accurately than would have been possible prior to the operation, but the amount must be limited because of almost certain injury and breakdown of surrounding normal tissues.

Is a maxillectomy ever done when there is no chance for cure? Yes, it is undertaken to remove disease tissue and the products of palliative radiation therapy when such complications as bone sequestration, severe odor, uncontrollable pain, and trismus result from this therapy.

**Preoperative Management.** Permission for removal of the orbit must be obtained preoperatively in all cases, for an unsuspected extension of disease is not uncommon. The surgeon may choose to begin antibiotic therapy before the operation, especially if the carcinoma is accompanied by secondary infection. Anteroposterior and lateral planograms of the maxillary sinus are often most helpful in determining the extent of the disease. It is preferable to obtain upper and lower dental impressions before the maxillectomy rather than during the immediate postoperative period. If this is not possible, the impression can be taken either immediately after the operation or following removal of the packing. The patient's blood is cross-matched with at least 1500 cc of whole blood, which should be in readiness at the time of the operation. In the past, ligation of one or both external carotid arteries has been a prelude to maxillectomy. For the most part, this has been abandoned, and hemorrhage is controlled and blood replaced as the problem is encountered.

Since the incidence of carcinoma of the maxillary sinus is high among persons of the older age group, a careful preoperative evaluation of the patient's general health is essential.

**Anesthesia.** Hypotensive anesthesia facilitates this extensive and bloody surgical procedure; however, only about 50% of patients with carcinoma of the maxillary sinus can fulfill the necessary qualifications for hypotensive anesthesia, which requires that the systolic blood pressure be maintained at 60 mm and even slightly lower if the patient is young and healthy. A cuffed endotracheal tube should be inserted through the nasal cavity opposite to the side being operated upon. Pharyngeal packing is inserted to prevent blood from entering the esophagus or trachea. The anesthetic agent of choice is one which allows the surgeon to use cautery and epinephrine solution simultaneously.

**Maxillectomy with Orbital Exenteration**

The patient is placed on the operating table in the supine position. His head is elevated above the level of the thorax in order to reduce venous pressure. Maxillectomy is a difficult, bloody, and high-risk operation. Heavy equipment is necessary.
The anatomic parts to be removed are: the orbital contents, the floor and medial wall of the orbit, the malar bone, a portion of the zygomatic arch, the antrum, the ethmoid sinuses, the anterior wall of the sphenoid sinus, the pterygoid plate, the hard palate, and the nasal septum if the ethmoid or nasal cavity is involved with the tumor.

**Incisions.** The eyelids are sewed together with #5-0 silk or polyethylene suture material. The incision begins over the lateral aspect of the nasal dorsum, just above the level of the inner canthus. It is made directly to the bone. It is extended down over the nasal bone midway between the lateral nasal crease and the dorsum of the nose, around the ala and the nasal labial crease, to the midline under the columella. Cross hatching of the incision is carried out in order to ensure a more accurate closure. A vertical midline incision is carried out in order to ensure a more accurate closure. A vertical midline incision is used to split the upper lip. The upper lip is compressed with a finger and thumb on each side while the lip-splitting incision is made. As pressure is released the superior labial and lateral nasal branches of the external maxillary artery are easily identified and ligated.

The incisions above and below the eyelid margin are made approximately 2 mm away from the tarsal plates. They rejoin lateral to the external canthus and extend laterally an additional 2 cm. Some surgeons advocate preservation of the lids so that a prosthesis may be worn. The cosmesis attending this operation is not entirely satisfactory and preservation of the lids is often not advisable, because the orbital defect is needed for long-term inspection and the detection of recurrent disease.

An incision is made along the entire length of the gingivobuccal sulcus and posteriorly around the maxillary tuberosity. If teeth are present, the median incisor on the side of the maxillectomy is removed.

Either of two methods is used to approach the hard palate. If the lesion extends to, or involves, the hard palate, then the mucous membrane over the hard palate must be removed with the specimen. In such cases a midline incision is made from the anterior midline alveolar ridge to the junction of the hard and soft palates. An incision is then made along the posterior rim of the hard palate. This connects with the gingivobuccal incision which has been extended around the maxillary tuberosity.

If the hard palate is not involved, the mucosal incision is made along the palatal side of the alveolar ridge parallel to the gingivobuccal incision. This connects with the gingivobuccal incision around the posterior aspect of the maxillary tuberosity. A mucous membrane flap is elevated, exposing the hard palate on the side upon which the maxillectomy is being performed.

**Elevation of the Facial Flap.** The nasal cavity is entered inferiorly after the upper lip has been reflected laterally. An electrocautery knife is useful here. This incision is extended laterally and then superiorly in the pyriform aperture to a point on the inferior margin of the nasal skeleton at the junction between the nasal bone and the ascending process of the maxilla. The periosteum is elevated over the nasal bone and ascending process of the maxilla to the level of the nasal process of the frontal bone, while the nose is retracted to the opposite side.
Elevation of the facial flap is continued in a subcutaneous plane. The skin of the lids is elevated superficial to the orbicularis oculi muscle. (On the other hand, if the tumor does not extend to this region, the orbicularis oculi muscle may be preserved with the facial flap to give a better cosmetic result.) The buccinator muscle is preserved with the facial flap. All other facial muscles attached to the anterior wall of the antrum must be transected. The buccinator can be followed easily, for its fibers are continuous with those of the orbicularis oris muscle and run in a posterior direction. That portion of the buccinator muscle which attaches to the maxilla is transected. Elevation of the flap is continued posteriorly to the anterior aspect of the zygomatic arch and to the lateral aspect of the malar bone.

**Orbit.** As has been mentioned, the skin of the upper lid is usually elevated to include the orbicularis oculi muscle unless there is extension of disease into the orbit. The superior orbital rim is identified. The periosteum is incised along the superior orbital rim and also on the medial and lateral orbital rims, to the level of the inner and external canthi. Elevation of the periosteum is begun superiority, and the contents of the orbit are dissected inferiorly. The optic nerve and vessels are transected with curved scissors. Troublesome bleeding can be controlled with packing left in place for a short time.

**Malar Bone.** The inferior orbital fissure is identified. A long, curved hemostat is inserted under the malar bone and up and out through the inferior orbital fissure. This hemostat is used to grasp one end of a Gigli saw, which is pulled through and used to transect the malar bone. The malar bone can also be incised with a Stryker saw. On occasion it may be necessary to remove the superior and lateral bony walls of the orbit, thus exposing the dura.

**Zygomatic Arch.** After detaching the anterior attachment of the masseter muscle, the zygomatic arch is transected with either a Gigli or a Stryker saw.

**Hard Palate.** The simplest way to transect the hard palate is with a 2-cm osteotome. The transection may be accomplished by inserting a Gigli saw into the nasal cavity and out at the junction of the hard and soft palates. The saw is grasped by a curved hemostat inserted through the incision at the junction of the hard and soft palates. When sawing, it is necessary to pull slightly toward the opposite side so that the saw will approximate the midline. Troublesome bleeding may occur from the greater palatine artery, but this can be controlled by packing or by inserting a cautery tip into the greater palatine foramen. In order to decrease the amount of bleeding, the electrocautery knife can be employed on the buccal and nasal sides of the hard palate prior to using the osteotome or Gigli saw.

**Ethmoid.** The upper nasal cavity is entered by one of two methods. A 1-cm osteotome is placed between the nasal bone and the ascending process of the maxilla. The osteotome is inserted to the level of the nasal process of the frontal bone. This is approximately at the level of the inner canthus, cribiform plate, roof of the ethmoid labyrinth, anterior and posterior ethmoid arteries, and the suture line between the orbital process of the frontal bone and the lamina papyracea. The exposure also can be accomplished by removing the ascending process of the maxilla with a rongeur.

The periosteum is elevated laterally, exposing the lacrimal sac and lamina papyracea. The anterior and posterior ethmoid arteries are identified and cauterized. The anterior and
posterior ethmoid foramen accurately identify the level of the cribriform plate and roof of the ethmoid sinuses. An osteotome is used to transect the specimen just below the roof of the ethmoid sinuses. This osteotome is extended posteriorly to the depth of the posterior ethmoid artery. If the disease involves the ethmoid sinuses, their bony roof and cribriform plate should be removed, thus exposing the dura. In such cases, cerebrospinal fluid leakage usually occurs. Repair is made with a split-thickness skin graft or a mucosal flap from the septum. When the ethmoid sinuses are grossly involved, it is also advisable to resect the nasal septum.

**Posterior Dissection.** The masseter muscle is detached from the maxilla. There are two methods to handle the posterior dissection. If the posterior wall of the antrum remains intact, an osteotome is inserted between the maxilla and the pterygoid process. Most often it is impossible to determine whether or not the posterior wall of the antrum is involved with the tumor and thus an alternate method must be used. The pterygoid muscles are detached from the medial and lateral pterygoid plates. A large curved osteotome is placed behind the pterygoid plates, and the pterygoid process is transected near its origin from the remainder of the sphenoid bone. Brisk bleeding from the internal maxillary artery may be encountered in this area.

**Specimen Removal.** After the pterygoid processes have been freed the specimen is attached only by the posterior and medial aspect of the bony orbit and the pterygomaxillary fossa. A heavy pair of scissors is placed behind the pterygoid plates and then wherever the specimen remains intact. As soon as the specimen is removed, a large hot-pack is inserted into the cavity. Time can now be taken for examination of the specimen to determine the extent of the disease. The packing is removed and the internal maxillary artery is ligated. The remaining portions of the ethmoid labyrinth, the anterior wall of the sphenoid sinus, and other areas where there could be possible extension of the disease are resected.

**Skin Grafting.** A 0.0015- to 0.0018-inch thickness skin graft is obtained from the medial aspect of the thigh, a nonhair-bearing area. All areas void of mucous membrane are grafted. One graft is used to line the orbit, roof of the ethmoid sinuses, and the cribriform area. A second graft extends from the anterior wall of the sphenoid sinus to the anterior skin incision, thus lining the skin flap. This graft is sutured to the gingivobuccal incision inferiorly and subcutaneously anteriorly. Chromic catgut (#4-0) is used for suturing the skin graft. Overlapping portions of the graft can be trimmed, postoperatively, after the packing has been removed. As a general rule these grafts take very well and it is not necessary to suture them carefully in place. The entire skin-grafted cavity is lined with a layer of absorbable gelatin material, so that when the gauze packing is removed the skin graft will not be pulled away. The defect (cavity) is packed with aureomycin ointment-impregnated iodoform gauze. This packing is held in place with a temporary prosthesis or by bridging #00 chromic catgut or #3-0 Dermalene sutures from the midline to the gingivobuccal incision.

**Skin Closure.** Using the cross-hatchings as a guide, the flap is replaced subcutaneously with #3-0 chromic catgut sutures. The mucous membrane is sutured with #4-0 chromic catgut. Dermal suture material (#5-0) is used for the skin closure. A light dressing is placed over the orbit, face, and side of the nose. A nasogastric feeding tube is inserted by way of the nasal cavity opposite the operated side. This remains in place for approximately 4 days or until the patient is able to feed himself properly. If there is any sign of impending
respiratory obstruction, or a radical neck dissection has been carried out with the maxillectomy, a tracheotomy should be performed.

**Postoperative Care.** The packing is removed between the seventh and tenth postoperative day. An impression for a temporary prosthesis is made at this time, if this was not done immediately after the operation. Moist cotton packing can be used temporarily to fill the defect. This is changed several times a day, especially after each meal. The cavity should be carefully cleaned each day with hydrogen peroxide solution and irrigated with warm saline solution. Excessive skin that has been grafted is trimmed. A permanent dental prosthesis is made four to six weeks postoperatively when all healing has taken place.

As a general rule a dental prosthesis is preferable to a reconstructed palate because this provides for easier inspection of the cavity, and recurrent disease can be identified at an early date. If the mucous membrane and periosteum of the hard palate have been preserved, the defect in the palate may be eliminated. When the hard palate is reconstructed, the resultant skin-lined cavity, which produces much debris, may result in a crusting and an odor problem. There are three methods for constructing the palate: (1) by using a pedicled flap consisting of the entire forehead based on one temporal artery (this is tunneled in through the cheek); (2) by using a cervical pedicled skin flap which is pulled up and through the cheek; or (3) by swinging the nasal septum, which has been incised anteriorly, superiorly, and posteriorly and hinged inferiorly, laterally to cover the palatal defect.

**Maxillectomy with Preservation of the Orbit**

A medial and lateral tarsorrhaphy should be performed prior to making the maxillectomy incision. This is done to prevent edema and ectropion of the lower lid postoperatively. The rhinotomy and the upper lip, gingivobuccal, and palatal incisions are made as described previously. The horizontal incision under the eye extends across the lower lid within 2 to 3 cm from the tarsal places. The lower lid is elevated in a plane above the orbicularis oculi muscle. The flap is elevated, preserving the orbicularis oculi and buccinator muscles. The entire front face of the maxilla, ascending process, inferior orbital rim, zygomatic arch, and malar bone are exposed.

A periosteal incision is made along the inferior orbital rim. The periosteum is elevated from the floor and lower medial and lateral walls of the orbit. A curved hemostat is inserted under the malar bone, the tip presenting in the inferior orbital fissure in order to grasp one end of a Gigli saw, which is used to transect the malar bone. If the floor of the orbit is to be preserved, the orbital periosteum is not elevated from it.

The remainder of the operation is as has been described for maxillectomy with orbital exenteration. The ethmoid is usually transected at slightly lower level. The remainder of the ethmoid cells are carefully removed after the specimen has been resected.

There are two methods to obtain support for the orbit if the bony floor has been removed.

1. The temporalis muscle is detached from the coronoid process of the mandible. It is slung under the orbital periosteum and sutured in the region of the inner canthus. The
temporalis muscle, as well as the remainder of the maxillectomy defect, is covered with a split-thickness skin graft.

2. An alternate, but not quite as effective, method to support the orbit is that of suturing a sling of skin graft under the orbital periosteum. As the graft becomes attached to the periosteum and contracts, it supplies a good support to the orbit.

It is best not to disturb the tarsorrhaphy incision for several weeks in order to prevent edema and ectropion of the lower lid. The remainder of the postoperative care is as has been outlined for maxillectomy with orbital exenteration.

**Partial Maxillectomy**

For very low lesions of the maxilla, such as those of the alveolar ridge and hard palate, a partial maxillectomy can be accomplished by using the gingivobuccal and palatal incisions only.
Surgery of the Upper Respiratory System

William W. Montgomery

Chapter 7: Facial Fractures

Introduction

Of first concern when confronted with a facial injury is the general status of the patient, with particular attention being paid to hemorrhage and shock. The patient's wounds should be protected from further injury. There is some controversy as to whether or not the bony repair should precede or follow the soft-tissue repair. As a general rule, the soft-tissue wounds should be cleansed, debrided, and repaired and the reduction of the fracture postponed. The surgeon should search carefully for foreign material. It must be remembered that each fragment of bone is a potential center for osteogenesis, and therefore none that has a chance for survival is removed. Small fragments which are completely detached usually do not survive. On occasion, reduction and fixation can be accomplished prior to soft-tissue repair. If there is to be an interval between soft-tissue repair and the reduction and fixation of the fractures, certainly this should not be longer than a week. The patient is given prophylactic treatment for tetanus, and antibiotics. Anti-inflammatory enzymes are administered as indicated. It may be necessary to consult a neurosurgeon, ophthalmologist, and/or dentist.

The fractured bones should be stabilized with a Barton bandage in order to prevent further mobilization, and to reduce the pain and shock as well.

A tracheotomy is performed if there is any indication of impending airway obstruction.

The desired objectives of the treatment of facial fractures are based on the prevention of the following:

1. Abnormalities in the position of the eye and ocular motility.
2. Facial disfigurement.
3. Sensory and motor nerve dysfunction.
4. Dental malocclusion.
5. Nasal obstruction.
6. Interference with sinus drainage.

The examination should include a search for the following signs and symptoms:

2. Ecchymosis: subconjunctival, circumorbital, and intra-oral.
3. Epistaxis: anterior and posterior.
4. Deformities: obvious and by palpation.
5. Eyes: ocular motility, diplopia, displacement, and pupillary function.
6. Sensory nerve function: infraorbital nerve and distribution of other branches of the second division of the fifth cranial nerve.
7. Malocclusion.
8. Trismus.
11. Tenderness and pain.
12. Evidence of infection: in the wound; sinus infection (a suppurating hematoma of the antrum).

**Nasal Fractures**

An accurate history of previous injuries or operations, as well as of the injuring force, is important. X rays are taken and should include the Waters' projection, lateral view, and a projection of the nasal bones from above, obtained by placing a dental x-ray film in the mouth, just under the hard palate.

**Simple Nasal Fracture**

**Anesthesia.** Local anesthesia can be used for the reduction of most simple nasal fractures. A local anesthetic agent should be placed at three sites. (1) Injection at the root of the nose will block distribution to the nose from the orbital nerves. (2) Injection in the upper lip, just inferiorly to the columella, and laterally on each side from this point, will block infraorbital nerves. (3) The sphenopalatine ganglion may be blocked by placing cotton pledgets, saturated with 4% cocaine or a like topical anesthetic agent, in the superior, middle, and inferior meatus of each nasal cavity. These pledgets should be left in placed for approximately 5 minutes and then be replaced by additional cocaine-impregnated cotton pledgets. Some prefer to block the sphenopalatine ganglion on each side by way of the greater palatine foramen.

**Technique of Reduction.** The instruments used for reduction of a nasal fracture are a straight round-end elevator, Ashe forceps, and Walsham forceps. Simple depressed fractures of the nasal bones can usually be elevated into place with a straight elevator, with the operator using the index finger of his left hand, if he is right-handed, or that of the right hand (if he is left-handed) for palpation.

Fractures of the nasal bones, in which difficulty is encountered in manipulating the fragments in place, may be reduced by placing one blade of either the Ashe or Walsham forceps inside the nose on the under surface of the nasal bone, while the other blade remains external on the outer surface of the nasal bone. Manipulation, tested by digital palpation, will result in proper placement of the fractured segment.

If there is deviation of the entire nasal structure to one side and buckling of the nasal septum, one blade of the Ashe forceps is inserted into each nasal cavity. The first manipulation with the forceps in this position is in an antero-superior direction, while the external nose is palpated and manipulated with the operator's fingers. The nasal pyramid is then returned to its midline position, and any buckling of the nasal septum is corrected.

Simple nasal fractures do not require intranasal packing. If, on the other hand, the nasal bones are severely comminuted and unstable, careful nasal packing, with either aureomycin ointment-impregnated iodoform gauze or finger-cot packing, will support the
fragments until they are fixed in place. Occasionally it is necessary to also use external splinting such as that employed following a rhinoplasty.

Certain nasal fractures, especially those associated with dislocation or buckling of the nasal septum, cannot be reduced by the closed techniques. Treatment should consist of open reduction and one of the various rhinoplasty techniques.

**Compound Nasal Fractures**

Many nasal fractures are compounded by either external or internal lacerations. The external wounds should be carefully debrided and the nasal fractures reduced, as has been described. Internal and external splinting is required quite frequently.

**Nasomaxillary Fractures**

A severe blow to the anterior aspect of the nose may result in a deformity often referred to as "the smashed nose." When severely depressed, many of these fractures cannot be dealt with by closed reduction, internal packing, and external splinting. These fractures often involve the ascending process of the maxilla, the nasal bones, the ethmoid bone, and the nasal process of the frontal bone. A fracture of the roof of the ethmoid sinuses or cribriform plate can be associated with "the smashed nose" and a resultant cerebrospinal fluid rhinorrhea. The nasolacrimal apparatus may also be injured.

An excellent way of treating these fractures is by the use of two pieces of 24-gauge, stainless-steel wire and lead plating. The nasal bones are elevated and held in position by an assistant while the stainless-steel wire is passed through the skin, a fracture line, the nasal septum, and out by way of a fracture line on the opposite side. By using a heavy straight needle, an attempt is made to place these sutures at approximately the junction of the nasal bone and the ascending process of the maxilla, one of them just below the nasal process of the frontal bone and the second approaching the inferior aspect of the nasal bones. The wire sutures are placed through lead and silicone sheetings which have been fashioned to the size and contour designated by the problem at hand. Intranasal packing may also be necessary for support. Since contamination is likely in this location, it is very important to use aureomycin-impregnated, 1-inch iodoform gauze for the intranasal packing. This packing can be removed at the end of 5 days; the external splints should remain in place approximately 10 days.

**Fracture of the Zygomatic Bone (Zygoma or Malar Bone)**

The zygomatic bone articulates with the temporal bone, frontal bone, the greater wing of the sphenoid bone, and the maxillary bone. Essentially, it forms the prominence of the cheek. It also forms a portion of the lateral and inferior rim of the orbit, the lateral wall of the orbit, and the zygomatic arch.
Signs and Symptoms

The signs and symptoms of fracture of the zygomatic bone are:

1. Flattening of the upper cheek.
2. Diplopia.
3. Limited ocular mobility.
4. Paralysis in the distribution of the infraorbital nerve.
5. Subcutaneous emphysema.
6. Epistaxis (bleeding from the antrum).
7. Trismus.

Diagnosis

Flatness of the face may be quite obvious. On the other hand, if edema and hematoma are present, flattening may be temporarily masked. The infraorbital rim is carefully palpated. The "stepping-off" deformity or notching of the infraorbital rim is characteristic of this fracture. Sensation is tested over the nose, cheek, and upper lip and compared with that in the uninjured side. Since the thinnest bone is in the region of the infraorbital foramen, the infraorbital nerve is quite often involved. The zygomatic arch is carefully palpated. This may be depressed. Pain or limited motion of the mandible is indicative of a depression of the zygomatic bone on the underlying coronoid process. Escape of air into the soft tissues may produce periorbital emphysema or proptosis. The crepitation is characteristic of zygomatic bone fracture.

The patient is tested for diplopia and extraocular motility. Diplopia is present in approximately 10% of the subjects. It is probably due to displacement of the lateral palpebral ligament. This ligament is not necessarily detached, but rather is carried away from its normal position by the displaced zygoma.

Transillumination of the sinuses will usually demonstrate limited or no transillumination of the antrum on the involved side. Lack of transillumination is due to edema of the mucosal lining of the sinus and the presence of blood. X rays will also demonstrate filling of the maxillary sinus and possibly air in the orbit or in the surrounding tissues. They will show the position of the fragments and displacement of the parts, but must not be relied on entirely for exact positioning or diagnosis.

Treatment

In a small group of these fractures there is no significant displacement and no therapy is required. Most fractures of the zygomatic bone are the result of a direct blow over the malar prominence which produces posterior and medial displacement of the bone. Other zygomatic fractures have accompanying lateral or medial rotation. With a lateral rotation, the inferior orbital rim is displaced downward; with medial rotation, the inferior orbital rim is displaced upward.

If, when the patient is first seen, severe edema and ecchymosis are present, it probably does no harm to wait until these have subsided, when reduction will be more easily
accomplished. As a rule, it is not possible to reduce fractures later than 3 weeks following their occurrence.

**Indirect Reduction** (Keen Method). In this method, reduction is accomplished by way of the gingivo-buccal sulcus. A small incision is made in the buccal mucosa behind the maxillary tuberosity. A curved elevator is inserted behind the tuberosity of the maxilla and the necessary force is applied to manipulate the displaced malar bone into its proper position. The manipulation can be guided externally by the operator's hand that is not holding the elevator. Often reduction of the fracture is effected easily and effectively by this method. Some surgeons object to this procedure because of the possibility of contaminating the field of the fracture. A cowcatcher splint, made of throat sticks, is all the dressing necessary.

**Temporal Route** (Gillies Method). Strong and effective force can be implemented through this approach. An incision is made at or above the hairline over the temporal fascia. The elevator must be passed through the temporalis fascia, but not through the temporalis muscle. The temporalis muscle proceeds inferior to, and attaches itself to, the coronoid process of the mandible. The elevator will be improperly directed if it is positioned either external to the fascia or deep to the temporalis muscle. The operator's hand not used for directing the instrument can be used for assisting with the manipulation.

**Intranasal Technique** (Shea Method). A nasoantral window is made in the inferior meatus in the usual fashion. A large, curved trocar is inserted into the antrum. With this leverage and with external palpation, the fractured bone can be manipulated into place.

**Transantral Route** (Lothrop Method). A Caldwell-Luc incision is made. A heavy, curved elevator is introduced into the antrostomy opening in the canine fossa. If the fragment(s) is not stable, the maxillary sinus can be packed with aureomycin-impregnated, 1-inch, iodoform-gauze stripping. The end of the packing is introduced into the nasal cavity through the nasoantral window. The packing is very effective in stabilizing the fractured bone, thus making this route more practical than the transnasal approach. A layer of Gelfoam above the packing will ensure against a sharp bony fragment becoming attacked to the packing.

**Open Reduction.** All displaced fractures in which it is either impossible to manipulate the fragments into position or the fragments are unstable after reduction must be treated by open reduction and internal wire fixation. The most practical places for intraosseous wiring are in the region of the zygomaticofrontal suture line, the infraorbital rim, and the medial aspect of the zygomatic arch. These areas are approached by incisions in the skin lines superior to the outer canthus, below the infraorbital rim, and over the zygomatic arch. Holes are drilled with a small bur after the fracture has been reduced and stabilized. Instruments such as the Kocher forceps, the Lahy thyroid clamp, and towel clips are useful for this manipulation. Usually, 26-gauge wire is suitable for fixing the fragments. The wire is tightened by twisting. After cutting the wire, it is important to bend the end flush with the surface of the surrounding bone.

If all methods of reducing an old fracture are unsuccessful, the malar deformity and floor of the orbit are repaired by using autogenous bone grafts. The bone can be obtained from the iliac crest; on occasion, however, the nasoseptal cartilage and bone or the anterior wall of the antrum will provide sufficient material for the graft.
**Kirschner Wire Technique.** Kirschner wires, which come in three diameters (0.62, 0.45 and 0.35 inch), can be drilled into bone without making a dermal incision. The wire must not extend more than 2 inches beyond the chuck of the drill in order to prevent bending and misdirection. An unstable zygoma, after simple reduction by the above-described methods, can be fixed by drilling a Kirschner wire through its body, across the nose, and into the opposite malar bone, while the fragment is held in the proper position. The wire is then cut off 0.5 inch from its entrance point and is covered with sterile cork.

### Fractures of the Zygomatic Arch

The diagnosis of a mandibular arch fracture is usually not difficult, for there is pain in this region which is aggravated by talking and chewing. Trismus may be present. Motion of the mandible may be limited. The symptoms are caused by the contact of the medially displaced zygomatic arch with the coronoid process and the temporalis muscles. The depressed fracture of the zygomatic arch can be seen as a depression in this area and is easily palpated.

#### Method of Reduction

A fracture of the zygomatic arch, without displacement of a fragment, can be treated by elevation with a heavy bone hook. A small incision is made over the center of the arch at the point of maximum depression. The hook is inserted beneath the arch from below, and the fracture is reduced by lateral traction.

The Gillies technique may be used to reduce a fracture of the zygomatic arch, especially when it is combined with a malar fracture.

Open reduction wiring of a zygomatic arch fracture is frequently necessary. This open reduction is accomplished through a horizontal incision over the zygomatic arch. The fragment ends are drilled and wired with #26-gauge stainless-steel wire.

### Midfacial (Maxillary) Fractures

Midfacial fractures should be treated as early as possible in order to restore normal function and acquire a good cosmesis. The objectives of therapy are to obtain normal dental occlusion and facial contour and to prevent infection.

During the immediate post-injury period, attention should be directed toward maintenance of an adequate airway and the control of infection. If the airway is impaired by pharyngeal edema or displaced by bony support, a tracheotomy should be performed. Severe hemorrhage from the internal maxillary artery or one of its terminal branches is not uncommon in association with a midfacial fracture. This hemorrhage is controlled by local packing. If this is not successful, ligation of the internal maxillary artery or external carotid artery should be considered.

If the patient is seen shortly after the accident, the reduction of the midfacial fracture is usually not difficult unless the bone is severely comminuted or infection is present. On occasion, reduction of a fracture is delayed either because of the patient's neglect or because
of an associated or severe injury, such as a cervical spine fracture or trauma to the intracranial structures. In these instances, granulation tissue and fibrosis interferes with reduction. It may be necessary to expose the fracture line and separate the malfixation with an osteotome. There are a number of methods to accomplish fixation of midfacial fractures:

1. Intramaxillary fixation with a Barton bandage, when the midfacial fracture is both stable and not displaced.
2. Intermaxillary fixation, using arch bars or wiring artificial dentures in place.
3. Open reduction and wiring of fracture segments.
4. Wire slings from the zygoma, inferior orbital rims to the teeth, or arch bars.
5. Internal pin fixation.

Classification of Midfacial Fractures

The Le Fort I is a lower midfacial fracture. It may be unilateral or bilateral. The fracture line is transverse through the lower maxilla and into the lower nasal cavity. The resulting segment of the maxilla includes the teeth, a portion of the maxillary sinus, the hard palate, and, on occasion, the lower segment of the pterygoid plates. There may be an associated vertical fracture, usually in the midline, dividing the lower midface into two segments.

The Le Fort II fracture line passes through the nasal bone, lacrimal bone, floor of the orbit, inferior orbital rim, and across the upper portion of the maxillary sinus and pterygoid plates to the pterygomaxillary fossa. Fractures of the cribriform plate and roof of the ethmoid sinuses, with spinal fluid rhinorrhea and damage to the lacrimal system, may occur with this fracture.

The Le Fort III is a complete separation of the facial bones from their cranial attachments. The fracture line extends across the suture line between the nasal bones and the nasal process of the frontal bone, along the ethmoid junctions with the frontal bone, and across the supraorbital fissure, the lateral wall of the orbit, and the frontomaxillary and zygomaticomaxillary suture lines. The Le Fort III fracture is usually associated with multiple fractures producing the "dish-face" deformity. It is commonly associated with intracranial complications such as spinal fluid leaks by way of the roof of the ethmoid sinuses and cribriform plate.

Specific Treatment

Le Fort I. Stable fractures of the lower midface which are not displaced can be treated by using a snug Barton-type dressing. This treatment is effective even when the patient is toothless and wears dentures. When the patient has dentures the maxillary denture is applied and adjusted so that it is in occlusion with either the lower teeth or the lower denture. Intermaxillary fixation is carried out for 2 days, by using a Barton-type bandage or a head cap.
with a chin support. The patient is placed on a liquid diet for 2 weeks. At the end of this period the fracture is usually well healed.

When occlusion is perfect and the fracture segment does not move with palpation, the Barton-type bandage may be omitted. The patient, however, should be placed on a liquid diet for a period of 2 weeks.

Intermaxillary fixation must be applied when dental occlusion is not perfect.

Loose teeth should be considered. Most often a loose tooth, unless very unstable, will become fixed in place without treatment. If a tooth is very loose, it is wired to adjacent teeth with a #26-gauge stainless-steel wire. A dental arch bar is applied and wired in place to stabilize a number of loose teeth when there are fractured segments of alveolus. In the latter instance it is necessary also to apply a mandibular arch bar and rubber bands for intermaxillary fixation to ensure proper dental occlusion.

On occasion there is loss of a portion of the maxillary alveolus with exposure of the maxillary sinus. This must be treated as an oroantral fistula. A packing in the maxillary sinus with its ends protruding into the nasal cavity through an oroantral window is essential in these cases.

A fractured alveolar segment in an edentulous patient may be handled in one of the following ways:

1. A good reduction and positioning of the segment may be accomplished by inserting the dentures and securing immobilization with a Barton bandage.

2. The fracture line is exposed and the segment is fixed in place by direct wiring.

3. The alveolar segment may be fixed by inserting a Kirschner wire after proper repositioning of the fractured segment.

**Vertical Fractures with Le Fort I.** In a vertical fracture associated with a lower midfacial fracture, if there is no displacement, no specific therapy is necessary. When the vertical fracture line is either separated or displaced and the patient has upper teeth, one side of the arch bar is applied and wired and place, and the vertical fracture is reduced. The opposite side of the arch bar is then wired in place. If the teeth are widely separated in the anterior midline, they should be wired together before the dental arch bars are applied. The application of a mandibular arch bar and intermaxillary fixation are necessary to ensure good dental occlusion.

Direct exposure of the fracture line in the wiring of the fragments is the treatment of choice when confronted with a vertical fracture in which there is separation of the segments and the patient's upper jaw is edentulous. A Kirschner wire may be used to pin a unilateral segment, consisting of a Le Fort I and a vertical segment, to the stable opposite side. If there are bilateral segments, each may be pinned to the opposite zygoma. An unstable fragment in a bilateral Le Fort I fracture, with or without a downwardly displaced vertical fragment, may require a combination of the application of dental arch bars and wire sling support from the
infraorbital rim or the zygomaticofrontal suture line, or both. A small skin incision is made over the zygomaticofrontal suture line or infraorbital rim and a long segment of #25-gauge stainless-steel wire is inserted through a drill hole. Both of the ends of this wire are inserted into a #16 or #18 spinal needle. The needle is passed from the infraorbital rim down along the front face of the maxillary sinus to the alveolar ridge. The ends of the wire are grasped from below and the needle removed. One end of the wire is placed behind, and the other in front of, the arch bar. The fracture is reduced and the ends of the wires twisted. For posterior support the needle containing the two ends of the wire is passed medial to the zygomatic arch and along the lateral surface of the maxilla to the alveolar ridge. Again the ends of the wire are grasped from below and the needle is removed. Following the fracture reduction the ends of the wire are secured to the posterior aspect of the dental arch bar.

**Le Fort II Fracture.** In the Le Fort II fracture, undisplaced and stable fragments are treated conservatively as has been described for Le Fort I fractures. A superiorly displaced segment is rocked loose and pulled inferiorly. Downward traction and restoration of normal dental occlusion can be accomplished by intermaxillary fixation with arch bars and rubber bands. In a unilateral Le Fort II fracture, stabilization can be secured with a Kirschner pin directed through the stable fragment and into the stable opposite side.

A Le Fort II fracture in which the segments are displaced downward is much less stable and difficult to manage. It is approached by direct wiring and the application of dental arch bars and wire slings from the inferior orbital rim or zygomaticofrontal suture line.

**Le Fort III Fracture.** It is difficult to outline specific methods for reduction and fixation of the Le Fort type III fracture, for there are usually multiple fracture lines and other associated facial fractures. Whenever possible the fracture lines are approximated superiorly and the fragments are wired in place. The pinning technique is not usually feasible. The application of a wire sling from the zygomaticofrontal region to a maxillary arch bar is often necessary in addition to intermaxillary fixation.

**Fractures of the Orbit**

During this past decade the incidence of orbital fractures has increased along with automobile accidents. The advent of the seat belt may have had much to do with the increase in the numbers of orbital fractures, for, as an automobile suddenly decelerates during a crash, the head of the driver is thrust forward, and the face strikes either the steering wheel or the dashboard. Such an accident is the cause of approximately 50% of orbital fractures. The human fist accounts for about 20%, while a ball, a human elbow, or a fall on the face account for approximately 25% each. The remaining 5% are due to various unusual accidents.

**Anatomy**

In order to understand the mechanism of the orbital fracture, certain anatomic relationships must be reviewed. The lateral wall of the orbit is formed by the frontal process of the zygomatic bone and the greater wing of the sphenoid bone. This wall is rather thick and quite sturdy. The orbital process of the frontal bone forms the orbit's superior wall. This also offers good support. The anterior wall is formed by the lamina papyracea and the lacrimal bone. The lamina papyracea, as its name implies, is quite thin, but is fairly well
supported by the ethmoid cell partition. The floor of the orbit is formed by the orbital process of the maxillary and zygomatic bones and extends backwards and upward on an inclined plane. A very thin area of bone is located immediately anterior to the inferior orbital fissure. The orbital floor is further weakened by the canal through which the infraorbital nerve passes. The orbit is conical in shape. A blow to the orbit will displace its contents posteriorly, resulting in the blow-out type of fracture. This usually occurs in the thin area that is just anterior to the inferior orbital fissure. Orbital fracture may, of course, occur in other areas, the second most common being the medial aspect of the floor of the orbit in the region of the infraorbital canal or of the lamina papyracea.

**Signs and Symptoms of Orbital Fracture**

**Enophthalmos.** Fractures of the orbit may result in varying degrees of enophthalmos, which, when in excess of 5 mm, is disfiguring. It may not be apparent immediately after the injury because of edema or hemorrhage. As would be suspected from our knowledge of the anatomy of the orbit, there are a number of mechanisms or combinations thereof responsible for enophthalmos:

1. There may be an escape of orbital fat into the maxillary sinus along with the fracture of the floor of the orbit. This may occur with the comminuted fracture or the hinged, or so-called "trapdoor", fracture. In some instances the maxillary sinus has been found to be filled with this orbital fat.

2. The inferior rectus or inferior oblique muscles may herniate into the antrum and be entrapped by bony fragments in a blow-out fracture.

3. Atrophy of the orbital fat may occur subsequent to injury or infection.

4. Enophthalmos may also occur as a result of fracture and downward displacement of a major portion of the orbital floor, including the inferior orbital rim. This situation is usually associated with more complex fractures of the malar and zygomatic bones.

**Exophthalmos.** Occasionally, the orbital floor is fractured and displaced upward, causing exophthalmos. In such fractures the inferior orbital rim is usually involved. The force causing this type of fracture has been applied over the anterior wall of the maxillary sinus, just inferior to the inferior orbital rim.

**Diplopia.** Disturbance in eye muscle function is a relatively common finding in patients with fracture of the floor of the orbit, because the most common site of the blow-out type of fracture is in that portion of the floor which is weakened by the infraorbital canal or groove. The inferior oblique muscle arises from the orbital floor near the lateral margins of the lacrimal groove, and the inferior rectus muscle is located, in direct relation with the infraorbital canal, on the inferior aspect of the orbital contents.

The inferior oblique and inferior rectus muscles are those involved with disturbances in oculomotor function associated with fractures of the floor of the orbit. The site of the fracture and entrapment of these muscles has much to do with the clinical picture. If the muscle is entrapped anterior to the equator of the globe, the involved eye will be fixed in a
downward position. The oculomotor imbalance will not be greatly marked with downward gaze but much exaggerated with upward gaze. If the muscle is entrapped posterior to the equator of the globe, the involve eye will be fixed in the elevated position. In these instances, the oculomotor imbalance will not be marked with upper gaze and exaggerated with downward gaze. If the inferior rectus muscle is entrapped at the level of the equator of the globe, the involved eye will appear normal in the primary position but will remain fixed when downward or upward gaze is attempted. In fractures of the floor of the orbit lateral to the infraorbital canal, oculomotor function is rarely affected.

The branch of the third cranial nerve supplying the inferior rectus muscle courses along the lateral border of this muscle and enters the inferior oblique muscle at approximately the point where the two muscles cross. Injury to these branches of the third cranial nerve, especially the inferior oblique branch, can be associated with fractures of the floor of the orbit and the manifestations of such injury must be differentiated from those due to muscle entrapment.

Transient diplopia may be associated with fracture and dislocation of the zygoma. This is most commonly seen when the bone has been displaced as a single fragment. It is caused by hemorrhage and edema which produce superior displacement of the orbit.

**Facial Asymmetry.** Facial asymmetry is not the usual finding in patients with blow-out fractures of the orbital floor. It is typical, however, when the fracture involves the inferior orbital rim or in fracture-dislocation of the zygoma.

**Sensory Nerve Injury.** Hypoesthesia or anesthesia of the areas supplied by the infraorbital nerve may be associated with fracture of the floor of the orbit. Either manifestation is positive indication that the fracture involves the infraorbital canal or groove. Disturbance in the function of the infraorbital nerve associated with an intact orbital rim is indicative of an orbital floor fracture involving the infraorbital groove or canal. Anesthesia of the infraorbital nerve is positive indication for exploration and decompression.

**Ocular Complications.** There are a number of ocular complications which can occur in association with orbital fracture:

1. Subconjunctival hemorrhage and ecchymosis of the lids are the usual findings following blunt trauma to the orbit. They are transient and only rarely complicated by cicatricial entropion.

2. Corneal abrasion may occur, but is not common because the lids are usually closed at the time of injury.

3. Injury to the pupil and iris may produce mydriasis or iridodialysis.

4. The lens may be dislocated anteriorly or posteriorly; this can be complicated by iridocyclitis, secondary glaucoma, or corneal edema.
5. Hyphema (hemorrhage into the anterior chamber of the eye) is not uncommon in this type of injury. It usually clears in a few days but may be complicated by secondary glaucoma, pigmentation of the cornea, or heterochromia of the iris.

6. Glaucoma may well be the most common ocular complication following orbital injury producing a fracture. The increase in intraocular pressure may not occur for weeks or even years after the injury.

7. Injury to the retina may be associated with fracture of the floor of the orbit. Edema of the retina is common and usually transient.

**Diagnosis**

Diagnosis of a fracture of the floor of the orbit with a resultant disturbance in eye muscle function, facial asymmetry, enophthalmos, infraorbital nerve injury, or other complication is not difficult. On the other hand, this fracture can be overlooked when it is associated with devastating bodily injuries which require immediate lifesaving measures. Also, the symptoms can be masked by edema, hemorrhage, ecchymosis, and hematoma. On occasion, the defect may not become apparent for a number of weeks after the initial injury.

Certainly a patient with a history of injury to the orbit, a unilateral enophthalmos, disturbance of eye muscle function, and anesthesia or hypoesthesia of the infraorbital nerve associated with an intact orbital rim should be considered to have a blow-out fracture of the orbit. A break in the continuity of the orbital rim makes the diagnosis quite obvious.

Entrapment of the inferior oblique or inferior rectus muscle is diagnosed by testing the patient's gaze in the vertical plane. The diagnosis is confirmed by the traction test, which is carried out as follows: The conjunctiva is anesthetized with a drop of topical anesthetic solution. The tendon of the inferior rectus muscle is grasped through the sclera with a tooth forceps. Entrapment of the muscle is demonstrated by a restriction of ocular excursion.

X rays are of extreme value in diagnosing fractures of the floor of the orbit. The Waters view gives a good picture of the contour of the floor of the orbit and rim in relation to the maxillary sinus. The Caldwell view also demonstrates the floor of the orbit. The typical picture is that of depression of the floor of the orbit with prolapse of orbital contents into the antrum. A maxillary sinus filled with blood may mask these findings. There may also be a fracture in the lamina papyracea or the ethmoid bone, subcutaneous emphysema, or demonstration of air in the orbit. Antero-posterior laminograms of the orbit are quite useful in diagnosing fractures of the floor of the orbit.

**Treatment**

Indications for surgical treatment for fracture of the floor of the orbit are (1) the presence of enophthalmos; (2) a disturbance in the eye muscle function manifested by diplopia; (3) facial deformity; and/or (4) a persistent anesthesia in the distribution of the infraorbital nerve.
Operation is performed with the patient under general anesthesia. The patient's entire face is prepared so that the surgeon may have access to the floor of the orbit by way of the antrum as well as through an infraorbital incision. The side of the face to be operated upon is draped but the other side is left exposed so that it can be used for comparison.

The degree of enophthalmos is determined by comparison with the unaffected orbit. The oculomotor muscle function is tested with toothed forceps for forced duction of the eye muscles. The freedom of motion of each muscle is tested and compared with the motion of the opposite normal side.

Fracture of the floor of the orbit, especially when the patient is treated within two or three weeks following the accident, can quite often be satisfactorily reduced by way of the maxillary sinus. The anterior wall of the maxillary sinus is exposed by using the Caldwell-Luc incision. The peristomeum is elevated from the entire front face of the maxillary sinus, so that the infraorbital nerve and foramen may be examined. The size and contour of the maxillary sinus are determined by viewing the x-ray film. The anterior wall is carefully removed with a small cutting bur. It can be used as a bone graft to the floor of the orbit. Sufficient exposure is necessary for viewing the floor of the orbit from below and also for the insertion of a finger for palpation of the fracture.

Prior to reduction of the floor of the orbit with a finger in the maxillary sinus, it is useful to reduce the enophthalmos from above by using traction sutures of #4-0 silk passed around the tendons of the superior and inferior oblique muscles. This accomplishes two things: (1) it will usually free an entrapped muscle, and (2) it provides additional space for replacement of the orbital contents and elevation of the floor of the orbit. In most instances, when the orbital contents are replaced and the fracture reduced, the orbital contents and the floor of the orbit remain in place. Whether or not the orbital floor remains in good position, the antrum should be packed. This is a requisite especially when the fracture is associated with discontinuity of the orbital rim or a depressed fracture of the malar bone. A layer of Gelfoam is placed against the roof of the antrum so that the packing will not become adhered to or involved with a spicule of bone. The entire antrum is then packed with aureomycin-impregnated conforming gauze, the end of which projects into the nasal cavity through a nasoantral window. The Caldwell-Luc incision is sutured in the usual fashion.

The infraorbital approach to the floor of the orbit is used in those cases in which reduction is not readily attained by the inferior approach. The incision for this approach is made in the natural skin fold of the lower lid, approximately 3 mm below the margin of the tarsal plate. It is extended obliquely downward in its lateral portion. The skin is elevated from the orbicularis oculi muscle for a distance of approximately 3 mm below the incision. At this point the orbicularis oculi muscle is split longitudinally. The orbital septum is followed downward to the point where it is inserted into the inferior orbital rim. The peristomeum is incised along the rim and elevated from the floor of the orbit. The floor of the orbit can be exposed by gradually inserting an orbital retractor; while this is being done a finger in the antrum often facilitates the maneuver and aids in reducing the herniated orbital contents and replacing the bony fragments. Traction on the sutures around the insertions of the inferior and superior rectus muscles is also helpful at this time. There are a number of grafts and substances which can be utilized to support the orbit when there is a badly comminuted fracture of the orbital floor. These include iliac bone grafts, the anterior wall of the antrum,
the nasal septum, fascia lata, and silicone rubber sheeting. As with any similar procedure, use of autogenous material offers the best chance for success and for avoiding complications. The iliac bone graft is taken from the inner aspect of the ilium. The cortical surface of the bone should face upward.

If an additional space-occupying substance is needed, especially in an old fracture with marked increase in the over-all size of the orbit, fascia lata may be placed superior to the bone graft in order to further support the orbital contents and eliminate the enophthalmos.

**Anesthesia of the Infraorbital Nerve.** If there is complete anesthesia of the infraorbital nerve distribution, and the fracture is found to involve the infraorbital canal and foramen, a decompression procedure is in order. This is carried out by way of the infraorbital incision. A block of bone which includes the superior rim of the infraorbital canal is removed. The nerve is carefully dissected and decompressed and the block of bone replaced.

### Fractures of the Mandible

Fractures of the mandible are the most common type of facial fracture. This is to be expected, taking into consideration the position of the jaw in relation to the remainder of the skull. Management of these fractures is most important not only for cosmesis, but also for dental occlusion and mastication.

**Anatomy**

In order to evaluate and treat a fracture of the mandible properly, knowledge of the anatomy of the mandible and its surrounding structures is essential. Familiarity with the origin, insertion, and direction of pull of the various muscles of the mandible makes evaluation of any particular fracture with reference to its displacement and determination of the best method for reduction and immobilization relatively simple.

**Muscles of the Mandible.** There are three groups of muscles which provide the variety and versatility of mandibular function. These are the elevators, the depressors, and the protrusors.

**Elevators of the Mandible.** The *masseter* muscle extends from the zygomatic arch to the lateral surface of the mandible. Its insertion covers most of the lateral surface of the coronoid process, ramus, and angle of the mandible. The masseter muscle elevates the mandible.

The *temporal* muscle arises in the temporal fossa, descends medial to the zygomatic arch, and inserts on the medial surface on the coronoid process. It both elevates and retracts the mandible.

The *medial pterygoid* muscle arises from the pterygoid fossa and the pyramidal process of the palatal bone and is inserted on the medial and inferior surface of the ramus at the angle below the mylohyoid groove. It elevates the mandible by exerting a force in an upward, forward, and inward direction.
Depressors of the Mandible. The geniohyoid muscles originate from the body of the hyoid and insert on each side of the midline into the postero-inferior aspect of the mandible. They pull the anterior mandible inferiorly.

The tendon joining the anterior and posterior bellies of the digastric muscle is attached, but not fixed, to the hyoid bone by a pulley made of deep cervical fascia. The anterior belly inserts into the digastric fossa on the inner surface of the mandible. The digastric muscle depresses and pulls back the anterior mandible.

Protrusors of the Mandible. The lateral pterygoid muscle originates with two heads, one from the lateral pterygoid process, and the other from the greater wing of the sphenoid bone. It inserts into the anterior surface of the neck of the mandible. It pulls the head on the mandible forward medially. The lower fibers exert a downward pull on the head of the mandible.

The mylohyoid muscle extends from the mylohyoid line in the median raphe. It does not influence mandibular function other than when there is a fracture of the symphysis or anterior body regions. Under these circumstances, it either brings the fragments together or causes overriding of the fracture.

Diagnosis of Mandibular Fracture

The diagnosis of fracture of the mandible is not difficult to make when there is a history of injury to the jaw and the following signs and symptoms are present:

1. Swelling, ecchymosis, or laceration of the skin overlying the mandible or the intraoral mucous membranes.

2. Pain. Following fracture of the mandible, pain due to injury of the inferior alveolar nerve, mandibular periosteum, and soft tissue can be quite severe. Pain also may be the result of entrapment of the muscles between fragments and/or muscle spasms.

3. Anesthesia. There may be anesthesia of one side of the lower lip, alveolar ridge, and teeth when the inferior alveolar nerve is injured or sectioned. This is indicative of a fracture of the body of the mandible.

4. Tenderness elicited by either external or intraoral palpation.

5. Malocclusion. Any dislocation associated with fracture of the mandible will produce at least a degree of malocclusion which is noted by the patient. The patient will not only complain that his teeth do not meet properly, but also will be able to indicate the site of dislocation. The patient with dentures will complain that he is unable to insert them and that attempts to do so are painful.

6. Mobility and crepitation. Manipulation of the mandible will elicit mobility at the site of the fracture. This mobility often produces crepitation. In the edentulous patient, on intraoral palpation a ridge may be detected at the site of the fracture.
7. Malfunction. Complaints of abnormal and painful chewing are not uncommon. There may also be some interference with speech.

8. Impairment of the airways. Severe fracture of the mandible with displacement, hematoma, ecchymosis, and edema of the soft tissues renders the patient unable to cope with his salivary secretions and bleeding. There can be a complete obstruction of the airways necessitating an emergency tracheotomy.

**Classification of Mandibular Fractures**

The Dingman classification is both practical and simple. The mandible is divided into seven regions: body, symphysis, angle, ramus, coronoid process, condylar process, and alveolar process. The management of fractures of each of these areas will be discussed separately.

**Dingman classification of mandibular fractures:**

1. The region of the *body* is that portion of the mandible between a vertical line drawn between the canine and first premolar teeth, extending to the anterior border of the attachment of the masseter muscle (20% of mandibular fractures).

2. The *symphysis* area is that portion of the mandible between the symphysis and mentum and a vertical line drawn beneath the canine and first premolar teeth (15% of mandibular fractures).

3. The region of the *angle* is defined as that portion of the mandible lying underneath the attachment of the masseter (20% of mandibular fractures).

4. The *ramus* of the mandible is that portion below the coronoid process, above the posterior border of the insertion of the masseter muscle (3% of mandibular fractures).

5. The *coronoid process* is that portion above a line which extends downward and forward from the inferior aspect of the sigmoid notch (2% of mandibular fractures).

6. The *condylar process* is that portion of the mandible superior to, and separated from, the ramus by a line drawn posteriorly and slightly inferiorly from the inferior aspect of the sigmoid notch (35% of mandibular fractures).

7. Fractures of the *alveolar process* involve the teeth and the alveolar process immediately inferior (5% of mandibular fractures).

**General Treatment of Mandibular Fractures**

For the proper management of the mandibular fracture, certain factors and principles must be observed. Usually the patient can describe the severity, direction, and force of the blow that caused the fracture. This information is of value in determining the site and severity of the bone injury.
Whether or not there is displacement of the fractured bone must be determined. The site of the fracture can be ascertained roughly by palpation and manipulation, but more accurately by x rays.

The direction of the fracture line is often important. For example, in a fracture in the region of the body extending downward and forward from the molar region the segments are relatively stable and are not likely to be displaced because of muscular action. In a fracture in the same region extending downward posteriorly from the molar region the segments are unstable and are quite apt to be displaced.

The bevel of a fracture is also important. If the edges of the bone in a fracture of the body are beveled in an anteromedial direction, the posterior segment will be displaced medially. If they are beveled in the opposite direction the mandible will be rendered stable by the muscle pull.

In general, with a knowledge of the origins and insertions of the muscles and ligaments attached to the mandible, along with knowledge of the location and direction of the fracture, the surgeon should be able to predict quite accurately the degree and direction of displacement.

Multiple fractures of the mandible are quite common. Each fracture should be considered separately.

It is important to determine whether or not a tooth is involved in the fracture line. As a rule, the presence of teeth render the fracture segments more stable that they would be in the edentulous mouth. On occasion a tooth may become displaced and interposed between the fracture segments, making reduction difficult and necessitating the tooth's extraction.

If the patient is edentulous or partially so, it is important to learn whether or not he has a denture. If the denture has been broken at the time of injury, it should be repaired immediately so that it can be used for both splinting and immobilization of the mandible.

Mandibular fractures do not necessarily require immediate reduction. It is often wise to wait several days so that other injuries may be evaluated, x-ray studies may be made, as indicated, and measures may be instituted for reduction of the swelling and prevention of infection.

Since a fracture of the mandible must be considered to be compounded, broad-spectrum antibiotic therapy is instituted along with oral hygiene. Elevation of the patient's head, placing him in the semi-sitting position, and the application of cold compresses should assist in the reduction of swelling. Immobilization, with a Barton bandage, will stabilize the fragments temporarily, prevent further displacement and bleeding, and also help to control muscle spasms and pain. X rays should include the antero-posterior views, right and left lateral views, and intraoral occlusal views.
Fractures of the Body of the Mandible (20%)

The body of the mandible is that portion delineated by a vertical line, drawn posteriorly between the canine and first premolar teeth and the anterior border of the attachment of the masseter muscle.

Treatment. In fractures of the body of the mandible the segments are either stable or unstable. In a fracture extending downward and forward from the molar region the segments are relatively stable, and, because of muscle action they are unlikely to be displaced. In a fracture of the body extending downward and posteriorly from the molar region the segments are likely to be unstable and displaced. Most fractures through the body of the mandible occur in patients with teeth and can be managed by closed reduction and intermaxillary fixation with arch bars and rubber bands. In a stable fracture of the body of the mandible the segments can be immobilized by wiring together two teeth on each of the fracture line. If the fragments are displaced inferiorly, or if the widest separation of the fracture line is inferior, then open reduction and inferior interosseous wiring is the treatment of choice. If the widest separation is superior, then the interosseous wiring is placed below the alveolar ridge, by the intraoral route.

Considerable displacement occurs with bilateral fractures through the body of the mandible. The anterior fragments are pulled downward and the posterior fragments are displaced upward and medially. Bilateral open reduction, interosseous wiring, and intermaxillary fixation are required. It may be necessary to use intramedullary pinning or a metal plate to stabilize a comminuted fracture of the mandibular body.

Open Reduction. A 4-cm incision is made at least 1 cm below the inferior border of the mandible. The center of the incision is placed over the fracture line and the dissection is carried through the platysma to the underlying fascia. The mandibular branch of the facial nerve is superficial to this fascia and must be avoided. Usually the facial artery and vein can be identified. These are ligated and reflected upward along with the fascia, thus preventing injury to the marginal mandibular branch of the facial nerve. The dissection is carried directly to, and through, the periosteum on the inferior border of the mandible. The periosteum is elevated medially and laterally on both sides of the fracture line. Granulation tissue, small bone fragments, and entrapped muscle must be removed from the fracture site.

In a fracture running from the outer to the inner surface of the mandibular body in an oblique direction, it is best to place wire around the inferior margin of the mandible and through a single drill hole which includes both fragments.

In order to accomplish a restoration of exact occlusion, intramaxillary fixation with arch bars and rubber bands is usually necessary in a patient with teeth. In a fracture through the body of the mandible in an edentulous patient, with artificial dentures, stabilization may be attained by circumferential wiring, which includes both the body of the mandible and the denture. Postoperative oral hygiene is extremely important with this type of fixation. The fracture is reduced and the segments held in place by wiring through either two or four drill holes. These drill holes are made less than 1 cm superior to the inferior border of the mandible in order to avoid the mandibular canal and mandibular branch of the fifth cranial
nerve. After twisting the wire it is cut to the length of approximately 5 mm, bent at right angles, and tucked into one of the drill holes.

Interosseous wiring through four drill holes is used when the fracture segments are quite unstable.

The periosteum is carefully approximated, the subcutaneous layers are closed with #4.0 chromic catgut suture material, and the skin is closed with #5.0 silk or plastic material. A Penrose drain may be inserted if there has been gross contamination or if there is a possibility of continued bleeding and hematoma formation. In either case, postoperative antibiotic therapy is essential.

**Intraoral Reduction of Any Edentulous Fracture.** The superior aspect of the fracture line can be readily identified by the stepping effect at the fracture line, which is easily palpated on the alveolar ridge. An incision is made along the superior aspect of the lateral alveolar ridge posterior to the fracture line. It is continued anteriorly and inferiorly over the body of the mandible, so that a flap of tissue including all layers of the bone can be reflected inferiorly and superiorly. The periosteum is elevated over the inner and outer aspect of the alveolar process on each side of the fracture line. Drill holes are made 0.5 cm below the crest of the alveolar ridge. It is best to place a retractor or elevator medial to the mandible when making the drill holes so that the soft tissues will not be injured. A #25-gauge stainless-steel wire is passed into one drill hole and out the opposite one so that it can be twisted on the lateral surface of the mandible. The medial surface of the mandible must be inspected to make certain that a loop of wire does not remain here. The twisted end of the wire is cut and tucked into one of the bur holes. It is important to place this wire 0.5 cm below the alveolar crest so that it will not interfere with the proper fitting of an artificial denture.

In a supero-inferior oblique fracture in an edentulous mandible the fragments can be immobilized by circumferential wiring.

In severely comminuted fractures an intramedular pinning technique or the application of a metal plate may be required.

**Fractures of the Mandibular Symphysis**

The portion of the mandible designated as the symphysis is the region between the symphysis menti and a vertical line drawn between the canine and first premolar teeth. Approximately 15% of mandibular fractures occur in this area.

**Treatment.** Only a small percentage of these fractures appear in the exact midline. These are handled easily, for these is usually no displacement of the segments. A mandibular arch bar is sufficient for immobilization.

A fracture of the region of the symphysis is usually oblique, is often accompanied by a condylar fracture, and the fragments are generally displaced. If the fracture is easily reduced by manipulation, intermaxillary fixation with arch bars is employed. Otherwise it is necessary to approach the fracture line directly and to utilize an open reduction.
The incision for open reduction is made 1.5 cm behind the inferior border of the mandible. This site is important, for a scar anterior to it will be quite noticeable. If there is edema and ecchymosis at the time of the operation, the exact placement of this incision is difficult. Some surgeons prefer to mark the line of incision preoperatively with the patient in the erect position.

The incision should be 1.5 to 2 inches in length. It is carried through the platysma, directly to the inferior border of the mandible. A slight anterior retraction of the incision may be necessary for this dissection. All bleeding is controlled with electrocoagulation.

As soon as the inferior border of the mandible is approached, the fracture line should be easily palpable. The periosteum of the inferior border of the mandible is incised on each side of the fracture line. The periosteum is elevated on the anterior aspects of the mandible on each side of the fracture line. It is also necessary to elevate the periosteum in the posterior aspect of the mandible. In so doing, the anterior attachment of the belly of the digastric muscle is detached. The dissection is continued until both ends of the fracture are clearly viewed.

Bone chips and granulation tissue are removed. Muscle that has become trapped in the fracture line must be dissected free.

The fracture is reduced by using bimanual manipulation and also with the aid of bone forceps. If the reduction is simple and the segments do not tend to be unstable after the reduction, a hole is drilled through the mandible on each side of the fracture line. The mandible is then wired with #24 or 26 stainless-steel wire. The twisted end is buried in one of the drill holes. The wound is closed without drainage by carefully approximating all layers. Hemostasis is imperative.

If the fracture line is oblique, it may be best to drill a hole directly through both fragments and twist the wire below the inferior margin of the mandible, rather than place a drill hole on each side of the fracture line. Once the open reduction has been completed the upper and lower arch bars are applied for intermaxillary fixation.

A fracture of the symphysis in an edentulous patient is somewhat more difficult to stabilize, especially when the fracture line runs obliquely, supero-inferiorly. Four holes are drilled for a figure "8" wiring. It also may be necessary to place a wire around the entire symphysis. This can be accomplished by inserting the wire through a #18 or #19 spinal needle and inserting it first anteriorly around the symphysis and then, after threading the other end of the wire into the spinal needle, around the posterior surface of the mandible. The wire is twisted antero-superiorly.

**Mandibular Fracture in the Region of the Angle (20%)**

The region of the angle is defined as that portion of the mandible lying underneath the attachment of the masseter muscle. It is not uncommon for a fracture in this region to be accompanied by a fracture of the body of the mandible on the opposite side. Subcondylar fractures are also commonly associated with an angle fracture.
If there is no displacement or only slight displacement of the fragments, intramaxillary fixation with arch bars and rubber bands is the treatment of choice. Open reduction is accomplished by either the external or intra-oral approach and wire fixation. As a general rule, the intra-oral approach is used with the edentulous patient and is carried out as has been described for fractures of the mandibular body.

The extra-oral open reduction should be accomplished in patients with teeth. A 4-cm incision is made 1.5 cm below the angle of the mandible. Dissection is carried through the platysma and then superiorly through the inferior border of the mandible. The masseter muscle is identified and incised along the inferior margin of the mandible. The periosteum is incised anteriorly and posteriorly through the fracture line, and elevated both anteriorly and posteriorly. When making the drill holes it is important to protect the soft tissues posteriorly with either a retractor or an elevator. The wiring is accomplished as has already been described. Figure "8" wiring may be necessary when the fragments are unstable. If a molar tooth interferes with proper reduction of the fracture, it must be extracted. Intermaxillary fixation with arch bars and rubber bands may or may not be necessary in addition to the open reduction.

Mandibular Fractures in the Region of the Ramus (3%)

The ramus of the mandible is that portion below the coronoid process and neck of the mandible, above the posterior border of the insertion of the masseter muscle.

Fractures of the ramus are uncommon because of the thickness of this structure and the protection afforded it by the masseter, temporalis, and medial pterygoid muscles. They represent only 3% of all mandibular fractures. The fragments are usually adequately immobilized by intramaxillary fixation. This holds true even when a fracture of the ramus is associated with other fractures of the mandible.

Mandibular Fractures of the Coronoid Region (2%)

The coronoid process is divided from the ramus by a line extending downward and forward from the inferior aspect of the sigmoid notch. Fractures through the coronoid process are quite rare and represent only 2% of all mandibular fractures. Probably the reason for this is that the coronoid process is protected by the overlying zygomatic arch and the masseter muscle. Fractures of the coronoid process are caused either by direct trauma or by sudden contraction of the temporalis muscles.

Usually fractures of the coronoid process do not require any specific surgical intervention because of the splinting effect of the temporalis and masseter muscles. If the fracture interferes with dental occlusion, intramaxillary fixation will be necessary.

Fractures of the Condylar Process of the Mandible (35%)

The condylar region is that portion of the mandible superior to, and separated from, the ramus by a line drawn posteriorly and slightly inferiorly from the inferior aspect of the sigmoid notch. The region is divided into a neck and an articular head.
Fractures in the condylar region are most often caused by indirect force, for this area is well protected by the zygomatic process and the muscles and ligaments associated with the temporomandibular joint. Fractures in the condylar region represent 35% of mandibular fractures. For the most part these fractures occur either above or below the insertion of the lateral pterygoid muscle.

Fractures in the condylar region can be diagnosed by depressions caused by a premature closure of the bite on the involved side. These depressions are due to an upward pull of the elevators of the mandible and result in an open-bite deformity in an anterior direction on the opposite side. There may be edema and ecchymosis over the temporomandibular joint region. Tenderness is usually elicited in this area. There is pain in the region of the temporomandibular joint or ear with motion of the jaw. A bilateral fracture in the condylar region will result in an open-bite deformity due to premature contraction of the molars. This is caused by overriding of the fracture segments and contraction of the elevators of the mandible. In bilateral fractures, the patient is usually unable to protrude the mandible for these fractures occur below the level of the attachment of the lateral pterygoid muscle.

As a general rule, fractures of the condylar process should be treated by intramaxillary fixation with arch bars and rubber bands. A satisfactory occlusion and good function will usually result even when the fragments heal and are malpositioned. After the arch bars have been applied the operator's thumb is placed over the lower mandibular molar teeth and inferior pressure is exerted. At the same time the fingers of the operated are used to apply external pressure superiorly against the anterior mandible. By so doing the open-bite deformity can often be immediately corrected and the teeth brought into good occlusion using intramaxillary fixation. If this is not possible, rubber bands are applied to the arch bars and the teeth will usually fall into good occlusion within a day or two.

Open Reduction of Condylar Fractures. Open reduction is indicated in the adult, edentulous patient with bilateral subcondylar fractures with an open-bite deformity, and in children in whom there is a considerable degree of separation in the fracture line so as to interfere with the growth center of the condyle. The incision for open reduction of the condylar process is in the immediate preauricular region, beginning at the root of the helix and extending inferiorly to the inferior aspect of the tragus. The dissection is conducted along the anterior surface of the conchal cartilage to the fascia over the temporomandibular joint. This incision and approach avoid injury to the facial nerve, superficial temporal artery, and internal maxillary artery. The fascia over the temporomandibular joint is incised, the fracture line is identified, and the periosteum elevated away from the fracture line.

A second incision is made 1 cm posteriorly and below the angle of the mandible. The masseter muscle is exposed. The periosteum over the angle of the mandible is incised, and elevated medially and laterally. A drill hole is made through the angle of the mandible and a #25-gauge stainless-steel wire inserted through this. This wire is left long and grasped with a needle holder or heavy hemostat so that downward pressure can be exerted on the ramus. By using this traction wire, the mandible is pulled inferiorly. A periosteal elevator is inserted to elevate the periosteum on the postero-medial aspect of the ramus of the mandible. The periosteal elevator is held behind the fracture line to protect the soft tissues, and a drill hole is made through each fragment. A long piece of wire is placed through the drill holes and
grasped by a hemostat, which has been inserted from below along the postero-medial aspect of the ramus of the mandible. The two ends of the wire are pulled through the incision at the angle of the mandible and twisted from the point. Scissors are inserted through this same route to cut the twisted ends of the wire.

It may be necessary to carry out open reduction of the condylar process bilaterally. Intramaxillary fixation by arch bars and rubber bands is also necessary.

**Fractures of the Alveolar Region**

Fractures of the alveolar process involve the teeth and the alveolar process immediately inferior to them. These fractures may be an extension of fractures occurring in other regions or they may occur independently. In some cases a large segment of alveolar bone may be displaced by a direct blow.

Since soft-tissue damage is usually associated with this type of fracture, the mucous membrane must be carefully re-approximated after the reduction has been accomplished. In alveolar fractures, immobilization may be accomplished by wiring the teeth of the fractured segment to adjacent teeth, or by applying an arch bar. As a general rule, it is probably best to use arch bars and rubber bands to establish intramaxillary fixation and good dental occlusion.

**Postoperative Management**

Oral hygiene is essential when intra-oral apparatus or wiring has been employed. The patient should keep his teeth and gums as clean as possible and free from foreign material. This can be done with the aid of an Asepto syringe and warm saline solution. A small toothbrush may also be useful for removal of debris.

Antibiotics are usually administered, because any fracture of the mandible should be considered as being compounded. They can be given in a liquid form or by the intramuscular route, and their use should be continued for at least one week.

Proper nutrition is essential. A high-protein diet with vitamin and mineral supplements is administered. With the advent of blenderized meals this is not the problem that it was in the past.

It is important to place the patient in a semi-sitting position and to apply cold compresses during the first day or two following either the injury or the operation.

A careful follow-up of the patient is imperative, with examinations at approximately one-week intervals at which time the intramaxillary fixation apparatus is inspected. It may be necessary to tighten wires or to readjust their ends in order to protect the soft tissues. The rubber bands may become weakened or broken and should be replaced when necessary.

Approximately 4 weeks after the reduction the rubber bands are removed from the arch bars and the stability of the mandible is tested. If the mandible feels stable, the patient is instructed to return in a few days. At this time, if his teeth are still in good alignment, the
arch bars are removed. If at the end of 4 weeks the fracture does not feel stable or if the teeth are not in good occlusion, the rubber bands are replaced for 2 additional weeks. If a tooth has been involved in the fracture line, it is best to leave the intermaxillary fixation in place for 8 weeks.
Epistaxis

Epistaxis is best classified according to its location: anterior, superior, or posterior. *Anterior* bleeding occurs in Little's area on the anterior septum, from either a branch of the anterior ethmoid artery, septal branch of the superior labial artery, septal branch of the sphenopalatine artery, or the greater palatine artery. *Superior* bleeding occurs from either the anterior ethmoid artery, posterior ethmoid artery, or the superior nasal branch of the sphenopalatine artery. *Posterior* epistaxis results from rupture of the sphenopalatine artery or one of its branches.

**Etiology**

**Trauma.** Externally, any displacement of the cartilaginous or bony nasal framework may be compounded by a tear in the mucous membrane and result in epistaxis.

Internal trauma may result from sneezing, excessive nose-blowing, or nose-picking.

**Infection.** Acute inflammation of the nasal mucous membranes may lead to epistaxis. The superficial erosion and exposure of blood vessels, coupled with the irritation of nose-blowing, often results in nosebleeds. This type of epistaxis is usually anterior and is easily controlled. Associated with chronic rhinitis, however, it can be most troublesome. It usually occurs in areas where there is crusting and ulceration of a mucous membrane, and often accompanies atrophic rhinitis or a septal perforation.

**Pressure Changes.** Epistaxis is not infrequently associated with the atmospheric pressure changes occurring during air or submarine travel and is more common in people living at higher altitudes than in those living in lower altitudes because of lower atmospheric pressure and lack of moisture.

**Foreign Body.** Epistaxis frequently is due to a foreign body in the nasal cavity. This is most common in children and mentally deranged patients. Nasal stuffiness or obstruction, accompanied by an odoriferous purulent discharge, is a manifestation of an intranasal foreign body.

**Neoplasms.** Benign lesions, such as angiofibroma, and malignant lesions are frequently complicated by epistaxis. The bleeding occurring with angiofibroma can be serious and difficult to manage. Each patient with epistaxis should be carefully examined to exclude the possibility of either benign or malignant neoplasm.

**Familial Telangiectasia (Rendu-Osler-Weber Disease).** The bleeding occurring with this disease usually begins during middle life. It can become so frequent and severe that it dominates the patient's life completely. The small cherry-red telangiectatic spots occur
anywhere in mucous membrane or skin, but are most frequently found in the nasal cavity, mouth, pharynx, and skin of the face (see section on septal dermoplasty).

**Systemic Diseases.** In most cases the exact cause of epistaxis is obscure. Epistaxis often occurs in patients with systemic diseases such as hypertension, arteriosclerosis, anemia, leukemia, deficiency states, hepatic cirrhosis, and chronic nephritis.

**Vicarious Menstruation.** Vicarious menstruation should be expected when epistaxis is experienced repeatedly during menstruation.

**Coagulation Defects.** The diagnosis of bleeding due to coagulation defects is made by means of tests such as blood counts, blood smears, determination of bleeding and clotting times, and platelet counts. Pseudohemophilia occurs more frequently in females than in males. In epistaxis due to this condition the only abnormality found is that of prolongation of the bleeding time.

**Anterior Epistaxis**

It is fortunate that anterior bleeding is the most common type of epistaxis for it is the easiest to control. Local measures to produce reflex vasoconstriction are helpful. These include placing an icebag on the back of the patient's neck, putting a wad of paper or cotton beneath his upper lip, and continuous irrigation of the nasal passage with ice water. Quite often anterior epistaxis will cease spontaneously if the patient remains calm and in a sitting position with his head slightly forward. He is instructed to breathe through his mouth and squeeze both nostrils shut. If these measures are not effective, a piece of moist cotton is placed in the anterior nasal cavity and compressed against the bleeding point by applying external pressure.

**Cauterization.** Cauterization may be necessary to control either a prolonged, solitary or repeated episode of anterior epistaxis.

Anesthesia is easily obtained by inserting 4% cocaine-impregnated cotton strips into the nasal cavity and waiting for 5 to 10 minutes. The vasoconstricting action of the cocaine slows down or controls the epistaxis which will facilitate the cauterization. Other topical anesthetic agents, such as 4% Xylocaine or 2% Pontocaine, with epinephrine solution added can be used as substitutes for the cocaine solution.

If it is impossible to control the bleeding by anterior packing, especially when dealing with an arteriosclerotic vessel, the area adjacent to the bleeding point should be injected with a local anesthetic agent, combined with epinephrine solution, prior to cauterization. Injection should be made with a #25 or #27 needle.

**Chemical Cauterization.** A silver nitrate stick is the most commonly used implement for chemical cauterization for epistaxis, but this provides superficial cauterization, which may not be efficient. A small chromic acid bead on the end of a wire produces excellent cauterization. A tiny cotton pledget dipped in 50% trichloroacetic acid solution is also very effective. The chromic acid bead is made by first heating a wire applicator so that it becomes cherry-red and then dipping it into chromic acid crystals. It is important that the chemical be
placed only at the site of the bleeding; it should not be applied when the bleeding is profuse. The application of a dry cotton swab immediately after the cauterization prevents distribution of the chemical to adjacent areas of mucous membrane.

**Electrocautery.** Should chemical cauterization fail, the electrocautery may be utilized. Most types of instruments work well. The red hot tip cautery does not stick to the eschar produced as readily as do other types of electrocautery. Bleeding tends to occur as the eschar is pulled away by the cautery tip. Following cauterization, the patient is instructed to avoid straining, nose-blowing, and sneezing for a few days, and to insert a pea-sized piece of petroleum jelly on the septum, just behind the columella, each morning and evening for one week.

**Packing.** One-inch wide petrolatum-strip packing may be inserted into the anterior nasal cavity for treatment of troublesome anterior bleeding. In order to prevent its passing into the nasopharynx, it is important to secure the end of the packing in place externally with a piece of tape. The anterior packing should remain in place for from one to 3 days. Hemostatic agents, such as Gelfoam, oxidized cellulose, and topical thrombin, are of value when placed directly over the bleeding point. If the anterior packing is to remain in place for a number of days it is best to use antibiotic-impregnated iodoform gauze rather than petrolatum gauze, to help prevent secondary infection and odor.

**Superior Epistaxis**

Antero-superior bleeding usually emanates from a medial or lateral branch of the anterior or posterior ethmoid artery. Postero-superior epistaxis is likely to come from a branch of the sphenopalatine artery. If the bleeding point can be seen it is cauterized after packing with a topical anesthetic agent and after a vasoconstrictor, as has been used for control of anterior bleeding. If the bleeding point cannot be located, then anterior packing must be utilized.

**Anterior Packing.** The patient is placed in a sitting position with his head tilted slightly backward and supported either by an assistant or a head rest. With a nasal speculum and bayonet forceps, iodoform gauze, which has been impregnated with antibiotic ointment, is carefully packed into both nasal cavities. The packing is begun posterosuperiorly and continued in a forward direction. The anterior ends of each strip of packing are tied together so that they will not be lost in the nasopharynx. The anatomy of the nose is such that this packing tends to become displaced inferiorly. Therefore, the inferior nasal cavity is packed a finger-cot packing. If both nasal cavities are packed, a piece of rubber catheter is placed through the finger-cot packing, into the posterior nasal cavity, to prevent annoying interference with eustachian tube function during swallowing. This packing should remain in place for from 3 to 5 days.

**Ligation of the Ethmoidal Arteries.** Persistent superior bleeding is, on occasion, best treated by ligation of the anterior and posterior ethmoid arteries. These arteries are ligated just lateral to the point where they enter the medial wall of the orbit.

The anterior and posterior ethmoid foramina are situated in, or adjacent to, the frontoethmoidal suture line (between the orbital plate of the frontal bone and the lamina
papryacea). In some persons the foramina may be situated slightly above this suture line. According to Kirchner and associates the anterior ethmoid foramen is between 14 and 18 mm behind the maxillo-lacrimal suture line. The posterior ethmoid foramen is between 4 and 7 mm anterior to the optic foramen. The distance between the anterior and posterior ethmoid foramina averages 10 mm.

An external ethmoid incision is used for exposure. The lacrimal sac and orbital periosteum are retracted laterally as has been described for external ethmoidectomy. The suture line between the orbital plate of the frontal bone and the lamina papryacea can easily be found. This is followed posteriorly until the anterior ethmoid artery is located. There are a number of ways to deal with the artery. A #3-0 silk suture can be looped around it with a hook-shaped needle carrier. A second method is that of cauterizing the artery just as it enters the anterior ethmoid foramen. This method is usually rapid and effective, except when the artery ruptures causing troublesome bleeding. A third method utilizes self-locking hemostatic clips, which are applied after the artery is placed under tension by laterally retracting orbital periosteum. The anterior ethmoid artery is divided so that the posterior ethmoid artery can also be identified and ligated. Closure and postoperative care are the same as described for external ethmoidectomy.

Posterior Epistaxis

Posterior epistaxis can be severe, frightening, and difficult to control. It is the result of rupture of the sphenopalatine artery or one of its branches. Usually the patient gives a history of blood flowing profusely into the pharynx, as well as from the anterior nares. Much blood can be lost in a relatively short period of time. Often, much of this blood is swallowed, and the patient reports vomiting "coffee-ground" material.

Unless the patient shows signs of shock, he is placed in the sitting position. The nasal cavities are packed with cotton strips which are impregnated with 4% cocaine, or a topical anesthetic agent, plus epinephrine solution (1:1000). It is important to place these strips behind both the middle and inferior turbinates. It may be necessary to fracture the middle or inferior turbinate medially in order to find the site of hemorrhage. If the bleeding site can be seen, it is worth the effort to attempt cauterization or to cover the area with a pledget of oxidized cellulose. The pledget can usually be wedged between the turbinate and the lateral nasal wall, in the inferior or middle meatus. If the bleeding cannot be controlled by such measures, then it is necessary to use anterior and posterior packing.

Anteroposterior Packing. The patient is sedated with either morphine or Demerol as soon as the decision to employ anteroposterior packing is made. Both the nasal cavity and soft palate are anesthetized topically with 2% Pontocaine or 4% cocaine solution. It is most important to tell the patient what is being done, for the experience of having postnasal packing inserted can be a frightening one. A soft rubber catheter is placed in the nasal cavity on the side of the epistaxis and advanced until it appears in the pharynx. The catheter is grasped with a bayonet forceps, or a Kelly clamp, and delivered through the mouth. One set of strings from the posterior pack is tied to the end of the catheter protruding from the mouth. The catheter is withdrawn from the nose, bringing the strings to the nasal orifice. The operator tenses these strings with one hand, while delivering the posterior pack into the nasopharynx with the index finger of the other hand, or with a Kelly clamp. An assistant can
hold the strings protruding from the nasal orifice while the anterior packing is being inserted. This packing consists of one long strip of 1-inch antibiotic-impregnated iodoform gauze. One end is packed firmly against the anterior aspect of the posterior pack and then the entire nasal cavity is carefully filled with the gauze strip. The two strings protruding from the nostril are tied over a cotton dental roll or a rolled-up 2- x 2-inch gauze pad to pull the posterior pack forward and thereby exert anterior pressure against the intranasal packing. The strings protruding from the posterior aspect of the pack into the pharynx and out the mouth are cut flush with the uvula. It is not necessary to bring these out through the mouth and tape them to the cheek. If the uvula becomes excessively edematous, it should be incised.

A patient with an anteroposterior pack is kept in bed in a semi-sitting position for at least 24 hours. His feet, legs, and thighs are encased in elastic stockings. An ice collar is applied and ice packs are placed at the side of his nose. Tranquilizers and medication for relief of pain are given as needed. A soft diet is prescribed, and laxatives are administered to prevent constipation. As a general rule it is best to give antibiotics when anteroposterior packing is used in order to combat the inevitable sinusitis. Lost blood is replaced, as indicated, by transfusions. Daily hemoglobin and hematocrit determinations are essential. a general evaluation of the patient is conducted in order to detect any underlying cause of the epistaxis.

There are many disadvantages to anteroposterior packing. The patient is extremely uncomfortable, for mouth breathing results in a dry and sore throat. Deglutition is difficult. Complicating sinusitis often occurs. With the packing in place, blood may ascend by way of the nasolacrimal duct, and exit from the ocular punctum, or by way of the eustachian tube, causing hematotympanum and rupture of the tympanic membrane. Even after all this the bleeding may recur when the nasal packing is removed.

**Transantral Ligation of the Internal Maxillary Artery.** Posterior epistaxis from the sphenopalatine artery can be a serious medical problem, especially when bleeding persists during or following the removal of anterior and posterior nasal packing.

Ligation of the external carotid artery is not effective in many cases of posterior epistaxis. Ligation of the internal maxillary artery, on the other hand, has proven very effective for the control of sphenopalatine artery hemorrhage (Malcomson; Chandler and Serrins).

**Anatomy of the Third Division of the Internal Maxillary Artery.** The internal maxillary artery is the larger of the two terminal branches of the external carotid artery. It arises behind the neck of the mandible and is divided into three parts: the mandibular, pterygoid, and pterygopalatine (third division). The pterygopalatine division follows a tortuous course as it traverses the pterygomaxillary fossa where it gives off seven branches.

**Posterosuperior Alveolar Artery.** This vessel descends on the tuberosity of the maxilla and divides into numerous branches, some of which enter the alveolar canals to supply the molar and premolar teeth and the lining of the maxillary sinus, while others continue forward on the alveolar process to supply the gums. The posterosuperior alveolar artery may share a common trunk with the infraorbital artery.
Lesser Palatine Artery. In our cadaver dissections, the lesser palatine artery was found to originate from the superior aspect of the pterygomaxillary artery, directly medial to the origin of the posterior superior alveolar artery. It descends parallel to the greater palatine artery, supplying the posterior upper alveolus, gums, and hard and soft palate.

Nasal Accessory and Superior Pharyngeal Arteries. These arteries may have a common origin. The nasal accessory artery supplies the floor of the nose, inferior meatus, inferior turbinate, and lower middle meatus. The superior pharyngeal artery is distributed to the upper pharynx and the orifice of the eustachian tube.

Infraorbital Artery. The infraorbital artery passes anteriorly along the floor of the orbit, within the infraorbital canal, to emerge externally through the infraorbital foramen. It has numerous branches. Within the infraorbital canal, it supplies the inferior rectus and inferior oblique muscles, and the lacrimal sac. Anteriorly, its branches descend through the alveolar canals to supply the upper canine, and incisor teeth and the mucous membrane of the maxillary sinus. Its terminal branches supply the tissues of the midface.

Arteries of the Foramen Rotundum and Pterygoid Canals. These arteries may arise separately or together in a common trunk. If they share a common trunk, they divide and pass into their respective foramina and are distributed to the enclosed nerves and connective tissues.

Greater Palatine Artery. The greater palatine artery descends through the pterygopalatine canal with the greater palatine branch of the sphenopalatine nerve, emerges from the greater palatine foramen, and extends forward on the medial aspect of the hard palate to the incisive canal. The terminal branch passes through this canal to anastomose with the branches of the sphenopalatine artery. Other branches are distributed to the gums, palatine glands, oral mucosa, soft palate, and palatine tonsils.

Sphenopalatine Artery. The sphenopalatine artery is the terminal branch of the internal maxillary artery. It passes through the sphenopalatine foramen into the nasal cavity behind the posterior tip of the middle turbinate. Here it gives off the posterior lateral nasal branches, which extend forward over the meatuses and turbinates to anastomose with branches from the ethmoid and palatine arteries and to assist in supplying the maxillary, ethmoid, and sphenoid sinuses. The terminal branches of the sphenopalatine artery cross the undersurface of the sphenoid and end on the nasal septum as the posterior septal arteries, which anastomose with the anterior and posterior ethmoids, and superior labial and greater palatine arteries, to supply the floor of the septum and the roof of the nose.

Surgical Technique of Transantral Ligation of the Internal Maxillary Artery. The operation may be performed with the patient under either general or local anesthesia. When local anesthesia is the choice, 2% Xylocaine with added epinephrine is injected into the gingivobuccal sulcus and around the infraorbital nerve.

A curved needle is inserted 2 cm in the greater palatine foramen, and 2 cc of the local anesthetic is slowly injected into the canal and pterygomaxillary fossa.
A Caldwell-Luc incision is used. The periosteum is elevated from the anterior wall of the antrum in the region of the canine fossa. The antrum is entered by using a curette, chisel, or rotating bur. As much of the anterior wall of the antrum is removed as is possible without damaging the infraorbital nerve. This can be accomplished with Kerrison forceps, but is best done with a rotating bur. A cocaine pack is placed in the antrum for a few minutes to further anesthetize the antral mucosa and to decrease bleeding. A mucosal flap, based laterally or inferiorly, is elevated from the posterior wall of the antrum. A self-retaining retractor is applied.

The surgical microscope, with a 300-mm lens, should be used during the remaining dissection. The thin posterior wall is broken through with a curette or small chisel. The periosteum is carefully separated from the posterior sinus wall, which in turn is removed with Hajek bone-cutting forceps. It is important to extend this bony dissection as far medially as is possible, for the vidian canal is often found directly posterior to the medial wall of the antrum. There are a number of small blood vessels directly underneath the periosteum covering the pterygomaxillary fossa. The periosteum is best opened by using a spatula blade with electrocoagulation current to accomplish the cruciate incisions. The four flaps thus created are easily elevated, exposing the underlying adipose tissue.

Pulsations of the internal carotid artery can often be seen, giving the surgeon some indication as to the location of this artery. Adipose tissue is carefully removed with dissectors, alligator and cup forceps, and suction tips, all especially designed for this purpose. As soon as the main artery is identified, it is elevated with an artery hook so that its branches may be more readily dissected free.

The sphenopalatine artery is retracted anteriorly with an artery hook and doubly clipped. I have found the various nonlocking hemostatic clips to be unsatisfactory, for they are gradually reopened by the strong pulsations of this artery. If possible, the infraorbital and greater palatine arteries should be identified so that the arterial occlusion can be accomplished medial to their origin.

It is not necessary to section the artery when using the self-locking clips. The sphenopalatine artery can be ligated with #3-0 silk suture material if the self-locking clips and its applicators are not available. The suture is passed beneath the artery with a ligature carrier, or small, curved or right-angle hemostat, and tied by hand or with the aid of a long, thin needle holder.

The posterior central mucosal flap is reflected over the pterygomaxillary fossa and covered with Gelfoam. Any intranasal packing is removed. Slight bleeding should not be of concern, for it will cease spontaneously. A nasoantral window is added for drainage only if bleeding has been a problem throughout the operation or if the patient has had intranasal packing in place for sufficient time for sinusitis to become a complication. If a nasoantral window is fashioned the antrum is packed with antibiotic-impregnated iodoform gauze, which is removed on the second or third postoperative day. The Caldwell-Luc incision is closed with loosely tied catgut sutures.

**Postoperative Care.** Postoperative care should include the administration of antibiotics, placing the patient in the semi-sitting position, and the application of an ice pack over the
patient's face to prevent edema and ecchymosis. The ice pack should be applied as soon as
the patient reaches the recovery room. It should remain in place for 24 hours.

**Septal Dermoplasty for Hereditary Hemorrhagic Telangiectasia**

In many cases the severe recurrent epistaxis associated with Rendu-Osler-Weber
disease can be controlled by skin-grafting both sides of the anterior nasal septum as outlined
by Saunders. The epistaxis associated with this systemic disease can be a most severe
problem. In some cases, daily hemorrhages dominate the patient's entire existence.
Gastrointestinal bleeding and hemorrhage from the lips, tongue, and gums also occur.

The telangiectatic lesions may be found on any epithelial surface. They are bright red,
usually about a millimeter or two in diameter, slightly raised, and blanch with pressure.
Microscopically the vessels in the telangiectatic lesions are superficial, thin-walled, and void
of muscular or elastic tissue. Thus bleeding with minimal trauma occurs with a lack of
spontaneous cessation of hemorrhage.

**Septal Dermoplasty Technique.** Approximately 30 cc of 1% Xylocaine solution are
required to anesthetize the donor site on the thigh for a split-thickness skin graft. The upper
lip, columella, nasal septum, and nasolabial sulcus are also anesthetized with 1% Xylocaine
solution.

A split-thickness skin graft, approximately 2.5 by 4 inches in size and 0.016 to 0.020
inch in thickness, is sufficient to cover both sides of the anterior nasal septum and the floor
and tip of the inferior turbinate. The skin-graft donor site is covered with petrolatum gauze,
or Telfa or Owen's silk, and then with an overlying pressure dressing.

A nasolabial incision is made to acquire better exposure of the anterior nasal cavity.
This incision should extend slightly into the floor of the nose. One suture through the ala,
weighted with a heavy hemostat, serves for retraction.

A vertical postcolumellar incision is made anterior to the mucocutaneous junction. This
incision is made along the full vertical dimension of the anterior nasal septum, but not
through mucoperichondrium. The mucous membrane is resected, preserving the
perichondrium, with a knife, scissors, and sharp curettes. It is essential that all mucous
membrane be removed so that mucus-secreting epithelium will not be present under the skin
graft. Bleeding is controlled with cautery and topical epinephrine solution.

The skin graft is halved, one half to be used for the anterior third of the nasal septum,
the other for the anterior portion of the lateral wall and inferior turbinate. The skin graft is
secured in place anteriorly with #4-0 chromic catgut sutures and then pushed posteriorly so
that it covers all areas which have been denuded of mucous membrane. The graft may be
tacked in place with a few additional sutures if necessary. If indicated, the operation is
repeated on the contralateral side. The nasal cavity is loosely packed with antibiotic-
impregnated iodoform gauze. The nasolabial incision is approximated subcutaneously with
#4-0 chronic catgut and the skin is closed with #5-0 dermal suture material.
The intranasal packing remains in place for 4 or 5 days. The nasolabial skin sutures are removed after one week. The patient is instructed to apply petrolatum or mineral oil to each side of the nose several times a day. The nasal cavity should be examined once a week, at which time crusts and excessive skin graft are removed. Instructions for long-term nasal care are necessary, for some degree of crusting will persist. This can be controlled with saline irrigations and the application of petrolatum.

**Nasoseptal Perforation**

The symptoms associated with nasoseptal perforation can be distressing. The crusting and epistaxis accompanying a large perforation are usually controlled by topical agents which effect lubrication. On the other hand, the noisy respiration (whistle) produced by the small anterior perforation is quite annoying for the patient and for those who surround him. It is usually this symptom which prompts the patient to seek aid.

The causes of septal perforations have been thoroughly reviewed by Seeley. The structural abnormality consists of a bilateral mucosal incompetence, coupled with the absence of septal cartilage, and, at times, bone. Most commonly the limits (margins) of the perforation are covered with mucous membrane which has extended over the exposed cartilage. Chemical agents, such as those used with cauterization of blood vessels in the treatment of epistaxis, are probably the most common cause of perforations. Metabolic disorders, particularly diabetes mellitus, are predisposing factors to septal perforations because of impaired vasculature and greater susceptibility to infection. Infection, either directly by necrosis of tissue or indirectly following incision and drainage of a septal abscess, can result in a septal perforation. Trauma to the septum - accidental, iatrogenic (nose-picking), or surgical - occasionally results in a septal perforation. Congenital perforations, although rare, have been reported.

Ballenger has stated that large nasoseptal perforations are not amenable to surgery. Small defects, usually 1.5 cm in diameter or less and located anteriorly in the septum, are the most common and happily the easiest to repair. As would be expected, there have been many techniques introduced for the repair of these perforations. Most methods utilize unilateral or bilateral sliding flaps of septal mucous membrane.

After the inner rim of mucous membrane has been removed, simple primary closure of septal perforation with through and through sutures, usually results in failure.

Hazeltine's method, as described by the Ballengers, represents the principle of sliding mucosal flaps. With small perforations, the advantage of this procedure is that both sides are covered; thus the chances for a permanent closure are greatly enhanced. A unilateral septal flap, described by Berson, has been noted to have a rather high incidence of failure.

Autogenous septal cartilage grafts have been used to lend support to the septal flaps. Central necrosis and curling of the graft is described by Goldman, and by Huffman and Lierle. These authors noted that cartilaginous grafts, inserted during submucous resection of the nasal septum, underwent resorption as a late complication. Missal reported a rejection of five out of seven Ivalon septal implants. He speculated that the rejection was secondary to specific hyperimmunity of nasal tissue to foreign substances. Behrman reported three cases
of fascia lata graft in which the fascia lata was sandwiched between septal mucosal flaps. In two of the three patients, infection occurred, but healing eventually took place in all three.

An entirely different approach to repair of the septal perforation is Seiffert’s method as described by Aubry. The septum is tented toward the largest middle turbinate until direct approximation occurs. Both the inner rim of the perforation and the adjacent area of middle turbinate must be denuded of epithelium. The nasal septum is held against the middle turbinate with a tamponade in the opposite nasal cavity until union has been made between the septum and middle turbinate. The union is then divided by resection a portion of the middle turbinate. It would seem that this method of repair is rather uncomfortable for the patient, as well as quite difficult for the surgeon.

Ismail in 1964, presented 13 cases of septal perforation repair made by utilizing a free full-thickness graft from the middle turbinate. The procedure is described as being technically easy, and the results are creditable.

Meyer has presented the possibility of the use of an acrylic or nylon obturator in the treatment for septal perforation. No reports of the results was published. It might be speculated that long-term usage of an obturator could lead to such complications as secondary infection and epistaxis.

An inferiorly based flap fashioned from the anterior lateral nasal mucous membrane was advocated by McGovern. The mucous membrane flap is reflected medially and inferiorly so that its lateral, or raw, surface can be sutured to the nasal septum surrounding the perforation. The flap must traverse the nasal cavity and be subsequently divided after the perforation has been closed. It would seem that such a pedicled flap would be difficult to create and maintain.

Goldstein (Ballenger, 1947) presented a technique using a pedicled flap of the septal mucous membrane directly behind the perforation. This flap is based just posterior to the perforation. It is rotated through the perforation and inserted between the septal cartilage and the mucous membrane on the opposite side of the septum. In preparation for the mucosal flap, the mucous membrane is removed from the inner margin of the perforation, and the septal mucous membrane is separated from the cartilage surrounding the perforation on the opposite side of the septum.

Seeley and Climo have presented a more extensive and involved approach to the problem. Both authors advocate the standard rhinoplasty incision because of the greater visibility it permits at the time of operation and because of the more extensive mucosa available for approximation. The posterosuperiorly based flap enjoys an excellent blood supply.

Another method of closure found to be most useful is that which employs a superiorly based pedicle flap on the nasal septum, to which is attached a piece of septal cartilage the size of the perforation. This procedure is in concert with thoughts of Huffman and Lierle that, "if the cartilage could be left attached to at least one side of the septal membrane as part of a compound flap," there is a higher incidence of success. The repair can be accomplished from either side of the nasal septum. A circumferential incision is made approximately 3 to 4 mm
around the edge of the perforation. The mucous membrane is carefully raised toward the perforation and elevated away from its inner margin. This maneuver affords enough epithelium so that it may be approximated with #4-0 chromic catgut on a very small, cutting, curved needle, thus closing the perforation on the contralateral side of the septum.

A superiorly based mucoperichondrial flap, which is large enough to cover the perforation and the surrounding defect, is fashioned. The inferior half of this pedicle flap is made through the cartilage, whereas the upper half is elevated in a place between the perichondrium and the cartilage. The cartilage attached to the lower half of the pedicle flap is then trimmed so that it is just the size of the septal perforation. The flap is swung anteriorly into the defect and sutured in place with #3-0 chromic catgut sutures. Keogh has described a similar procedure with apparently good results. He has chosen to cover the exposed cartilage of the pedicle flap with a free skin graft, rather than invert the nasal mucosa through the perforation.

Rubber finger-cot packs covered with aureomycin ointment are inserted into both nasal cavities. These should remain in place for at least 2 days. The patient should be instructed to avoid blowing or picking his nose during the early postoperative period. Thus far, results from this method have been quite encouraging.

Abscess of the Nasal Septum

Abscess of the nasal septum most commonly follows hematoma secondary to trauma or an operation upon the septum. It can also occur secondary to intranasal or sinus infection. It occasionally follows a furuncle of the upper lip or nose. Its most common site is the anterior cartilaginous area.

Signs and Symptoms

An abscess of the nasal septum usually develops over a period of several days. The patient complains of chills, fever, pain, and increasing unilateral or bilateral nasal obstruction. There may or may not be erythema and swelling of the external nose. On examination, either one or both sides of the nasal septum are seen to be swollen and red. There may be a loss of cartilaginous septum when the purulent discharge accumulates between the mucoperichondrium and cartilage and remains there for some time. Thus, early, adequate drainage is of great importance.

Diagnosis

Usually the diagnosis of abscess of the nasal septum is obvious when there is a history of trauma, surgical procedure, or intranasal infection. There is unilateral or bilateral nasal obstruction due to swelling of the medial wall of the nasal cavity. The fluctuation may be palpated with a cotton applicator. On occasion the development of a septal abscess may be insidious and difficult to diagnose. In such an instance, aspiration of the area with a #20-gauge hypodermic needle will be required to determine its presence. A topical anesthetic should be applied prior to the aspiration.
Treatment

Adequate drainage and antibiotic therapy constitute the treatment of choice. Cocaine solution (4%) is applied to the nasal cavity, first by spray, and then by packing with cotton strips. With a #11 or #15 surgical blade, a vertical incision is made in the area of maximum convexity. Pus is removed by aspiration and sent to the bacteriology laboratory for culture and sensitivity tests. A section of mucoperichondrium is removed with a ring punch to ensure adequate drainage. A small section of Penrose drain is then secured in place with catgut suture. When the swelling is bilateral, incision and drainage are carried out on both sides of the septum. The drain or drains remain in place until discharge has subsided (2 to 3 days). Specific antibiotic therapy is continued for at least 10 days to prevent recurrence of the abscess and loss of cartilage.

Nasal Polypectomy

Nasal polyps develop from a prolapse of overloaded edematous respiratory epithelium. The stimulus for this reaction is an irritant, which may be an allergen - bacterial or chemical. Polyps develop in areas in which tissue constructions are delicate, such as in the middle meatus and sinuses. The common sites of origin are the crest of the uncinate process, the sinus ostia, the anterior surface of the ethmoid bulla, and the mucous membrane of the sinuses, especially of the ethmoid and maxillary sinuses.

Signs and Symptoms

Nasal polyps almost invariably occur bilaterally and are quite often associated with chronic allergic or bacterial sinusitis. The symptom which brings the patient to his doctor is a gradually increasing nasal stuffiness which can terminate in complete nasal obstruction. Some patients tolerate the nasal obstruction and do not seek medical attention until they have widening of the external nose or until the polyps protrude from the nostrils. Other symptoms are those of chronic, allergic, or bacterial sinusitis.

Diagnosis

Nasal polyps are smooth, glistening, grapelike masses, yellowish or pink in color. They are rarely found in one nasal cavity only. The patient has a history of gradually increasing nasal stuffiness. As a rule, the symptoms are not seasonal and the patient has signs and symptoms of chronic sinus disease. Sinus x rays will show that the nasal cavities are partially or completely occluded. The ethmoid cell partitions are washed out, and there is usually increased density in the ethmoid labyrinth. The maxillary sinuses may show evidence of either thickened membrane or polyps. A choanal polyp may be present.

Surgical Technique of Polypectomy

The removal of nasal polyps as an office procedure is an art. An improperly conducted polypectomy is a most unpleasant experience, both for the patient and for the surgeon. If the patient seems apprehensive, slight sedation or a tranquilizer, given one half hour before the procedure, is quite helpful.
For anesthesia, the nasal cavities are packed with cotton strips impregnated with 4% cocaine solution or 2% Pontocaine solution, with added epinephrine. The packing is removed after 10 minutes. Fresh cotton strips, impregnated with the anesthetic agent, are inserted at least one additional time, until adequate anesthesia is obtained. The areas usually missed during a first attempt are in the superior and posterior nasal cavity and middle meatus.

A nasal snare with a loop, 1 inch in diameter, is used. It is adjusted to a size that can be inserted into the nasal cavity without producing pain. The operator grasps the shaft of the snare in its midsection as one would grasp a pencil. He inserts the loop in a vertical plane and then rotates it to the horizontal plane below the level of the polyp. He then slowly manipulates it over the polyps in an upward and lateral direction, toward the middle meatus, which is the usual site of polyp origin. He grasps the handle to close the wire loop while steadying the snare at its center with his free hand. The polyps are removed with forceps or metal suction tips.

This procedure is repeated until all polyps have been removed. If bleeding becomes troublesome at any time the nasal cavity is packed with cotton strips impregnated with epinephrine solution, and the operator proceeds to remove the polyps in the opposite nasal cavity. Smaller polyps are removed with Brownie, Takahashi, or ring forceps. It is best not to use traction on polyps having their origin in the superior meatus, for these may extend to the olfactory slit. Trauma in this region can produce a defect in the cribriform plate resulting in cerebral fluid leakage and its complications.

All tissue, regardless of the number or size of the polyps, or of the number of past polypectomies, should be sent to the pathology laboratory for sectioning and diagnosis. Many malignant tumors are masked by overlying nasal polyps.

Those patients who have had repeated polypectomies and in whom x rays show evidence of either chronic polypoid ethmoiditis or maxillary sinusitis, or both, should be admitted to the hospital for both polypectomy and the appropriate sinus operation, ie, intranasal ethmoidectomy or the Caldwell-Luc operation. These procedures are quite gratifying, for a significant percentage of the patients will either not have recurrence of the polyposis or will have a remission of several years' duration.

**Choanal Polyp**

The choanal polyp is a separate clinical entity. This polyp is most often unilateral and can attain enormous size. The symptom which troubles the patient is nasal obstruction. The obstruction is at first unilateral, and then, as the choanal polyp increases in size, it obstructs the entire nasopharynx. On occasion a choanal polyp may appear below the level of the uvula.

The patient should be admitted to the hospital for removal of the choanal polyp and a Caldwell-Luc operation. Simply removing the polyp is unwise, for unless the condition responsible for its origin, chronic maxillary sinusitis, is treated, a recurrence is probable.

To remove the choanal polyp, a piece of #5 snare wire, about 1 foot in length, is doubled upon itself to form a loop which is inserted into the nasopharynx by way of the nasal cavity. The ends of the snare wire are held with the surgeon's left hand. The surgeon's right
hand is inserted into the nasopharynx by way of the patient's mouth. The tip of the surgeon's finger palpates the end of the wire loop and maneuvers it up over the dome of the choanal polyp. Traction is then applied with the surgeon's left hand, and the wire loop is pulled forward in contact with the stalk of the choanal polyp in the middle meatus as it exits from the ostium of the maxillary sinus. The ends of the wire are then inserted into, and attached to, the snare apparatus. The stalk of the choanal polyp is sectioned, and the polyp is removed from the nasopharynx by way of the mouth.

A Caldwell-Luc operation is then performed, removing all polyps and diseased membrane.

**Postoperative Care**

Hemorrhage rarely occurs following a polypectomy. If it does it should be handled as any other epistaxis. It is best to tell the patient that in all probability the polyps will return and that it is impossible to predict when. If purulent secretion is noted at the time of polypectomy, this should be cultured and the appropriate antibiotics administered. Sinus x-rays are indicated at this time. Many surgeons elect to institute short-term steroid therapy (10 days) following polypectomy in an attempt to reverse the process completely or to prolong the remission.

**Intranasal Tumors**

Tumors of the nasal cavity vary from small, benign lesions to massive, destructive, and invasive malignant tumors. Benign lesions tend to be smooth, firm, localized, and covered with mucous membrane. Malignant lesions are usually friable, granular, infiltrating, and susceptible to bleeding.

**Signs and Symptoms**

The signs and symptoms of intranasal tumors are as follows:

1. Nasal stuffiness or obstruction usually unilateral.
2. Nasal discharge, either mucoid or purulent.
3. Bleeding, scanty or profuse, usually unilateral.
4. External deformity (an expanding lesion may displace the nasal bones laterally and cause widening of the nose; masses may appear externally after eroding through bone, especially in the region of the inner canthus; destruction of bone can cause depression deformities).
5. Polypod change, which may be associated with other tumors, benign or malignant, and may mask the underlying pathologic condition in spite of repeated polypectomies and histologic examinations (thus, when suspicious of a tumor, a thorough examination (x rat, etc) is most important as well as admission to the hospital, where more adequate biopsies may be obtained with the patient under general anesthesia if necessary; any complication, such as hemorrhage, can be best managed at the hospital).
6. Pain (this may be severe when the tumor is accompanied by cellulitis or osteomyelitis).
7. Tearing (caused by invasion of the lacrimal sac, lacrimal duct, or obstruction of the nasolacrimal duct orifice by a lesion in the inferior meatus).

8. Such symptoms as pain in the teeth, exophthalmos, diplopia, paresthesia, or anesthesia of the cheek, which may indicate extension of disease to the sinuses or orbit.

**Diagnosis**

Diagnosis is established by means of anterior and posterior rhinoscopy, x-ray study (planograms), or biopsy.

**Classification**

Lesions found in the nasal cavities may be classified as follows:

<table>
<thead>
<tr>
<th>Benign Lesions</th>
<th>Malignant Lesions</th>
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<tbody>
<tr>
<td><strong>Ectodermal</strong></td>
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<tr>
<td>Glioma</td>
<td>Olfactory esthesioneuroblastoma</td>
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<tr>
<td>Encephalocele</td>
<td>Malignant schwannoma</td>
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<tr>
<td>Neurofibroma</td>
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<tr>
<td>Meningocele</td>
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<tr>
<td><strong>Epithelial</strong></td>
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<tr>
<td>Dermoid cyst</td>
<td>Squamous cell carcinoma</td>
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<tr>
<td>Sebaceous cyst</td>
<td>Basal cell carcinoma</td>
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<tr>
<td>Epidermoid cyst</td>
<td>Transitional cell carcinoma</td>
</tr>
<tr>
<td>Papilloma</td>
<td>Adenocarcinoma</td>
</tr>
<tr>
<td>Inverted papilloma</td>
<td>Malignant melanoma</td>
</tr>
<tr>
<td><strong>Mesodermal</strong></td>
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<tr>
<td>Hemangioma</td>
<td>Ameloblastoma</td>
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<tr>
<td>Lipoma</td>
<td>Fibrosarcoma</td>
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<tr>
<td>Mixed tumors</td>
<td>Chondrosarcoma</td>
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<tr>
<td>Chondroma</td>
<td>Osteogenic sarcoma</td>
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<tr>
<td>Fibroma</td>
<td>Plasmacytoma</td>
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<tr>
<td>Osteoma</td>
<td>Lymphoblastoma</td>
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<tr>
<td>Angiofibroma</td>
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<tr>
<td>Ossifying fibroma</td>
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Certain of the benign lesions are classified as clinically malignant, either because of their location or their rapidly progressive growth and tendency to recur after removal. The inverted papilloma, mixed tumor, and chondromas are classified as such and should be treated as malignant tumors.
**Principles of Treatment**

**Chondroma, Chondrosarcoma, Malignant Mixed Tumor, and Inverted Papilloma.**
The recurrent chondroma, chondrosarcoma, and malignant mixed tumor should be treated by wide resection, for they are multiple, sessile, friable, and very susceptible to bleeding. Inverted papillomas which recur rapidly, show signs of early malignant change, or demonstrate extensive recurrence or invasion should be treated by resection followed by a full course of postoperative radiation therapy. Repeated biopsies are often misleading, for the malignant portion of the lesion may be deep. The malignant inverted papilloma (papillary squamous carcinoma) tends to metastasize to the lungs and submaxillary lymph nodes.

**Ossifying Fibroma.** Ossifying fibroma is considered to be a localized manifestation of fibrous dysplasia. It may appear first as an intranasal tumor and is frequently noted in childhood. It usually involves the anterior ethmoid bone, sphenoid bone, nasal bone, orbit, and base of the skull. Surgical treatment is usually unsatisfactory, incomplete, and complicated by hemorrhage.

It is now well known that the less spectacular form of fibrous dysplasia (ie, that of a solitary monostotic lesion) is not associated with any known physiologic changes and is by far the more common than the polyostotic form, the ratio being about 40:1. The monostotic form is considered by some to be an entirely different entity from the polyostotic form with non-bony manifestations.

The clinical characteristics of ossifying fibroma may be described briefly as follows:

1. The lesion has a definite female preponderance (3:1).
2. The bone lesions usually have their inception in childhood, although they may not become clinically evident until later. Occasionally, however, the onset may not be until later in life.
3. The facial bones, femur, tibia, and ribs are the bones most commonly involved.
4. The tumor usually is a slow-growing asymptomatic tumor which ceases to grow, or very markedly slows in growth rate, after adolescence.
5. There are no diagnostic laboratory findings, although, in patients with an actively growing lesion, there is an elevation of serum alkaline phosphatase (apparently derived from the abnormal elevation of this substance in the connective tissue cells of the tumor).
6. The roentgenographic picture is one of replacement of bone tissue outward, from within, toward the cortex, producing the typical "ground-glass" appearance. In the facial bones particularly, the lesions are generally sclerotic and, therefore, radiopaque.
7. The lesions, if multiple, are usually unilateral.

The prognosis is excellent. Complete removal is desirable and offers the best chance for permanent cure. Recurrence is usually the price of incomplete removal. There are, however, reports of patients who had incomplete excision without subsequent recurrence during a number of years of follow-up study. If the tumor is not symptomatic in an adult and does not appear to be growing, no therapy may be necessary. It would seem that, as with most benign tumors, individual consideration should be given to each patient in regard to the growth rate of the tumor, location of the lesion, extent of the surgical defect which would be produced by excision, and the age of the patient, since, as stated previously, growth rate
generally slows or ceases with increasing age. The physician should be alert for signs of malignant change such as pain or sudden acceleration of growth.

The fact that malignant degeneration of fibrous dysplasia does occur is still not universally accepted. To date there have been 29 cases of malignant degeneration of fibrous dysplasia involving the nose reported. These cases all appear to be well substantiated, and several are histologically confirmed.

There is no appreciable difference in the incidence of degeneration between the monostotic and polyostotic lesions when one considers the number of lesions in the individual with the polyostotic form.

The influence of prior radiation is not clear, but radiation therapy does appear to have a predisposing propensity to malignant degeneration, as 12 of the 29 patients had received radiation therapy on an average of about 14 years prior to the onset of signs of malignant change. Conversely, it can be stated that radiation therapy is not necessarily a prerequisite for malignant degeneration, as 16 of the 29 patients had none at all. Certainly, radiation therapy should be avoided if practically possible, as it is not only implicated in the malignant degeneration of fibrous dysplasia, but is also believed to be the most significant factor in the production of bone sarcoma. Many patients with fibrous dysplasia have received radiation therapy without having malignant degeneration; therefore it is most important that consideration be given to each patient individually and all factors evaluated carefully.

Any lesions of fibrous dysplasia which suddenly exhibits an accelerated growth rate or causes severe pain must be suspected of having undergone malignant degeneration. Once the diagnosis is established, the treatment is the same as that for any bone sarcoma. Complete surgical excision of the lesion with a wide margin of uninvolved bone and soft tissue is the treatment of choice. There is a great tendency for local implantation and recurrence. Regional node dissection is not routinely advocated, as metastasis is usually by the hematogenous route. The most frequent site of metastasis is the lung. The prognosis of osteogenic sarcoma is actually not as bad as is generally believed, and occasionally patients with solitary pulmonary metastasis, in whom the entire metastatic lesion has been removed by lobectomy or pneumectomy, have experienced 5-year survivals. Radiation therapy is also frequently beneficial. It should be emphasized that osteogenic sarcoma is not a hopeless condition and that surprisingly good cure rates have been reported.

**Treatment of Intranasal Tumors**

Very small lesions of the anterior nasal septum or nasal vestibule, whether malignant or benign, can be resected with adequate surgical margins by way of the nostril. Electrosurgical excision is certainly of great value when removing these small lesions. For malignant lesions involving the septal mucosa, the resection should include the mucoperichondrium and cartilage. All other lesions should be approached by using the lateral rhinotomy incision.

**Technique of Lateral Rhinotomy.** The entire face is prepared for the operation and draped. The eyelids are closed through the tarsal plates with #5-0 or #6-0 suture material.
The patient is placed in the supine position with his head and face parallel to the floor and supported by a rubber doughnut pillow. His head is placed above the level of his chest to reduce venous pressure.

A local anesthetic agent, with epinephrine added, is infiltrated into the line of incision.

The skin incision begins, as does the external ethmoid incision, half way between the inner canthus and the nasal dorsum. A #15 blade is used for making this incision. The skin is carefully incised to the subcutaneous layers and blood vessels. The angular artery and vein are identified, clamped, and ligated. If they are inadvertently incised, bleeding can be quite troublesome. Smaller vessels can be cauterized. The incision extends down along the side of the nose rather than in the nasomaxillary skin crease until it reaches the superior aspect of the alar crease. It is then continued in the alar crease to the nostril.

The alar incision is extended through all layers and into the nasal cavity. This is continued until the nasal bone (pyriform crest) is reached. A traction suture of #00 chromic catgut, weighed with a heavy hemostat, is placed subcutaneously to provide better exposure. If the tumor is fairly anterior on the nasal septum or in the nasal cavity, additional exposure may not be necessary.

The periosteum is elevated from the nasal bone and ascending process of the maxilla with a broad square-ended periosteal elevator. Sufficient nasal bone and ascending process of the maxilla are removed for proper visualization of the nasal cavity. This exposure usually is sufficient for resection of a fairly anteriorly placed lesion or is at least adequate for evaluation and plan of attack.

Malignant lesions of the nasal septum should be handled by septectomy with as large a margin as is possible. Skimpy surgical margins or attempts to preserve the opposite mucoperichondrium or periosteum only invite recurrent disease which may be impossible to cure.

Lesions of the floor of the nasal cavity are, in essence, lesions of the palate. Malignant lesions in this area require wide excision. X rays may demonstrate evidence of bone destruction. If the malignant lesion has not invaded the bone of the hard palate, the lesion and the underlying hard palate are resected with an adequate margin. The mucosal incision can be made with the electrosurgical knife and the bone removed with the tangential Stryker saw, preserving the underlying mucosa and thus preventing a palatal defect.

If the malignant lesion has invaded bone, then all layers of the nasal floor are removed, leaving a palatal defect. The defect is blocked temporarily with gauze or cotton packing. After healing is complete, a dental prosthesis can be made.

Often it is difficult to block out a specimen from above. In these cases the procedure is combined with a palatal approach. A flap is elevated and reflected laterally and the bony hard palate removed. The anteroposterior incision is made to the contralateral side of the midline so that there will be bone under the suture line.
There are a number of operations for lesions of the lateral wall, depending upon their origin. As a rule the operation involves either removing the upper half (middle turbinate), lower half (inferior turbinate), or both.

With lower half lesions, the periosteum is elevated laterally, exposing the anterior wall of the antrum. The incision in the anterior wall of the antrum is made with a tangential Stryker saw. The incisions above and below the inferior turbinate are made with either heavy turbinate scissors or with a chisel. The specimen is transected posteriorly, with either a snare (preferably one that is insulated so that cautery can be used) or right-angle scissors.

The technique for resecting the upper half or entire lateral nasal wall is very similar, except that superiorly the lacrimal fossa and lamina papyracea must be exposed. The ethmoid bone is transected superiorly, just below the plane of the anterior and posterior ethmoid arteries. For malignant lesions - or potentially malignant lesions - the operation should also include a complete ethmoidectomy.

Benign and small malignant lesions of the superior nasal cavity can be resected with a good margin by using the lateral rhinotomy incision. It is quite often necessary to reflect the nasal bone of the involved side to the opposite side, or it may be necessary to remove this bone with the specimen. A cerebrospinal fluid leak may occur. This can be repaired with either a septal mucosal flap or a skin graft.

Lesions which invade the cribriform area or roof of the ethmoid sinus present a serious problem. Most often they are recurrent lesions (cylindroma). The best chance for cure is by means of a combined intracranial-intranasal procedure. The floor of the anterior cranial fossa is exposed by way of the frontal flap. A block including the cribriform plate and roof of the ethmoid sinus (crista galli and roof of orbit, if necessary) is outlined from above. A similar block is outlined from below by way of a lateral rhinotomy which may be extended. The two approaches are connected and the specimen removed. The defect is repaired from above with fascia lata. A split-thickness skin graft is used intranasally. A mucosal flap from the septum cannot be used, for at least the upper portion of the septum is removed with the specimen. To accomplish a complete rhinotomy the skin incision is extended superiorly across the nasal dorsum. Inferiorly, the incision does not extend into the ipsilateral nasal cavity but just below it - across the base of the columella and into the opposite nasal cavity. Lateral osteotomies are made on each side with a chisel. These are connected superiorly at the nasofrontal suture line. The nasal septum is divided with straight scissors in the same plane as the osteotomy incisions, and the nose is reflected to one side. In addition to the superior nasal cavity, the frontal, maxillary, and ethmoid sinuses are easily accessible by this approach. When closing the wound, the nasal septum should be carefully reapproximated. The skin incision is closed with #4-0 chromic silk suture and #5-0 or #6-0 dermal suture.

Intranasal portions of encephalocele which do not atrophy after intracranial section of the stalk are best approached by this exposure.

When the diagnosis of glioma is established by intranasal biopsy, a bifrontal craniotomy is performed prior to resection of the intranasal tumor. If intracranial connections are found, they are removed along with the nasal mass by the lateral rhinotomy exposure. If no connections are found, the lateral rhinotomy is performed at a later date.
For large malignant lesions which may be radiosensitive there is some value in combined preoperative x-ray therapy. If adequate surgical margins are not obtained, a full course of postoperative radiation therapy is indicated.

**Rhinophyma**

A rhinophyma is a slowly growing tumor usually involving the lower half of the nose. It may, however, involve the entire nose and part of the cheeks. Cases have also been reported in which the ear and chin are affected. The lesion is said to be an advanced stage of acne rosacea (Anderson and Dykes).

Basically the process is an inflammatory one with an associated hypertrophy of the subcutaneous and sebaceous tissues. The sebaceous glands become markedly enlarged and the dilated ducts are filled with sebum and keratotic debris. Masses of atrophic skin having large pores develop. Sebum accumulated between the masses of tissue and superficial vessels invades the surface of the rhinophyma, giving it the reddish color.

The main complaint of a patient with rhinophyma is the unsightliness of the nose. On occasion the growth may become large enough to obstruct the nostrils. A foul odor is usually present when the growth is large and ovulated. Occasionally, the rhinophyma becomes large enough to interfere with vision.

Rhinophyma is usually thought to be associated with alcoholism. Actually, there is no basis for this belief, since there is no consistent relationship. Other factors such as rich diet, gastrointestinal disorders, exposure to sunlight, and vitamin deficiency have also been indicated as etiologic possibilities without any real basis.

**Treatment**

If acne rosacea is the precursor of rhinophyma, possibly intensive care by the dermatologist would prevent its development. Once the rhinophyma has developed, surgical treatment is the only effective therapy. There are two basic methods of surgery. One consists in excision of the rhinophyma within the sebaceous gland layer so as to leave remnants of glandular epithelium which will undergo metaplasia to form the skin covering the nose.

This procedure may be conducted with either local or general anesthesia and entails sculpturing, by means of either a straight razor or a #10 surgical blade. A small electric dermatome may also be of assistance during this shaving and sculpturing procedure. Bleeding can be quite profuse and is controlled by electrocoagulating the larger vessels and packing the surface of the nose with epinephrine solution-impregnated gauze sponges. The incision around the rhinophyma should be beveled in order to eliminate the sharp demarcation between the surrounding skin and the limit of the rhinophyma. Blood loss during the procedure usually does not exceed 500 cc.

The area is dressed with petrolatum gauze or aureomycin-impregnated conforming gauze covered by a bulky dry dressing. The dressing should be changed at the end of 5 or 6 days. Re-epithelialization is usually complete by the end of 4 weeks, and the cosmetic result, although not perfect, is satisfactory to most patients.
The second method of surgical treatment for rhinophyma is total excision in the areolar layer between the disease and the supporting structures of the nose. Some form of skin grafting is, of course, necessary. Split-thickness grafts obtained from the lateral neck are said to be superior to those taken from the thigh (Anderson and Dykes). Excellent results have been reported by Macomber and by Smith through the use of full-thickness skin grafts obtained from the supraclavicular region. Matching skin grafts are taken from both supraclavicular areas for each half of the nose. The skin grafts must be very carefully sutured in place and covered by a dressing similar to that described above. Healing is usually complete at the end of one week.

**Atrophic Rhinitis (Ozaena)**

Atrophic rhinitis is a chronic, inflammatory disease involving the nasal mucous membrane with atrophy and fibrosis of all layers. The epithelium undergoes metaplasia to the squamous type. The cilia are destroyed, and there is a decrease or complete absence of glandular structures. The vascular supply to the mucous membrane undergoes obliterative endarteritis. The condition is referred to as "ozaena" when an odor is present.

The etiologic basis of this condition has not been established. Although bacteria are usually found associated with the disease, infection is not accepted as the primary cause. Endocrine and metabolic factors have been labeled as possible causes. Cultures usually show mixed infection. Klebsiella ozaenae, Perez bacillus, Proteus vulgaris, and coliform-group bacilli are the organisms responsible for the odor associated with this condition.

**Signs and Symptoms**

The signs and symptoms of atrophic rhinitis are:

1. Crusting.
2. Foul odor.
3. Complaint of nasal stuffiness, especially when crusting is extensive.
4. Wide nasal passages.
5. Bleeding mucous membrane.
7. Thick, greenish, purulent discharge.
8. Extension of the disease to the nasopharynx, pharynx, and larynx.

**Medical Treatment**

The nasal discharge is cultured, and specific antibiotic therapy instituted locally and systemically. The nasal cavities are irrigated with warm normal saline solution or Alkalol at least twice daily. The irrigation container is placed well above the patient's head. The nozzle is inserted into one nasal cavity. The patient is then asked to lean forward over a washbasin, breathing quietly through his mouth. The irrigating solution will enter by one nostril and leave by way of the other. Frequent visits to the rhinologist, at least during the early phase of treatment, may be necessary for removal of crusts. Such medication as vitamin A, given in high doses; nicotine acid tablets, 50 mg three times a day; and syrup of hydriotic acid, 1
teaspoonful in half a glass of water three times a day, are well worth a trial. A lubricating nasal spray or one containing iodine can be used after irrigations.

**Surgical Management**

Surgical treatment is designed to narrow the abnormally patent nasal passages. Basically, there are two techniques for implantation of substances such as bone chips from the iliac crest, deproteinated bovine chips, dolomite, and silicone. These are: implantation through a sublabial incision and implantation by way of an incision into the nasal vestibule. There have also been reports of beneficial effects following the submucosal injection of silicone or Teflon paste.

The sublabial incision is made just anterior to the canine fossa in the gingivobuccal sulcus. A small amount of pyriform crest is removed for better access to the periosteum of the lateral wall and to reduce the incidence of mucosal tearing when the implant is inserted. The periosteum is elevated lateral to the inferior turbinate as far superiorly as possible. The pocket between the periosteum and bone is then packed with the chosen implant. It is most important that there be no communication between the nasal cavity and the implant, for if a communication exists, infection and extrusion of the implant are inevitable. The sublabial incision is closed tightly without drainage. No intranasal packing is required.

Postoperatively, there will be complete nasal obstruction on the side operated upon for approximately one week, after which the swelling will gradually subside.

Implants inserted by way of incisions into the nasal vestibule can be positioned subperiosteally in the lateral wall, in the floor of the nose, or in the nasal septum. The sharp anterior margin of the pyriform crest is the guide to the periosteum of the lateral wall. Because of the pathogens that are present in the nasal cavity in association with atrophic rhinitis, infection is slightly more prone to follow implants positioned through this route than those inserted through a sublabial incision.

**Reconstructive Nasal Surgery**

For centuries man has been quite conscious of the size, shape, and color of the structure projecting anteriorly from his face. His, and the attention of his fellows, is immediately focused on the slightest defect of his nose.

Nasal defects are caused by trauma, infection, or operation for tumor removal. Surgical repair of these defects dates back many centuries and probably represents man's first attempt at reconstructive surgery. Surgeons have not only utilized the surrounding tissues for repair of nasal defects, but have also employed remote, pedicle and free autografts. In the following paragraphs are presented descriptions of those procedures best suited for repair of defects in the various anatomic sites on the nose, and, finally, the technique for total nasal reconstruction.
Repair of Lower Lateral Nasal Defects

On occasion, a small notchlike defect in the central lower lateral region of the nose can be repaired by means of a simple advancement procedure.

An incision, in the shape of an inverted V, approximately 0.5 cm above the small notchlike defect is made.

The surrounding area, including the ala, is extensively undermined so that the inferior margin of the incision can be retracted downward with a skin hook.

The resulting surgical defect is repaired in a linear vertical suture line.

This type of defect can also be repaired by a V-Y advancement technique. The inverted V incision is made, again undermining the surrounding area, including that of the alar margin.

The notchlike defect is erased as the defect is repaired, creating a 'Y' suture.

A large posterior, lower lateral alar defect can be repaired by using a superiorly based pedicle flap which is based posteriorly and inferiorly to the nose. A modification of this technique is that of obtaining a composite graft from the conchal region consisting of the conchal cartilage and the overlying postauricular skin. During a first-stage procedure, the conchal cartilage and skin are buried beneath the end of the flap. The cartilaginous part of the composite graft faces the subcutaneous layer. After a few weeks the flap is elevated, tailored, and sutured to the alar defect. In so doing, the postauricular skin forms the external layer of the repair.

Incision is made in the nasolabial sulcus. The flap is elevated in the subcutaneous plane and the area posterior to the defect is undermined. The flap is then rotated anteriorly, so that the posterior angle of the flap is rotated anteriorly to be attached to the anterior angle of the skin defect. Lateral vertical edge of skin is inverted and sutured horizontally to the mucous membrane margin. The medial vertical skin margin is inverted and rolled to produce the lower edge of the nasal ala. A full-thickness postauricular skin graft is obtained, fashioned and sutured in place, so that it covers the external nasal defect.

A defect of the lower lateral nose may be repaired by creating a defect above the deformity, which, in turn, is repaired by using a composite graft.

An incision is made slightly curved in the shape of an inverted 'U'. The incision is carefully carried through the subcutaneous layer to the level of the intranasal mucous membrane. A plane is established just external to the mucous membrane. Undermining is carried out in all directions, especially superiorly, to form and ellipse. The elliptic defect develops as the lateral alar margin is depressed. It is usually necessary to incise the mucous membranes intranasally, to lower the lateral alar margin, and also to make certain that the mucous membrane is present in the floor of the defect. A postauricular full-thickness graft is fashioned so that it accurately fills in the defect. Intranasal packing is inserted, and an external pressure dressing is applied.
A notchlike defect in the anterior aspect of the lower lateral nose can be repaired by rotating an inferiorly based flap in a postero-inferior direction.

Deformities of the lower lateral nose can also be repaired with composite auricular grafts. The graft is measured to be slightly larger than the nasal defect. The postauricular side of the composite graft is used for the external nasal surface. The skin-to-mucosa membrane layer is completed before the external dermal sutures are applied.

The skin on the inner margin of the defect, as well as all scar tissue, is resected. It is most important to remove this scar tissue in order to obtain an adequate blood supply for the composite graft. The posterior margin of the auricle, just inferior to the beginning of the triangular fossa, is usually the best site from which to obtain the full-thickness graft. If the graft is not too large, the auricular defect may be repaired in a straight line. For repair of larger and irregular defects, refer to otoplasty, later. The skin is sutured to the intranasal mucous membrane with #4-0 chromic catgut. It is important to make certain that the skin is in contact with the mucous membrane in all areas. The composite graft is sutured in place. A very fine polyethylene or silk suture material is used for external closure. The nasal cavity is packed lightly, but usually no external dressing is necessary.

An anterior, lower lateral, nasal alar defect is repaired by means of a two-stage procedure, using a posteriorly based full-thickness nasal pedicle flap.

A defect in the lower lateral nose above the alar region can be repaired by using an inferiorly based pedicle flap. A superiorly based nasofrontal pedicled flap can also be used to repair this defect.

A malignant infiltrative lesion in the region of the ala and lower lateral nasal wall should be widely resected. This resection includes all layers of the lateral nasal wall. Repair is made with a long nasolabial flap. The tip of this flap is folded in to form the defect in the nasal lining. The cosmetic result following this repair is quite good. A cartilage graft may be used to support the lateral alar rim.

The resected area includes a portion of the inferior nasal vestibule and anterior aspect of the floor of the nasal cavity. Bleeding should be controlled by either electrocoagulation or catgut suture. A superiorly based nasofacial flap is quite suitable for repairing this defect, which is too large to nourish a composite graft from the auricle. The length of the flap is determined by measuring the external defect and adding the required length for the intranasal lining. This flap should, of course, not be longer than twice the width of its base. Following resection of the lower lateral nasal wall, the nasal septum, anterior tip of the inferior turbinate, and floor of the nasal cavity can be seen. The flap is elevated in a plane which includes the fascia covering the muscles of facial expression. The skin is elevated superiorly, laterally, and inferiorly so that the defect lateral to the nose can be closed. Subcutaneous #3-0 or #4-0 chromic catgut and dermal #5-0 polyethylene or #6-0 silk suture material are used for this repair. In order to close the defect in the floor of the nasal orifice, the mucous membrane posterior to the defect and the skin inferior to the defect are undermined sufficiently so that there is very little tension in the suture line. This defect is closed with a single layer of dermal sutures. A goodly portion of the defect lateral to the nose has been closed. This causes some elevation of the upper lip and tends to pull the lower lid downward. If it is apparent that
the ectropion will result, then it is best to perform a medial tarsorrhaphy, leaving the sutures in place until the tissues have relaxed. The defect in the floor of the nasal vestibule has been repaired. The tip of the nasofacial flap is reflected onto itself after the length necessary to cover the lower lateral nasal defect has been measured carefully. Chromic catgut suture material (#4-0) is used. The flap has been sutured in place with a single layer of dermal suture material. The extra width of the superior portion of the flap causes an outward bulge or convexity which roughly approaches a normal contour. The nasal cavity is loosely packed anteriorly with petrolatum-impregnated iodoform gauze. A dry, external pressure dressing is applied to the right eye, right face, and lateral surface of the nose. This remains in place for 48 hours. The intranasal packing can be removed after 3 or 4 days. If the cosmetic result and contour of the repair are not satisfactory, a cartilage graft can be inserted in the alar region at a later date.

**Repair of Nasal Tip Defects**

There are a number of techniques for repair of a defect of the nasal tip. A free composite postauricular skin graft is probably the most popular. For this type of repair a pattern is made from the defect to that the full-thickness graft will fit exactly into place. The graft is sutured with one layer of fine dermal suture material and covered with a pressure dressing. The postauricular composite graft technique is by far the simplest one, but on occasion the color and texture match is not good.

A second method for repair of the nasal tip involves the use of bilateral nasolabial skin flaps, which are sutured together in the midline. This technique is most satisfactory if the nasal tip defect is large and not suitable for a postauricular composite graft or a rotational flap as described below. The cosmetic result and color match with bilateral labial flaps are excellent.

In a third technique for repair of defects of the nasal tip a local advancement flap is employed. This procedure is somewhat more difficult than that utilizing the postauricular composite graft, but the color match and texture are considerably better.

**Repair of nasal tip defect - technical details**

A moderate-sized defect of the nasal tip extends to or through the lower lateral cartilages. An exact pattern of the defect is made and placed in the postauricular region from which a full-thickness skin graft, slightly larger than the pattern, is obtained.

The postauricular composite graft is carefully placed in the defect and sutured with one layer of fine dermal suture material. A pressure dressing is applied over the graft and left in place for 48 hours.

The incisions for construction of a flap consisting of skin and subcutaneous layers, overlying the nasal dorsum and root, are shown.

The flap is carefully elevated over the perichondrium of the upper and lateral cartilages and over the fascia overlying the frontalis muscle superiorly. A rather extensive underlying is required superiorly in all directions. As the flap is advanced inferiorly the sharp
tip is rounded and sutured to the opposite skin just above the level of the inner canthus. Superiorly, the defect is closed in a vertical suture line.

The repair and advancement are continued from above, downward. A small "dog ear" may occur at the base of the flap as a result of this inferior rotation. If this has not disappeared after a few months, it can be excised. A pressure dressing is applied over the entire nose and forehead and left in place for at least 24 hours. The cosmetic result following this procedure is surprisingly good.

**Repair of Lateral Nasal Defects**

Large lateral nasal defects are repaired by using superiorly or inferiorly based nasofacial skin flaps. As a rule, the superiorly based flap gives the best cosmetic result.

Smaller lateral nasal defects can be repaired with either the advancement technique or with a postauricular composite graft.

**Repair of lateral nasal defects - technical details**

Defects on the side of the nose can be repaired with a superiorly based cheek flap as outlined. The flap is based near the lateral aspect of the nose. The medial incision for the flap is in the nasolabial crease, and the tip of the flap is pointed to facilitate closure. A triangular segment of skin is removed from the tip so that it can conform with the lateral nasal defect. Laterally, rather extensive undermining is necessary.

The flap is advanced and sutured into place. The defect is closed so that the resultant scar will simulate the nasolabial sulcus. Since tension is not particularly in an inferior direction, a medial and lateral tarsorrhaphy is usually not necessary.

A smaller defect on the side of the nose can be repaired by means of an advancement technique. This operation is especially feasible if the defect can be converted to a triangular shape. An incision is made from the inferior angle of the defect to the nasolabial sulcus. A triangular piece of skin approximately the size of the defect is removed just lateral to the alar sulcus.

After the skin has been undermined rather widely over the cheek, creating a flap which can be advanced superiorly, the skin is sutured.

**Repair of Nasal Root Defects**

Operations for repair of defects in the root of the nose are numerous. A technique which gives an excellent cosmetic result, unless the patient has scanty eyebrows, is outlined. A small inferiorly based glabellar flap is useful for lateral defects of the nasal root.

**Repair of nasal root defect - technical details**

The incisions for the repair of the defect remaining after resection of a lesion at the root of the nose are indicated. The measurements of the flap to be reflected from the forehead
to the root of the nose are made according to the width and height of the defect. One incision is made in the upper margin of the eyebrow. This is a most important incision, for if the scar is even 1 mm above the eyebrow, it can become an unsightly one. The incisions above that one approach it and abut at a very sharp angle laterally.

The triangular piece of skin between the two incisions is removed, exposing the fascia over the frontalis muscle in this area. The skin is undermined superiorly in a plane over the frontalis muscle so that the flap can be pulled into the defect without too much tension. If the defect at the root of the nose is large, and the skin of the forehead is taut, it may be necessary to elevate the superior flap in a plane between the frontalis muscle and the periosteum of the frontal bone. In such cases it is usually also necessary to make a horizontal incision through the fascia underlying the frontalis muscle.

The flap and defects above the eyebrows are sutured subcutaneously with multiple, carefully placed, #4-0 chromic catgut. The skin is then repaired with #5-0 polyethylene or #6-0 silk suture material.

A small defect in the side of the root of the nose can be repaired by using a pedicled flap in the glabella region. The flap, based on one frontal artery, is oblique.

The flap has been elevated and transposed to cover the defect. Rather extensive undermining is necessary to close the defect in the glabella region.

The defect in the glabella region is repaired by subcutaneous suturing with #00 catgut and approximating the skin edges with fine dermal suture material. This flap is rotated less than 90 degrees and has an excellent blood supply.

**Subtotal Nasal Reconstruction**

Subtotal nasal reconstruction is necessary for repair of defects following resection of a large lesion of the nose. These defects are not difficult to repair, even when most of the nasal dorsum has been removed, providing sufficient bony and cartilaginous support remains.

It is usually not necessary to cover the defect with split-thickness skin graft following resection of a large lesion of the nasal dorsum, nor is this required for observation for recurrent tumor, providing careful frozen sections are made of the skin margins at the time of resection. Secondary repair after skin grafting is technically more difficult, and the cosmetic result is not very satisfactory. Large defects of the nasal dorsum which do not involve the cartilage and bone can be repaired by using the Indian type of pedicled forehead skin flap, or the island forehead flap. An alternate method for repair of a large defect of the nasal dorsum is by means of bilateral nasal facial flaps.

A thorough knowledge of the blood supply to the bases of the various pedicled skin flaps used to accomplish subtotal and total nasal reconstruction is essential.
**Subtotal nasal reconstruction - technical details**

Blood supply to the face is complex. Forehead flaps used for reconstructive surgery are based on the frontal branches of the superficial temporal artery, the supraorbital artery, frontal artery, or frontal branch of the angular artery. The large forehead flap used for total nasal reconstruction is based on all of these arteries.

**The Island Forehead Flap**

After the lesion and its margins are resected, a pattern of paper or cloth is carefully made of the defect. This pattern is transferred to the median forehead. Following the outline of the pattern an incision is carried through skin and subcutaneous layers to the fascia over the frontalis muscle. It is then carried through the frontalis muscle laterally and superiorly, but *not* inferiorly, exposing the periosteum over the frontal bone. A wedge of skin and subcutaneous tissue are resected superiorly and inferiorly in order to facilitate the vertical midline closure of the defect.

An incision connecting the inferior aspect of the forehead defect and the upper margin of the nasal defect facilitates exposure and dissection of the subcutaneous vascular pedicle. It also aids the rotation of the island flap, as it is reflected inferiorly to cover the nasal defect.

The flaps have been elevated in a subcutaneous plane between the nasal and forehead defects. The subcutaneous vascular pedicle is dissected posteriorly between the frontalis muscle and the frontal periosteum, in the region of the glabella.

Using a "peanut" sponge the posterior aspect of the vascular pedicle is dissected further without jeopardizing the blood supply of the island flap.

The island flap is rotated 180 degrees into position to cover the nasal defect. By exposing the area between the nasal and forehead defects, rather than tunneling, the vascular pedicle can be more neatly arranged to prevent kinking and interruption of the blood supply. The carefully repaired vertical defect that results is a small price to pay for prevention of such sequelae. Rather extensive undermining is necessary over the periosteum of the frontal bone in order to close the forehead defect. Vertical incisions through the fascia underlying the frontalis muscle on each side of the defect may be necessary in order to effect a primary closure.

The island flap has been sutured into place. The forehead defect is then repaired, and the incision between the two defects sutured. A dressing applied with moderate pressure over the dorsum of the nose and forehead, which necessitates having both eyes covered, is left in place for 24 hours.

Most of the epithelial covering of the nose has been lost, including that of the columella. The cartilaginous and bony areas of the nasal pyramid remain intact. The midline Indian forehead flap, as popularized by Dr. V. Kazanjian, probably provides the most practical method for repairing this defect. This flap is based on the medial and lateral frontal arteries.
The forehead flap is rotated 180 degrees forward and sutured to the nasal defect. If the columella is absent a superiorly based pedicled skin flap is elevated from the midline of the upper lip and sutured to the inner posterior surface of the distal end of the forehead flap. A mucous membrane flap from the midline of the inner aspect of the upper lip may also be used for this purpose. This is also based superiorly and brought out through the buttonhole incision in the base of the columella.

If the forehead donor site is 2 cm or less in width, it may be closed by extensive undermining over the periosteum. Vertical incisions as indicated through the fascia underlying the frontalis muscle are usually necessary to accomplish this closure. The portion of the defect used for construction of the columella is closed in a vertical suture line. The defects representing the portion of the forehead flap used for the nasal alar region are closed with an oblique suture line. The remainder of the defect is closed in the vertical midline, with heavy subcutaneous sutures as well as dermal sutures.

If the defect is wider than 2 cm, it is necessary to use a large rotational scalping flap on each side of the forehead. The flaps are rotated medially and sutured in the midline. The coronal incisions are made along the hairline to the level of the external auditory canals. Care should be taken to preserve the frontal branches of the superficial temporal arteries.

The final repair following advancement of bilateral scalping flaps, which are based on the frontal branches of the superficial temporal artery, is shown. If the entire nose is devoid of epithelium, then the midline flap is not practical, and the scalping flap, must be used.

**Total Nasal Reconstruction**

Total reconstruction of the nose is a complicated and technically difficult undertaking as is manifested by the numerous techniques presented in the literature. When planning this multi-procedure reconstruction the surgeon must outline a schedule for the following:

1. Lining of the nasal cavity.
2. Bony support of the nasal pyramid.
3. Outline of forehead flap for covering of nose.
4. Reconstruction of the columella and alae.
5. Repair of the forehead.
6. Touch-up procedures to accentuate alae, narrow the bridge, and thin the columella.

**Lining.** The lining for a total nasal reconstruction can be obtained from remaining mucous membrane on the lateral nasal walls, forehead flaps, or paranasal pedicled skin flaps. These various flaps have a high percentage of take, for the blood supply to these areas is more than adequate with the numerous branches of the facial, sphenopalatine, and anterior ethmoid arteries.

A medial forehead flap can be used for the lining of the nasal cavity. This will not interfere with the forehead flap to be used for the covering of the reconstructed nose. The fulcrum for the bony cantilever support can be wired in place when the median forehead is detached.
When using a combination of local and nasolabial flaps to construct the lining of the nasal cavity, it is possible to apply the bony support and nasal covering at the same operation.

**Bony Support.** The technique of constructing a cantilever shaft of rib bone, as reported by Millard, is the best means of providing support for a total nasal reconstruction because of the simplicity of the technique itself and the resulting strength and stability. The beam of rib bone extends from the glabella to the nasal tip and is supported by a fulcrum between the two maxillary bones to finally resemble the gnomon of a sun dial.

The fulcrum to support this beam is made by mortising and wiring a piece of rib bone to the maxillary bones one each side of the nasal defect. Wire holes are then drilled through the fulcrum and the maxillary bones. After the wires on each side are twisted, one end is left long so that it can be used to attach the cantilever to the fulcrum.

The cantilever strut is also constructed of rib bone. It is rounded on one end and notched at the other. Prior to its application the soft tissue is elevated in the superior aspect of the nasal defect, exposing the nasal process of the frontal bone. The frontal bone is notched inferiorly to receive the notched end of the cantilever strut. After the cantilever strut has been mortised in place, it is wired to the fulcrum.

**Covering.** A scalping forehead flap provides the best covering for a total nasal reconstruction. This flap is based on the frontal artery and the frontal branches of the superficial temporal artery. Some surgeons prefer to delay this flap for at least 2 weeks.

As a first stage, in addition to delaying the forehead flap, the portion of the flap which is to form the alae and the columella may be raised and lined with split-thickness skin graft. The forehead flap is elevated in a plane above the periosteum of the frontal bone. It is folded on its pedicle, rotated into position, and sutured into place.

In some cases, the recipient area for the tip of the columellar portion of the forehead flap may have an inadequate blood supply. Tubing this portion of the forehead flap adds to its viability, but, on the other hand, can cause sufficient thickening of the columella so as to interfere with the airways. There are two methods which will both increase the blood supply of this columellar portion of the forehead flap and line its posterior surface. The first is that of forming a superiorly based skin flap from the upper lip. This flap is elevated subcutaneously in the midline. An alternate method is that of lining the inner aspect of the columella with a superiorly based mucous membrane flap from the midline of the inner aspect of the upper lip. This flap is reflected superiorly through a buttonhole incision in the region of the columellar base.

The periosteum of the frontal bone which is uncovered remains exposed and is covered with ointment-impregnated gauze or Telfa gauze. The portion of the defect supplying the columella for the reconstruction is closed in a horizontal, linear suture line. An external dressing of moderate pressure is applied both to the forehead and to the reconstructed nose.

The forehead flap is divided in the region of the root of the nose after 3 to 5 weeks and is reflected to its anatomic position on the forehead. That portion of the forehead
remaining uncovered can be covered with a split-thickness skin graft or with scalp flaps rotated into this area.

Touch-up procedures may be added at a later date to narrow the nose and to form a lateral alar crease. The nose can be narrowed by incisions in the nasofacial creases. A Z-plasty can be used to form nasoalar creases in this area.

**Total nasal reconstruction - technical details**

**Lining for nasal cavities**

Flaps consisting of skin and mucous membrane are constructed on each side of the upper nasal cavity. These are turned in from each side and sutured in the midline.

A small "Indian" midline forehead flap, based on a frontal artery, is reflected inferiorly to cover the flaps.

After approximately 6 weeks, the midline flap is divided at its base and dissected from the underlying lining of the upper nasal cavity. A piece of rib bone is bridged between the two maxillary bones. This bone, which is to function as a fulcrum for the bony cantilever support of the reconstructed nose, is mortised and wired to the maxillary bones. The flap is sutured back into place to cover this bony fulcrum. The final stage of the nasal reconstruction is performed at a later date. The flap is again reflected inferiorly to form the lining of the anterior aspect of the lower nasal cavity during the operation for construction of the bony support of the nose and rotation of the forehead flap for the nasal covering.

The superior nasal cavity is lined by constructing a flap of skin and mucous membrane on each side of the nose. As small amount of skin as possible is used in this flap, in order that the lateral defect in this area will be as little as possible. Triangular-shaped nasolabial flaps are constructed on each side in the nasolabial sulcus.

Both the superior and nasolabial flaps are elevated in the subcutaneous plane. The skin lateral to the nasolabial defect is undermined sufficiently to provide for a linear enclosure.

The superior flaps have been sutured to each other in the midline. Nasolabial folds are advanced superiorly and medially and sutured to each other and to the superior flaps. The nasolabial defect is sutured in a straight line. The scar will simulate a nasolabial sulcus.

**Bony support**

A small piece of rib bone is notched at both ends. Two holes are drilled in this bone to make a fulcrum which bridges across the upper aspect of the nasal defect between the two maxillary bones. On the right, is a cantilever strut which is notched at one end and rounded at the other. The notch fits posterior to the nasal process of the frontal bone.

The fulcrum is bridged between the two maxillary bones, and then mortised and wired in place. One end of each of the two wires is left long. These ends will be used to secure the cantilever strut to the fulcrum.
The cantilever strut has been mortised to the nasal process of the frontal bone and wired to the fulcrum. The mortising of the fulcrum to the maxillary bone and of the cantilever strut to the nasal process of the frontal bone adds great strength and stability to this bony support.

A lateral view of the cantilever strut and the fulcrum. An additional wire can be placed around the fulcrum and cantilever strut if necessary.

**Covering**

A scalping forehead flap is used for covering in a total reconstruction. The entire forehead is utilized. The flap is based on the frontal artery and the frontal branches of the superficial temporal artery on one side. If the flap is to be delayed, the areas to form the alae and columella are lined with split-thickness skin graft. Elevation of the flap is accomplished in a plane above the periosteum of the frontal bone.

The posterior surface of the columellar portion of the forehead flap can be lined by using a superiorly based pedicled skin flap from the midline of the upper lip.

An alternate method for lining the posterior surface of the columella is that of fashioning a superiorly based mucous membrane flap from the inner aspect of the upper lip. This flap is advanced through a buttonhole incision in the region of the columellar base.

The forehead flap is folded on its pedicle, rotated to form the nasal covering, and sutured in place. The forehead defect is carefully dressed and the dressing kept in place for from 3 to 5 weeks, until the forehead flap is divided at the root of the nose. That portion of forehead which remains unsurfaced is covered with a split-thickness skin graft.
Surgery of the Upper Respiratory System

William W. Montgomery

Chapter 9: Rhinoplasty

By Edgar Holmes, MD.

Surgical Anatomy

The surgeon's familiarity with the structure of the nose invites smooth, easy operating. The lack of it invites anxiety, awkwardness, poor results, and complications.

Over the nasal bones and lateral cartilages the skin is thin and fairly freely movable. The skin is much thicker, contains more glands, and is firmly adherent over the alar cartilages. The blood supply is mainly in the soft tissues. The dissection should lie in planes of cleavage whereby vessels are avoided and bleeding is minimized. The bony nose consists of paired nasal bones which are thin in their lower half to two third, and solid in their upper third. These bones rest upon the frontal spine (nasal process) of the frontal bone and are held, as if in a vise, between the two frontal (ascending) processes of the superior maxilla. The frontal (ascending) process of the maxilla forms the lateral aspect and lower two thirds of the nose. The maxilla also forms the floor of the anterior nasal cavities.

Description of the Cartilages

The cartilages of the nose are basically five. They form the support of the flexible portion of the nose. The septum lies in the midline, and firmly attached to it are the two lateral cartilages which in some persons are apparently fused. Below these cartilages, and resting upon them, are the lateral wings of the paired alar cartilages. When feeling one's nose, it is easily noticeable that the mid-portion can be moved freely from side to side, but can be depressed only slightly. The tip, which is formed by the alar cartilages, can be moved quite freely upward, downward, and in and out. It also will be noted that the lateral cartilages go beneath the nasal bones and are quite firmly attached to them for a varying distance of from 2 mm to 1 cm. This relationship is extremely important if there is a fracture of the septum which deviates the cartilaginous portion of the nose to one side. When this occurs, the lateral cartilages, after having been torn loose from the nasal bone at the time of injury, will heal in this new angulated position. One may straighten the septum to create a nose which is aligned in the midline, but it will migrate back again unless the lateral cartilages are free from the undersurface of the nasal bones, permitting them to re-align also. The septal cartilage extends up beneath the nasal bones, at least as far as the lateral cartilages, where it joins the perpendicular plate of the ethmoid, and here it thickens. Just beneath the dorsum the nasal septum becomes thicker and tends to bifurcate, or flare to its edge, where it comes in contact with the lateral cartilages. The septal cartilage and the lateral cartilages do not fuse in this area, although they appear to do so. A section through this area will show that the perichondrium is continuous around the septum and around each lateral cartilage. The edges of the cartilages are bound together with dense connective tissue.
The paired alar cartilages are the supporting skeleton of the nasal tip. Each cartilage has a lateral and a medial crus, or what is really an irregularly shaped U. The medial crura come together in the midline, and their lower portions flare slightly into each nostril. The lateral crura are bulbous, sometimes irregular at the tip, with a tendency to flare and flatten out laterally. The skin of the undersurface of the lateral cartilage is quite readily separated from it, but at the medial crus, the skin is adherent and difficult to separate. The alar cartilages move freely over the lateral and septal cartilages.

There are muscles attached to the lateral and alar cartilages which control the size of the vestibular opening. On close observation it will be noted that the nose is quite animated. Stand before a mirror and make facial expressions of surprise, disgust, and move the lips from side to side and appreciate the extent of this mobility. Next grasp the tip of the nose and observe that it is freely movable and not attached to the septum or lateral cartilages. When the planes of cleavage are not adhered to by the surgeon, and the muscles are cut through or torn, the nose will become quite motionless and appear lifeless.

The Septum

The septum is extremely important in rhinoplasty, particularly when it is post-traumatically bend and causes an external deformity, but obstructs the nasal airways as well. The quadrilateral cartilage of the septum forms a part of the nasal dorsum. If the septum is broken and thus depressed or deviated, the cartilaginous dorsum will become depressed or angulated. This cartilage is held firmly between the nasal bones and the groove in the premaxillary spine and vomer and also in its articulation with the perpendicular plate of the ethmoid bone. A blow to the tip of the nose which bends it sharply to one side will create a common deformity by fracturing the cartilage between the two fixed points, the tip of the nose and the premaxillary spine. If the blow is on the dorsum of the cartilaginous tip, the cartilage may disarticulate from the vomer groove and in so doing will depress the dorsum. This is observed following trauma with or without nasal bone fractures. If observed soon after injury, the cartilage should always be replaced and immobilized in position until healing occurs. This replacement of a broken and displaced septum will also maintain the support of the nasal bones once they have been reduced. However, this is sometimes extremely difficult to do, because of the marked lacerations, multiple fractures, and swelling of the soft tissues resulting from the trauma.

Anesthesia

The external nose is supplied by branches of the infraorbital nerve, the nasociliary nerve, and a nasal branch of the superior alveolar nerve. The lining of the nasal cavities is supplied by the anterior ethmoid nerve, the nasal branch of the superior dental nerve, and branches from the sphenopalatine ganglion, which also supply the septum and the lateral wall of the nose.

Local anesthesia is preferable in most cases not only for plastic operations upon the nose, but also for most intranasal procedures. Combined with correct preoperative medication, local anesthesia permits the surgeon to operate in a comparatively dry field on an unapprehensive patient. The inside of the nose should first be shrunk and superficially anesthetized with the combination of a vasoconstrictor and a topical anesthetic. A good
combination is 2 cc of 1:1000 epinephrine solution in 100 cc of 2% Pontocaine or 4% topical Xylocaine, which may be made up as a stock solution. The nose is sprayed with this solution before the patient is brought to the operating room. Once the patient is "prepped" and draped, the inside of the nose is ready to receive cotton moistened with the anesthetic. Cocaine (4%) is also very satisfactory, because it is a vasoconstrictor as well as an anesthetic. When a barbiturate is used for premedication there is practically no risk of a cocaine reaction. The topical anesthetic is placed in the region of the anterior ethmoidal nerve and the sphenopalatine ganglion either by a cotton-tipped applicator or by strips of cotton about 2 inches long, 0.5 inches wide, and 0.125 inch thick.

The external nose may be anesthetized either by a block or an infiltration anesthetic. The combination of the two is most satisfactory. Here, again, the choice of anesthetic may be left to the operator. Either procaine or Xylocaine with epinephrine 1:50,000 to 1:100,000 works well. The epinephrine, by its vasoconstricting action, holds the anesthetic in location and controls capillary bleeding.

There are several methods of injecting. The one I find most satisfactory is as follows: A 24-gauge needle, 1.5 inches long, attached to a 5-cc Luer Lok syringe is used. Choosing an injection site on the dorsum of the nose, about the level of the inner canthus, infiltration is carried out slowly, so as not to cause ballooning of the tissues, down to, and including, the infraorbital nerve, first on one side, and then on the other. By fanning the direction of the needle, the region of the glabella and the entire dorsum of the nose may be infiltrated. The upper lip and buttresses may be blocked by injecting into the infraorbital foramen. This may readily be performed by directing the needle through the skin adjacent to the ala of the nose, but 0.25 inch from it and then up to 0.25 inch below the infraorbital rim. A finger placed on the infraorbital rim is of assistance in locating the foramen. For the entire external nose, 4 to 5 cc is adequate. The next site of injection is at the base of the left ala, if the operator is right-handed. The injection is carried beneath the columella to the opposite side. Pulling the needle back, it may be directed into the base of the columella, and, by tipping the nose to one side, the needle may be directed up, in front of the septum. This will usually give complete anesthesia of the outside of the nose although additional injection into the vestibule is occasionally advisable to control bleeding. The dorsum of the nose may now be skeletonized completely in preparation for removal of the hump. Before doing this, I inject both sides of the septum beneath the dorsum and laterally on the undersurface of each nasal bone. If a submucous resection of the septum is necessary, topical anesthesia is combined with infiltration anesthesia, primarily for hemostasis.

With careful injection technique, tachycardia, palpitations, anxiety, or nervousness rarely follows, particularly when adequate preoperative sedation has been given. Of course, it is impossible to have a set anesthesia schedule, because no two people respond identically to medication. A routine preoperative medication may be employed, but, when the patient is in the operating room, supplementary anesthesia may also be prescribed at the surgeon's discretion. For basic anesthesia, 100 mg of Nembutal are given by mouth 2 hours before the operation. One hour preoperatively, another 100 mg of Nembutal, plus 50 or 75 mg of Demerol, and 0.4 mg of scopolamine are administered intramuscularly. This may be varied to suit the individual patient and is not prescribed as the only or ultimate preoperation medication.
Rhinoplasty Technique

Exposure of the Nasal Skeleton

The basic incision for exposure of the nasal skeleton, called the intercartilaginous incision, is made between the alar and lateral cartilages. This incision exposes the outer surface of the lateral cartilage where a dissection plane is encountered. Utilizing traction of the ala, the soft tissues are dissected away from the lateral cartilage with either a double-edged Joseph knife or a very flat, nearly pointed scissors. This may be done under direct vision, and getting out of the plane of dissection into the overlying muscles will be avoided. The dissection is carried up to the lower border of the nasal bones and to the edge of the frontal process of the maxilla, but not up over the bone. With a sharp blade, an incision is made through the periosteum over the nasal bones as near their lower border as practical. This bony edge is usually serrated, and it is necessary to make the incision 2 or 3 mm above the margin. This can be done under direct vision, but it is easier to do by touch. The blade is inserted on top of the nasal bones, brought down on its edge, and then raised and brought up to the point of incision. Starting laterally, near the frontal process, and using only the tip of the blade, the periosteum is incised up to the midline. A thin and narrow periosteal elevator may be inserted beneath the periosteum at the lower end of the incision and carried up to the root of the nasal bones. The entire elevator can then be brought broadside to the dorsal midline. It is quite difficult to separate the median raphe from the dorsum. A pair of scissors may be used to effect the separation, cutting close to the bone and cartilage.

The transfixion incision is next made with either a curved button knife or a #15 Bard-Parker knife blade. Holding the nasal tip up with a double-hooked instrument and pulling the columella away from the septum, the knife is pushed through the soft tissue just in front of the septal cartilage. The incision is carried down in front of the cartilaginous septum to the premaxillary spine. If it is desirable to extend this further, the columella is retracted and the muscles dissected away from the maxilla either with a periosteal elevator, knife, or scissors. The transfixion incision is next extended upward to communicate with the previously made intercartilaginous incisions.

The nasal framework is now exposed. Strands of tissue attaching the skin to the framework should be cut.

Removal of Nasal Hump

There are several ways of removing a nasal hump, which consists of both bone and cartilage. The three main methods employ (1) the nasal hump rongeur, (2) the osteotome, (3) the nasal saw.

Rongeur Technique. The sharpness of the surgeon's instruments for this procedure is very important. A nasal hump rongeur, as purchased, is rarely sharp enough and must be re-sharpened. If the hump is small, the instrument may be placed at the level that one wishes to remove the hump, and one closure of the instrument will cut the cartilage and bone straight through without much more having to be done. If the hump is large and particularly broad, it is necessary to uncap it by merely removing its top. This exposes each nasal bone and the septum as separate entities. Next the lateral cartilages are separated from the septum by using
scissors and making certain that the cut is made adjacent to the septum. Under direct vision, each side of the nasal dorsum is removed down to the desired level. This is followed by trimming the septum. In this way, fracture of the nasal bone in an undesirable place is avoided; such a fracture may occur if removal of a large hump is attempted with one cut of the rongeur. With the rongeur the surgeon is able to cut not only the cartilage, but also the membrane. It is easier to cut the membrane and cartilage in this manner than with a knife or scissors. Once the nasal dorsum is lowered to the desired level, it may be necessary to lower the bone near the glabella, where it is solid, by using a rasp or osteotome. Care must be taken that the plane of the rasp is parallel to the desired dorsal profile. The level to which the dorsum is lowered may be predetermined by a set of ideal aesthetic angles, but in reality it is up to the surgeon's aesthetic judgment to decide when enough has been done. It is always advisable to remove too little at first, because more can always be removed if this seems necessary. The reverse is not true, and the insertion of cartilage to restore the dorsum to the desired level is never as satisfactory as lowering the dorsum in an exact manner.

The rongeur method of removal of the nasal hump, as well as the two methods described below, requires practice before perfection is attained. The rongeur technique is my preference.

Osteotome Technique. The osteotome must be broad enough to include the entire width of the hump to be removed and sharp enough to cut through the cartilage without buckling or deforming it. The instrument must be knife-sharp prior to each use. Once the cartilaginous portion has been cut through, the osteotome, propelled with a mallet, is carried through the nasal bone. If the bone is hard and brittle, as is frequently found in older patients, an osteotome cut may result in a fracture ahead of the instrument and not in a desired location. For this reason I do not use this method even though it is easy and fast in most cases.

Removal of Hump with Bone Saw. In this method first one side of the bony hump is cut through with a bone saw and then the other. The remaining cartilage is cut with a knife.

Shortening Length of Nose

As soon as the hump has been removed it is always advisable to feel the dorsum, as well as to evaluate it visually. Sometimes an irregularity that is not visible can be felt, because the soft tissues and skin, a little swollen at the time of the operation, may obscure any irregularity.

It is now usually necessary to shorten the length of the nose so that the nasolabial angle and tip are in a satisfactory relationship. When the hump is lowered, it automatically makes the nasal tip too pointed in the profile view, and the nasolabial angle is prone to be too acute. The amount to be removed may be determined by grasping the columella with forceps, pushing the tip up into its proper position, and ascertaining how far the columella overlaps the septum. It is at this level that the septum must be excised. This may readily be done by grasping the septum and cutting through the cartilage and its overlying membrane on each side. A scalpel is more satisfactory than scissors for this procedure. It is important to round the septal tip prior to trimming the lower border. If this is not done, a sharp point
sticking up between the alar cartilages may be the result. This excision should leave the lower border curved as it was prior to removal.

**Mobilizing the Lateral Walls of the Nose**

With the hump removed and the septum shortened, the profile of the nose is now final. However, the front view may present a very flat, broad nose, because the nasal bones and septum are separated. To create a narrow, more normal-looking dorsum, it is necessary to mobilize the bony lateral walls of the nose so that they may be hinged or replaced until the dorsal portions are in contact with the septum. There are three separate procedures which must be employed to accomplish this: (1) a lateral osteotomy, (2) removal of bone at the solid angle, and (3) a superior osteotomy connecting the lateral osteotomy and the bone excision at the solid angle.

**Lateral Osteotomy.** The lateral osteotomy should be performed through the ascending or frontal process of the maxilla, laterally so that the nasal contour will have the desired proportions. If the base of the nasal pyramid is narrow, the lateral walls may be hinged along the osteotomy to permit the nasal bones to come in contact with the septum, and a pleasing contour will result. If the base is broad, it may be necessary to slide the freed ascending process and attached nasal bones medially, creating a step at the osteotomy. This will create the desired nasal contour and the bony irregularity will not be apparent, as it will be covered with soft tissue in the concave area. The step will be obvious by palpation only. The osteotomy may be done either with nasal saws or with a thin, narrow osteotome, either plain or with a blunt guiding tip. I use a saw, except when reducing an old fracture, because, if the bone is brittle, it may fracture in a line that will not be desirable. With an old fracture the surgeon may feel his way and cut through the old fracture line. In the majority of nasal fractures healing takes more by fibrosis than by callus formation.

To perform the osteotomy, an incision is made through the nasal vestibule, just anterior to the attachment of the inferior turbinate and directly over the sharp edge of the piriform aperture of the bone which may be first palpated with the handle end of the knife. With the cutting blade facing superiorly, a stab wound is made to the edge of the bone. The tip of the blade is carried laterally and on the external surface of the bone a millimeter or two, where an incision is made through the periosteum just long enough to introduce the periosteal elevator which is to be employed. As the blade is withdrawn, a cut is made equal to the periosteal cut through the tissues and the skin of the vestibules. A flat and narrow periosteal elevator is next inserted through this incision beneath the periosteum, and directed up along the bone to the level of the inner canthus. This brings the elevator just medial to the attachment of the medial canthal ligament. The elevator may be used as a retractor to permit the tip of the saw to be introduced into the tunnel thus constructed. As the saw is introduced, with its flat surface on the bony surface, the elevator is removed. The saw is pushed up to the extent of the tunnel and rotated into a cutting position. It is important that the plane of the cut be exact, not only in its relationship to the dorsum, but also in its relationship to the surface which is to be cut.

With the saw in position, the bone incision is usually made at a right angle to the surface of the ascending process. Controlled short strokes will result in rapid engagement of the saw in the bone. The engagement is readily determined by pressing on the skin over the
saw blade and releasing the saw handle. If the saw is engaged it will retain its position when its handle is flicked; if not engaged, flicking of the handle will cause the saw to fall loose. There is usually a convex bulge in this area of bone, therefore the saw cut through in the middle before doing so at the lower end. Attention should be paid to the upper end where the bone is thick; the saw may not penetrate through this area as rapidly as the rest of the bone. As the bone incision nears completion, the saw is removed. If any "saw dust" remains, it should be removed by cannula suction through the subperiosteal incision.

**Removal of a Wedge of Solid Bone between the Septum and Nasal Bones.** In order to narrow the nose as high as desired and rule out the possibility of a bulge between the narrowed dorsum and the glabella, it is necessary to remove a wedge of bone from the solid upper third of the nasal bones. The removal of this wedge of bone will prevent the lateral upper surface of the bone from protruding laterally when the vault is narrowed. This piece of bone, when removed, can no longer act as a fulcrum, thus permitting the entire lateral wall to be hinged in its uppermost part.

I use a pointed cutting rongeur to remove the wedge of bone. The male blade is inserted beneath the nasal bones, the female blade rests on the surface and extends as high as one wishes to narrow the nose. The bone is then removed with one closure of the instrument. If this instrument is not available, the same result may be obtained with a flat osteotome at least one third of an inch wide. A cut is made parallel to the outer surface of the nasal bone up to the midline along the dorsum. A second cut is made parallel and adjacent to the septum, up to the first cut. The bone thus freed may be removed with a straight mosquito hemostat.

**Osteotomy Connecting the Two Cuts.** The apexes of the two cuts just described are now connected by employing a narrow osteotome, which is introduced through the skin just lateral to the midline. The skin incision is made with the osteotome. By using the corner of the osteotome, and pointing the instrument diagonally toward the nasal tip, the bone may be scored down through to the cut made previously in the ascending process. The bone may now be hinged into position with the fear of an undesirable fracture eliminated. Some surgeons fracture the bone and ascending process laterally before bringing it into the midline. Others attempt to fracture it indirectly, hoping that the fracture line will be to their liking. This is never a safe method because the fracture line may result in undesirable irregularity.

**Surgery of the Tip of the Nose**

It is rare when a plastic alteration of the nasal tip is not necessary with a plastic procedure on the dorsum. Once the dorsum is altered and the nose narrowed, the shape of the tip, which depends on the contour of the lateral wings of the alar cartilages, will invariably be too broad and rounded. There are many procedures for altering the shape of the tip, but they all have in common the fact that there are certain areas where cartilage must be removed and other areas where the spring of the cartilage must be broken to permit adequate and permanent re-shaping. The basic surgical procedure to alter the shape of the tip was described by Joseph, and most other methods involve variations of his technique.

The lateral wing of the alar cartilage may be divided into an upper third and lower two thirds. This division varies, depending on the size of the tip and the amount of alteration to
be made. When the upper segment is removed, the tip rests closer to the lateral cartilages, and, in some cases, this is all that needs to be done. In most patients, however, it is necessary to remove a wedge from the apex, permitting the ala to hinge near its free border and allowing the lateral crura to come nearer the midline. To expose the alar tip an incision is made along the free margin of the alar cartilage. Small round-tipped scissors are introduced, separating the overlying soft tissues from the perichondrium of the cartilage. After complete exposure of the lateral wing, a transcartilaginous incision is made to separate the upper from the lower segments. The vestibular skin is then separated from the undersurface of the upper segment, thus freeing it and permitting its resection and removal.

I have found that the same end result may be obtained by making only one vestibular incision. In order to employ this technique, it is essential to determine how much of the alar cartilage should be removed to correct the tip deformity before any incision is made. Once this is accurately estimated, a primary incision is started at the apex of the triangular piece of cartilages to be removed. This incision is made through the vestibular skin and cartilage and angulated laterally at the dividing line between the upper and lower segments which have been described. Coming back to the apex, the incision is carried diagonally toward the midline and up to the upper and medial border of the alar cartilage at the midline. Through this incision and by scissors dissection, the upper segment of the lateral wing is separated from the overlying skin. When its upper border is reached, the lower border of the lateral cartilage is encountered. Adhering to the lateral cartilage, the dorsum is exposed as previously described in a routine rhinoplasty. Once the dorsum is exposed, the transfixion incision is completed, and the hump operation and shortening of the septum are carried out.

At this point, to complete the tip operation, the vestibular skin is separated from the upper lateral segment and the segment is removed. If there is still too much convexity to the tip, or not enough of a wedge has been removed, further alar cartilage may be excised until the desired contour is obtained. This excision may be made by evertng the lower segment to view where it may be readily trimmed with scissors.

If the lateral arm of the ala creates too much of a bulge the cartilage may be separated from the overlying skin, everted, and two or three cuts made perpendicular to the vestibular margin, breaking the spring and permitting the convexity to become a concavity if need be. This results in only one incision in the vestibule instead of two or three so that, in closing the wound and splinting the nose, there is only one incision to be closed with interrupted sutures. If all the vestibular skin is retained and the incisions are sutured, webs or an atresia of the nares will not result.

I usually employ two or three interrupted through-and-through sutures to secure the columella to the septum. Plain gut sutures (#3-0 threaded through a small straight cutting or non-cutting needle) are satisfactory. While pushing the needle through the septum or columella the surgeon must grasp the tissues with forceps, as this causes unnecessary trauma. The needle is positioned on one side; partially opened forceps are placed on the other side, thus creating a firm surface, immobilizing the tissues, and permitting the needle to go through. To close the vestibular incisions, #5-0 plain gut, with a small swedged curved cutting needle, is used.
Splinting the Nose

Splinting is employed basically to avoid subcutaneous accumulation of blood and tissue fluid. It will also prevent accidental displacement of the movable parts of the nose when the patient is asleep. Pressure is not necessary, but diffuse splinting over the entire operative field does reduce postoperative swelling and provides protection.

If a submucous resection of the nasal septum has been performed, surgical gloved fingers or large finger cots, with tips removed, are ideal for packing. A catheter is put through the cot, so that when inserted into the nose the patient has an airway, and the marked discomfort created by swallowing with the nose tightly closed is avoided. By using a Killian speculum, the rubber finger cot may be gently filled with strips of gauze. The finger cot packing may extend back to, but not into, the choanae.

The outside of the nose is taped with 0.5-inch adhesive tape. The strip is started just beneath the tip to hold the columella up and the alar cartilages together. Two or three pieces of tape are placed over the bridge of the nose, but need not extend onto the cheeks. This adhesive splinting is extremely important and must be performed with extreme care as it molds the tip. Wrinkling of the skin must be avoided. Petrolatum gauze is placed over the taped nose and forehead, wherever the dental composition mold is expected to come into contact with the skin. This will protect the skin from the heat of the melted composition and facilitate easy removal. A soft metal form (White's metal form) is cut to act as a carrier for the composition. There are other materials which may be used for splinting, but dental composition seems to be the one most universally employed because of its ease in acquisition and use. It melts in hot water and solidifies at around body temperature. After melting the composition in hot water, it may be molded and shaped over the nose with the metal facing externally. It is then chilled with ice water. The splint is held in place with adhesive strips which go completely around the head. The strips should adhere to the forehead and cheeks, but the portion that is to be placed over hair must be backed with adhesive tape so that it will not adhere to the hair.

The nasal packing may be removed the day following the operation. The external splint may be removed 1 or 2 days postoperatively, depending upon the amount of postoperative reaction, but the adhesive splinting should be allowed to remain for 3 or 4 days.

It is very difficult to overcome the tendency of round and bulbous tips to remain round because of the pad of subcutaneous fat beneath the skin. This pad may be excised using a plane of cleavage adjacent to the under-surface of the skin, instead of adjacent to the cartilage. An overly rounded tip may also result if the mucous membrane of the septum and lateral cartilages were not cut flush when the dorsum was lowered.

Correction of the Wide Base and Long Ala

When the main rhinoplastic procedure is completed, the nostrils may be found to have too broad a base. The operator must decide how much tissue should be removed to accomplish the desired adjustment of the alae. The amount of narrowing or shortening necessary may be estimated or it may be measured with calipers. If only slight narrowing is required, a wedge resection of skin from the floor of the vestibule may suffice. Should more
extensive alteration be required, the ala is cut free from the lip and a wedge removed, along with some of the alar buttress. The incision is closed with buried sutures of #5-0 plain catgut or #6-0 silk or nylon dermal sutures.

A prominent columella is the result of too much septal cartilage and premaxillary spine. Once the nose as a whole has been corrected, this prominence may be removed by excising the free border of the septum and the premaxillary spine.

Submucous Resection of the Septum

Etiology of Septal Deviations

The nose has two fixed points, the tip of the nasal bones and the tip of the premaxillary spine. The quadrilateral cartilage of the septum is in contact with these two points and fixed from the inward. When the tip of the nose is hit violently, it will invariably deflect to one side or the other and, in most cases, the cartilage has sufficient spring and will not break. If it should break, it does so along a line corresponding the margin separating extracranial from the intracranial projection of the nose. This is one of the most common nasal deflections. It is usually associated with a deviation of the entire nasal dorsum below the tip of the nasal bone.

If the blow is from above, so that the distance between the cartilaginous dorsum and the vomer ridge is decreased, the cartilage has a tendency to become dislocated from the vomer groove and displaced to one side or the other. This may or may not involve a fracture of the cartilage. Whether it does or not, the cartilaginous dorsum is depressed because of lack of support. If the patient is seen immediately after the injury, it is possible to lift the cartilaginous septum into position, where it may be splinted until it heals. This same principle holds true with a fracture of the nasal bones along with a fracture of the septum. With a very comminuted fracture, the components will invariably be found broken, twisted, or duplicated, as well as displaced from the vomer groove. If careful attention is paid to the reduction of the septum and its immobilization, the nasal bones will maintain their reduced position without complicated splinting.

A blow to the nasal tip may dislocate the quadrilateral cartilage from the vomer ridge and fracture it from the tip of the nasal bones perpendicular to the dorsum. Between the cartilage and the membrane is a pad of fibrous tissue which in some cases will be as thick as 3 to 4 mm.

Surgical Technique

Incision. In operating on most deviated septums, I find an incision on the convex side at the mucocutaneous junction, or just behind it, to be the most convenient approach. If the deviated septum is associated with a nasal deformity which will require a rhinoplasty as well, the septum is approached through the transfixion incision.

In making the incision in the membrane, care should be taken to cut to, but not through, the cartilage. The perichondrium is dissected from the cartilage with a semi-sharp flat elevator. In this step, care should be exercised to ensure that the elevator is under the
perichondrium as it is easy to start the separation between the mucous membrane and perichondrium. Such a separation soon becomes difficult and results in bleeding, tearing of membrane, and frustration. Once the plane of separation is obtained, a blunt instrument should be used. A Pierce elevator is an excellent one as it is well shaped, light, and the operator may readily feel what the instrument is doing. The elevation is usually easily accomplished in a non-fractured septum except along the vomer ridge. The perichondrium is continuous around the bottom of the cartilage in the vomer groove and in this area the periosteum lines the bony grooves so that there is no plane of separation along this line. In the area of the tubercle, however, the perichondrium and periosteum seem to blend into one another. This, plus the fact that the membrane is thicker in this area than in others, makes elevation easy. Continuing the elevation back over the perpendicular plate of the ethmoid bone the operator can readily progress down over the vomer. By using the Pierce elevator elevation along the vomer ridge can usually be accomplished without tearing the membrane.

In noses having old fractures with a marked ridge plus scarring and thinning of the membrane, this separation may be impossible without tearing. If tearing does occur, the operator should not be concerned as long as the membrane on the other side is left intact.

An incision is next carried through the cartilage parallel to the first membrane incision with the blade held at an angle of about 40 degrees to the surface of the cartilage. Care must be taken to avoid cutting through the membrane on the concave side, as to do so invites a postoperative perforation. A semi-sharp instrument which will cut cartilage without cutting bone is useful. With this type of incision it is usually easy to separate the membrane on the concave side without tearing it.

It is essential to leave the membrane in contact with one side of the cartilage which is to be left in place. This maintains nutrition to the cartilage and holds the cartilage in position when it is cut to correct a bend or angulation. The membrane should be left attached to the concave side. With all the deflected and obstructive cartilage and bone exposed these tissues may then be removed. It is not necessary to remove all of the vomer bone if it is not causing obstruction. In my experience, in the majority of the cases justifying a submucous resection of the septum a complete removal of the component parts is required before adequate alignment can be made.

While the obstructing cartilage and bone are being removed, care must be taken to leave an adequate amount of cartilage to create a supporting strut between the premaxillary spine and tip of the nasal bones. This strut will continue beneath the dorsum to the perpendicular plate of the ethmoid bone so that the dorsum will not become depressed by the natural contraction in the area of the removed cartilage and bone. Usually 4 to 5 mm of cartilage are adequate, although more may be left if these is no obstruction. If the surgeon is not careful, he is apt to separate the quadrilateral cartilage from the perpendicular plate of the ethmoid at the tubercle (just beneath the nasal bones), thereby causing a depression of the cartilaginous dorsum. If depression occurs, it is quite difficult to hold the dorsum in its proper position until healing takes place. The easiest way to support the dorsum is to employ a stainless steel wire threaded to a straight cutting needle. The wire is inserted from the outside through the thin lateral cartilages and through the septal cartilage, that is help up in position, and out through the other side. The ends of the wire are then cut, leaving sufficient length so
that they will not be lost in the tissues. When there is adequate healing the wires may be removed. This requires 4 or 5 days.

To avoid these pitfalls, a straight scissors is the safest instrument to use in making the first cut under direct vision, keeping the plane of the cut parallel to the plane of the nasal dorsum. The Ballenger swivel knife is next used to follow this first cut. With a firm, controlled, inward-downward pressure, the cut is extended to the perpendicular plate of the ethmoid bone and then downward to the vomer bone. When the vomer bone is encountered a straight pull downward and forward completes the cut. The freed piece of cartilage may then be grasped with a forceps and removed. If the external deformities are extreme and there is loss of dorsal support, the cartilage may be saved for future grafting.

To avoid dislocating the supporting cartilage from the perpendicular plate of the ethmoid bone, it is always advisable to use a through-and-through cutting forceps such as Jensen's. Once the obstructing cartilage and bone have been removed back to the thin portion of the perpendicular plate, a grasping rocking instrument may be used. Such an instrument must be employed where the bone is too thick to permit the use of the cutting forceps.

Some operators prefer using an osteotome to separate the deviated vomer ridge from the palate, but I have found that more bleeding tends to follow this procedure than when cutting forceps are employed, particularly if the anterior palatine artery is cut across. When the bone is broken and the artery is torn, bleeding is less.

If the anterior and dorsal cartilaginous septum that is left as support to the dorsum and nasal tip is angulated and creates obstruction or an external deviation, it must be mobilized and placed into proper alignment. First the pad of fibrous tissue which fills in the vomer groove must be cut out. The membrane is cut away from this tissue with a knife under direct vision. The pad is then easily separated from the cartilage and removed. This will allow 3 to 4 mm more room on the preoperative concave side and eliminate the possibility of obstruction when the cartilage is repositioned in the midline. Sometimes the displaced cartilage can be freed from the vomer groove by blunt dissection. If this is impossible, a sharp dissection is the best alternative.

Once the dislocated cartilage is completely freed and a new bed on which it may be placed is prepared, it is elevated and sutured in place with a mattress suture that goes through the entire septum and back beneath the premaxillary spine.

Before sewing the cartilage in place, it is necessary to break up any angulation beneath the tip of the nasal bones. This may readily be done by making a cut through the cartilage beneath the tip of the nasal bones where the membrane is still in contact with one side of this cartilage. Care must be taken not to cut the membrane as it will act as a splint to hold the mobilized distal cartilage in place. The cut through the cartilage should be perpendicular to its surface and yet form a 45-degree angle to the dorsum. This permits the cartilage to hinge at the tip of the nasal bones. The shelving projection which is left supports the distal cartilage and prevents it from slipping into the nose, which would result in a depression of the dorsum below the nasal bones. When an angulation of the cartilage is in a plane parallel to the vomer ridge the same principles are employed in correcting the deviated and displaced cartilage. The obstructed, deviated cartilage and bone are removed. The cartilage which must be saved is
straightened by removing a trough of cartilage parallel to the bend on its convex side, so that when straightened, there will be a square butt without further tendency to angulate. The membrane is not disturbed on the concave side of the remaining cartilage. The cartilage is freed and replaced, the angulation is corrected at the tip of the nasal bones, and the remaining mobilized cartilage is sutured in place.

So far, cartilage which has been primarily angulated or displaced has been considered. Not infrequently, cartilage which is markedly curved, not only in one plane but in two planes, is encountered, so that it is difficult to free and realign the strip which is normally saved for support in the midplane. When cartilage is found behind the deviation, which is fairly flat, most of the septum can be removed, including that which should be saved for support. The flatter cartilage is then shaped, reinserted, and sutured to support the dorsum and the columella. This should be done as a last resort, for a free graft will occasionally be absorbed even though it consists of autogenous septal cartilage. In certain cases, it is possible to utilize some of the vomer or even the perpendicular plate of the ethmoid for support. However, bony implants are rigid and very easily fractured.

**Correction of Depression of Nasal Dorsum**

Depression of the nasal dorsum is frequently encountered when there has been an injury to the nasal septum, either traumatic, infectious, or postoperative. When there is septal destruction due to infection and loss of support because of the removal of too much cartilage, the surgeon's only alternative is to add something to the existing dorsum to create the desired contour. I have always found it expedient to use living autogenous material when available. Discussion of the use of inert implants may be found in the literature.

The depression of the cartilaginous dorsum is due to loss of septal support secondary to destruction of the cartilage itself. Careful analysis of the anatomy will frequently indicate that if the depression on the dorsum and the tip of the nose are brought into alignment with existing nasal bones, the resulting profile is the one to be obtained. Not infrequently, it will be observed that individual alar cartilages are more developed than desirable and there is slight flaring or bulbousness of the tip. This makes an ideal situation because adequate cartilage is present to form a restoration.

**Alar Swing**

The incision employed to expose the cartilage of the dorsum is made from the tip of the vestibular apex parallel to and about 2 to 3 mm from the anterior border of the alar cartilage all the way to its lateral portion. This incision extends through the cartilage. At the apex the incision is carried backward, so that the medial crus is not involved, to the anterior border of the septum where a transfixion incision is made. The outer or top surface of the alar cartilage is then freed subperichondrally by blunt dissection. The separation is continued adjacent to the lateral cartilage to the nasal bone as for exposure for a rhinoplasty. The nasal bones are then exposed subperiosteally, if there is work to be done on them, although in this case it is usually not necessary. The skin must be separated over the nasal bones to the glabella.
With fine, blunt-edged scissors the alar cartilage is now separated from the vestibular skin, but it is left attached to the vestibular skin at the apex. This attachment maintains a fixed relationship in this area plus a small viable attachment. With the tip and the columella freed, the alar cartilages which have also been freed may be brought out through one nostril. Their upper edges are sewed together with interrupted sutures. A #5-0 plain catgut eye suture on a small curved needle is quite satisfactory for this purpose.

To be certain that the cartilages remain in the proper position during splinting, a suture of nylon, threaded to a straight needle, is placed through the lateral-most portions of the alae. This suture will take the uppermost position when the alae are placed over the dorsum adjacent to the nasal bone. The suture material may then be brought beneath the skin and to the surface while the skin is elevated with a rhinoplastic skin retractor. After one end of the suture material is brought through the skin, the needle is rethreaded on the other end and brought through the skin; a snap is clamped onto the suture material to provide traction.

Once brought into position, the tip is elevated, the dorsum shortened, and the bulging portion of the ala alleviated. The transfixion incision is then closed with interrupted sutures as are the vestibular incisions. Intravestibular packing for closure of vestibular incisions cannot be relied upon because improper healing will result in web formations.

When the depression is too great to be filled by a single layer of alar cartilage, the alar cartilage may be folded upon itself to create more bulk. To execute this procedure the alar cartilages are freed, delivered through the vestibule, and placed upon the skin of the nasal tip. The dorsal surface of the ala is then cut through to a very thin layer of perichondrium which is almost always present. This permits the cartilage to be folded along the cut line. The cut and folded surfaces of each ala are then sutured together and held in position as already described.

If septal cartilage is present, and the depression is the result of buckling of the septum, a submucous resection may be performed and large sections of the cartilage obtained, cut, sutured together, and sculptured to fill the defect.

In certain cases I have found it expedient to employ a combination of these last two methods, using the alar swing and septal cartilage to provide the support.

**Grafting Techniques**

It is sometimes impossible to obtain sufficient local cartilage in a nose which has lost both its cartilaginous and bony support and in which a saddle-back deformity is present. In such an instance, in order to provide support, transplant material must be obtained from a source that will offer an adequate supply. Many materials have been employed to supplement an inadequate supply of bone and cartilage in the restoration of a nasal framework; a word is in order concerning these substances. The materials fall into two main groups, organic and inorganic. Gold, silver, tantalum, Vitallium, and the plastics are several of the inorganic, while ivory, cartilage, bone, fibrin, and fascia are the organic materials used. With most of these materials the chance of a foreign-body reaction is very high. In recent years, the use of tantalum (Fox), a completely inert basic metal, and the alloys (Pressman), Vitallium and stainless steel, have been introduced. These substances, when employed in their solid form
and buried beneath the skin, may be well tolerated. They can be anchored to the tissues when multiple perforations exist permitting fibrous tissue to grow through. Or, these materials can be screwed into place if in contact with bone. In a dorsal implant in the nose, there is a constant, light pressure of the metal beneath the skin. This creates a very slow avascularization and pressure necrosis, necessitating the removal of the material. My first successful attempt at implanting tantalum occurred when the implant was inserted so that the alar cartilages were between it and the skin directly over it, so there was a wide distribution of pressure. Tantalum wool and other metals are mentioned only to be condemned, for, in my experience, they are poor materials for reconstruction of the dorsum of the nose.

Ivory, the product of living tissue, has been used as an implant for many years (Salinger). I have seen a patient in whom it had been retained for 25 years, until a slight blow to the tip of the nose caused a foreign-body reaction requiring its removal. Today, however, ivory is rarely employed as a rhinoplastic implant. Several plastic substances (such as the acrylic resins (Rapind), polyethylene (Heanley), Teflon, and the silicones) were found experimentally to be well tolerated by body tissues. If improperly shaped or inserted they will initiate a foreign-body reaction, and removal will be necessary.

Polyethylene sponge (Johnson and Grindlay), and silicone rubber are similar to cartilage in that they are flexible and can be readily tooled at the operating table with a sharp knife. The fact that they will not curl or change shape makes them more ideal than cartilage as inserts. There have been few reported failures, and these materials appear to be fairly good substitutes for autogenous cartilage and bone.

Let us consider some of the organic materials which may be used for nasal implants. Autogenous cartilage (Peer), transplanted into a vascular field, will usually be incorporated as living cartilage. If, on the other hand, this same cartilage should be buried in a scarred or avascularized area, it may atrophy as it is infiltrated and replaced by fibroblasts which, in turn, may greatly diminish in size so that for practical purposes the mass may disappear completely. It is my experience that this is more prone to happen in the young child than in the adult.

Large blocks of rib cartilage, which can provide all the cartilage needed for nasal operations, have the great disadvantage of curling soon after being cut. This problem is not only annoying to the surgeon, but disastrous to his reconstructive work. Septal and auricular cartilage very rarely curls. Three or more pieces may be sutured together to create sufficient bulk, and then shaped. This gives the surgeon an ideal material for the replacement of the lost dorsal support.

Attempts have been made to obtain ideal materials which could be had in large amounts and banked. Homologous (Spangler) and bovine (Cottle, Quilty, and Buckingham), cartilage come under this group of substitutes. Many of these implants are replaceable by fibrous tissue invasion; so many, in fact, that I discarded bank cartilage several years ago.

Many implants of heterogenous cartilage are apparently well tolerated up to one year postoperatively, but long-term results have been discouraging because these grafts disappear.
It is recognized that autogenous bone, buried in contact with bone and surrounded by good blood supply, will become incorporated as living bone (Cannon and Murray; Cottle et al). Obtaining this result is not quite as simple as it sounds. The grafted bone first dies; osteoclasts invade its structure and destroy its framework. At the same time, osteoblasts start laying down new bone, so that by the time the process of destruction is completed the entire bone has been replaced by a living structure firmly adherent to the recipient bone by a callus. Homologous bone, which is dead when buried in the host, goes through the same process of absorption and regeneration. The grafted bone merely acts as a framework through which the new bone is laid down. Bone, therefore, is an ideal medium for repairing large defects of the nasal skeleton and may be obtained from several sources.

Some operators prefer the tibia, which is accessible and already has a surface which needs little changing to form a desirable implant. Occasionally, removal of bone for a graft weakens the tibia, so that precaution must be taken against fracture. The rib and scapula have also been employed, but the source which is considered best by most surgeons is the crest of the ilium. Here large quantities of cortical and medullary bone may be obtained without affecting function, and the resulting scar may be covered by clothing.

What type of bone graft, cortical or medullary, is best for nasal implants has long been a matter of general discussion. It is conceded today that myelogenous bone may be received and integrated quicker than cortical, but cortical bone will make a better shaped graft which will be maintained. Whether or not a strut is employed to maintain an elevation of the tip of the nose, roentgenography has shown that the bone assumes a new architectural structure. One may see a cortex which corresponds to the contour of the nose and will withstand the stresses which are placed on it. The opponents of the use of autogenous bone as a nasal implant maintain that plastics or bank cartilage or bone do just as well and that they avert the need for another operation. These claims are partially just; yet, when a solid graft is indicated, autogenous bone gives the best results. The additional operative procedure which the opponents dislike is really minor, as it takes little time to expose the ilium and obtain the graft. While an assistant is closing the wound, the surgeon may be sculpturing the insert; thus, little added time is needed.

In summary, what the surgeon should strive for is an implant which is completely tolerated by its recipient host. Autogenous bone fulfills this end better than any other material and is preferred as an implant when a large skeletal defect of the nose is to be corrected.

There are several incisions through which the dorsum of the nose may be approached to prepare it for the reception of a graft. An incision through the skin of the nasal tip or the columella creates a direct view of the dorsum, yet it may be difficult to obtain an opening of sufficient size to permit the passage of a large graft. In addition to this, this incision leaves a visible scar. In order to overcome these objections, I have found the following approach to be satisfactory.

An anterior incision is made through the vestibular skin parallel to, and 0.125 inch from, the margin of the lateral wing of the alar cartilages. When the medial crura are reached, the incision is directed back to their posterior border and carried through and through as a transfixion incision. The vestibular skin is dissected free from the lateral crura of the alar cartilage up to the lateral cartilages, which are then exposed up to the nasal bones. An
incision is made parallel to the piriform aperture and through the periosteum, which is
elevated from the nasal bones up to the glabella. Usually the median raphe must be cut to
permit elevation of the periosteum in the midline, but it is always possible to create a pocket
to receive the upper end of the graft in the region of the glabella. The nasal periosteum is
elevated laterally down over the ascending processes, to permit the skin to form a normal-
appearing lateral side for the nose. The medial crura of the alar cartilages are freed from one
another by blunt dissection. This step is important, for the medial crura are sutured over the
graft at its tip and are to be dealt with later. If the columella is to be brought forward, the
dissection of the medial crura of the alar cartilages is continued down through the soft tissues
to the region of the premaxillary spine. A graft may be placed in this pocket. It may also be
advisable to make a pocket in the free border of the septum. The nose is now ready for the
reception of the graft.

The crest of the ilium is exposed. With a thin, broad osteotome, the cortex is
sculptured in situ to form the exact contour desired for the dorsal support. It is very easy to
tool the bone while it is in this position as it is completely immobile. Once the dorsum and
the bone which will correspond to the lateral sides of the nose and the lost ascending
processes are sculptured, the graft is removed as a block, with a good margin of bone in all
directions. If there is a possibility that bone will be needed to fill out the columella, it may
be taken at this time. Bleeding is controlled and the wound closed.

Once removed from the ilium, the bone is sculptured so that the finished product will
completely fill the defect into which it is to be inserted. Sculpturing is performed with
rongeurs, rasps, and high-speed burs. If any groove or space is left between the graft and
ascending process, an external depression in that area will result when the skin is pulled in
as healing progresses. If the operator is unable to tool the graft exactly to size, bone chips or
cancellous bone can be used to fill in these small areas. Best results are obtained when the
graft fills the entire defect. The solid upper half of the graft is carved so that it will rest
securely upon the nasal bones. Care is taken so that its upper end will insert into the pocket
at the glabella. This should hold it firmly in contact with the bone. The lateral wings will then
rest either upon the nasal bones or the ascending processes and, in turn, by cantilever action,
will support the tip. This procedure eliminates the use of a columellar strut. The graft is
tapered gradually from its contact with the lower border of the nasal bones until it comes to
the region of the alar cartilages. Here it is thinned from the lateral aspect and permitted to
come between the medial crura, which are sutured on top of it for support. This elevates the
tip above the graft, giving the profile a more normal appearance.

The original incisions are closed, and the nose is packed intranasally. A routine type
of external pressure bandage is applied. This autogenous bone graft has the advantage of
being in contact with a large surface of living bone. It is immobile, takes well, becomes an
integral part of the nasal framework, and supports the tip of the nose in a normal anatomic
relationship without resorting to a strut of bone between the anterior premaxillary spine and
the undersurface of the tip of the graft. If the columella needs to be more prominent, a piece
of bone may be inserted for this purpose, but not to act as a support for the tip.
Tumors of the Nasopharynx

Benign Tumors

In the nasopharynx, benign tumors are less common than malignant growths. They include: (1) pseudotumors (choanal polyp), (2) cystic tumors (Thornwaldt's cyst, Rathke's pouch, mucous cyst), (3) solid tumors (juvenile angiofibroma, benign mixed tumor, fibroma, chondroma, ossifying fibroma, sarcoid neurofibroma, xanthoma, glioma, teratoma).

Signs and Symptoms. The signs and symptoms of benign tumors of the nasopharynx include nasal obstruction, epistaxis, anterior and posterior nasal discharge, voice change, otalgia, and hearing loss.

Treatment of Benign Tumors of the Nasopharynx. The choanal polyp is resected with a snare inserted by the nasal route. Following this a Caldwell-Luc operation is performed to ensure against recurrence. The technique for the Caldwell-Luc procedure is described previously.

Cystic tumors of the nasopharynx, such as Thornwaldt's cyst, Rathke's pouch, and a mucous cyst, are left undisturbed unless they present symptoms. The outstanding symptoms indicating surgery are: repeated infections, interference with the nasopharyngeal airway, and discharge. Therapy consists of marsupialization or removal of the anterior wall of the cyst. This is accomplished with an adenotome.

Solid tumors of the nasopharynx are resected by the transpalatal route unless they are completely asymptomatic and are not increasing in size. Those benign tumors which have a tendency to undergo malignant change should be resected, even when attended with no symptoms.

Nasopharyngeal Angiofibroma

The juvenile nasopharyngeal angiofibroma, by far the most common benign tumor of the nasopharynx, warrants special emphasis. It almost invariably occurs in adolescent males. It is highly vascular, not encapsulated, and locally invasive. It is said to undergo spontaneous regression when the patient is between the ages of 20 and 25 years. The lesion has its origins from the postero-superior nasopharyngeal vault. There are many theories as to its pathogenesis. The most logical is its derivation from embryological cartilage between the basiocciput and the body of the sphenoid. The fact that there is ossification between the sphenoid and occiput at about 25 years of age somewhat substantiates this theory.

The histopathologic appearance of the juvenile angiofibroma varies considerably. The tumor may be smooth or lobular; in consistency it varies from firm to hard; it is usually
reddish in color, with occasional areas of ulceration and exudation. Microscopically, it is seen to have a fibrous capsule, and its vascular network varies in number, size, shape, and distribution of the vessels. The vessel walls consist of a simple endothelial lining and closely resemble those of the cavernous hemangiomata or erectile tissue. The variation in the number of vessels is apparent during surgical resection, epistaxis and hemorrhage being severe in some patients and minor in others. The stroma of the tumor is made up of fibrous tissue consisting of fine and coarse collagenous fibrils.

The signs and symptoms of the juvenile angiofibroma are nasal obstruction; recurrent epistaxis (often alarming); progressive deformity of the palate, face, and pharynx; otalgia and hearing loss; rhinolalia; and anosmia.

**Treatment of Juvenile Nasopharyngeal Angiofibroma.** There are numerous treatments for juvenile angiofibroma of the nasopharynx.

*Chemical Therapy.* Superficial chemical cauterization with such agents as phenol, trichloroacetic acid, and chromic acid has been used for many decades. The use of sclerosing agents such as sodium morrhuate has been reported as being successful in reducing the size of these tumors. The injection sites, however, tend to slough; this ultimately increases the bleeding surface of the tumor.

*Radiation Therapy.* External radiation is reported to decrease the amount of angiomatous tissue. Doses up to 2500 r have been employed. Maximum radiation should not be used because of its probable effect upon facial growth.

*Radium Therapy.* Reports of excellent resolution of the angiofibroma through radium therapy have appeared in the literature. Radon seeds of 1.5 mmicron are placed in the tumor, approximately 1 cm apart. With the use of radon seeds there is very little chance for interference with the facial growth centers.

*Thermal Therapy.* Diathermocoagulation of the juvenile angiofibroma has been popular but currently has fallen into disuse, except for electrocoagulation of the site of origin following resection. The feasibility of cryosurgery for resection of the juvenile angiofibroma is still doubtful. The freezing of a small or recurrent angiofibroma and allowing the tumor to remain in place and slough off may prove to be effective.

*Hormone Therapy.* Hormone therapy for juvenile angiofibroma has been in use for many years. For the most part the response is not marked and not lasting. Long-term hormone therapy in patients of this age group is decidedly detrimental. Preoperative use of stilbestrol is of great value, however, for the prevention of hemorrhage during surgery.

*Surgical Treatment.* Surgical removal of angiofibromas is still the treatment of choice. A careful hematologic work-up is indicated, for many of these patients are anemic. Whole blood or packed red blood cells are administered several days before the operation. The hematocrit value should be as near normal as is possible at the time of the operation. The patient's blood is typed and cross-matched for six units of whole blood, and the laboratory should be alerted that additional blood may be necessary.
Hormone therapy, consisting of 2.5 mg of stilbestrol given three times a day for 2 weeks prior to the operation will reduce the amount of hemorrhage during the surgical procedure. Breast tenderness and nipple enlargement will be noted after approximately 10 days of this therapy. These should be of little concern, for both disappear during the immediate postoperative period after the administration of stilbestrol has been discontinued.

Carotid arteriography contributes considerably to the diagnosis and surgical management. The carotid arteriogram is taken in the usual fashion. If the tumor extends beyond the midline, bilateral carotid arteriography is of value. The subtraction technique is helpful in outlining the vessels since these tumors are fairly well surrounded by bone. The vascular nature of the nasopharyngeal tumor is typical and fairly well establishes the diagnosis. The arteriography will also outline the extent and size of the tumor, the origin of its major arterial supply, and the site of its vascular pedicle.

Hypothermia or hypotensive techniques during the operation are of questionable value and add to the risk.

Numerous techniques for surgical resection of angiofibroma of the nasopharynx have been reported in the literature. Those which seem most practical are the transpalatal and the transantral procedure. The transpalatal approach allows for better control of hemorrhage than does the transantral approach and provides direct access to the site of origin. The transantral approach, following resection of the posterior and bony medial walls of the maxillary sinus, gives an excellent view of the posterior nasal cavity, upper nasopharynx, and pterygomaxillary space. A combination of both the transpalatal and transantral approaches is used for those tumors which extend into both the nasal cavity and the pterygomaxillary fossa.

**Malignant Tumors**

Malignant tumors of the nasopharynx are relatively rare (0.05% of all malignant tumors). They are more common in men than in women (3 to 1). Their incidence is increased in populations which are predominantly oriental (0.3 to 0.5% of all malignant lesions).

A histopathologic classification of malignant tumors of the nasopharynx is somewhat confusing because of the variance in nomenclature. One is as follows:

1. Transitional cell carcinoma.
2. Squamous cell carcinoma.
3. Undifferentiated carcinoma.
4. Lymphoepithelioma.
5. Lymphosarcoma.
6. Reticulum cell sarcoma.
7. Angiofibrosarcoma.

Transitional cell carcinoma is the most common. Most of the others rarely occur in the nasopharynx.
Signs and Symptoms. The signs and symptoms of carcinoma of the nasopharynx are divided into four main groups: (1) nasopharyngeal, (2) otologic, (3) ophthalmoneurologic, and (4) cervical metastatic.

The nasopharyngeal symptoms include obstruction of one or both sides of the nose, a change in speech due to hyponasality, anterior and posterior nasal discharge, and bleeding.

The otologic manifestations are due to obstruction of the eustachian tubes. A conductive hearing loss is not an uncommon sign of carcinoma of the nasopharynx. This may be associated with either serous or purulent otitis media.

The ophthalmoneurologic signs are due to the extension of the tumor from the nasopharynx into the surrounding spaces. Nearly all the cranial nerves are vulnerable when the tumor extends. The sixth cranial nerve is the one most commonly involved; diplopia due to paralysis of the lateral rectus muscle results. The third, fourth, and fifth cranial nerves are next in order for implication.

The most common site of metastatic extension of a nasopharyngeal malignant lesion is the neck and usually cervical metastasis provides the initial sign of the disease. The lymphatic drainage from the nasopharynx is by the way of the retropharyngeal glands to the upper deep cervical lymph nodes. Tumor of the cervical glands is most commonly palpated between the mastoid process and the angle of the mandible.

The signs and symptoms of malignant disease of the nasopharynx in order of their frequency are:

1. Enlarged cervical lymph nodes.
2. Blockage of the ear(s).
5. Change in speech.
6. Diplopia.

Diagnosis. The diagnosis is made by careful history-taking, physical examination, x-ray study of the nasopharynx, and exploration and biopsy. If there is clinical and radiographic evidence of carcinoma of the nasopharynx, one biopsy study showing no abnormality will not be conclusive evidence that a malignant lesion is not present. The tumor can occur submucosally and thus biopsy specimens must be obtained from a deep-down area in order to obtain a positive diagnosis.

Treatment. External radiation is the primary therapy for malignant tumors of the nasopharynx. Surgical treatment is rarely indicated except for low-grade, encapsulated malignant growth such as a malignant mixed tumor or a cylindroma, for complete extirpation of a malignant lesion of the nasopharynx is usually impossible. The midline transpalatal route is preferred if surgery is indicated. When the disease is limited to the nasopharynx, a 5-year survival rate of more than 50% can be expected. This drops to approximately 10% if there is extension of disease beyond the confines of the nasopharynx. A second course of radiation therapy is indicated for recurrent tumor at the primary site in the nasopharynx. This is
administered by either external radiation or radium in a nasopharyngeal mold. It is of interest that the longer the time elapse between the initial therapy and the recurrence, the better the prognosis after the second course of therapy.

**Resection of Tumors of the Nasopharynx**

The incisions for the transpalatal approach for nasopharyngeal tumors are identical to those for the repair of choanal atresia. After the horizontal incision has been made through the nasopharyngeal mucous membrane at the junction of the hard and soft palate, the nasopharynx can be inspected. Usually at least the posterior aspect of the lesion can be seen. As much of the bony hard palate at the site of the lesion is removed as is necessary for proper exposure of the tumor. Unless the tumor is large and extends anteriorly into the nasal cavity and laterally into the pterygomaxillary fossa, it can be readily resected at its site of origin. This area is tightly packed for a few minutes. Following removal of this packing, the bleeding can be gradually controlled by electrocoagulation. The insulated suction tip is valuable in accomplishing this coagulation. It is best to insert a posterior and anterior pack consisting of iodoform gauze impregnated with aureomycin ointment. Even though the bleeding appear to be controlled at the termination of the procedure, this packing should remain in place for at least 3 days.

If the tumor is large angiofibroma extending anteriorly into the nasal cavity and laterally into the pterygomaxillary fossa, none of the lesion is resected after the transpalatal exposure of its nasopharyngeal portion until a Caldwell-Luc procedure has been executed to expose the portion of the tumor that extends into the pterygomaxillary fossa and nasal cavity. Having acquired a good view of the entire lesion from two angles, by the transantral and transpalatal approaches, the tumor can be readily resected, and the site of the origin quickly packed, thus markedly reducing the amount of hemorrhage. The site of origin is treated as has been described. If necessary, the pterygomaxillary fossa and maxillary sinus can be packed in addition to the anterior and posterior nasal packing.

**Choanal Atresia**

Choanal atresia may be membranous or bony, unilateral or bilateral. Approximately 90% are of the bony type (Flake).

Unilateral choanal atresia often eludes diagnosis because of the absence of subjective symptoms in the neonatal period. In fact, it may be overlooked until adulthood when the patient complains of an inability to breathe through one side of his nose and of a thick, unilateral nasal discharge. The discharge may be purulent if the sinuses are chronically infected.

Complete bilateral atresia of the choanae presents as a neonatal emergency. If the infant having bilateral choanal atresia begins life crying, he is able to breathe through his mouth and thus asphyxiation is prevented. As soon as he stops crying and closes his mouth his airway is obstructed and he then becomes cyanotic. If the correct diagnosis is not made immediately and an oral airway is not inserted, the condition can be fatal. Choanal atresia probably accounts for a number of neonatal asphyxiations of undetermined causes. Thus, it is most important that the obstetrician and pediatrician be well aware of this deformity. If the
infant survives the neonatal period with the aid of an oral airway, gastric feeding tube, McGovern nipple, or, possibly, a tracheotomy, he will have the classic signs and symptoms of bilateral choanal atresia. These are: (1) constant mouth-breathing, (2) bilateral, thick nasal discharge, (3) absence of taste and smell, (4) undernourishment, and (5) defective speech. In addition there are secondary complications such as chronic sinusitis and conductive hearing loss.

Examinations for the diagnosis of unilateral or bilateral choanal atresia include (1) attempt at passing a rubber catheter or probe through the patient's nose, (2) mirror examination of the nasopharynx, (3) digital examination of the nasopharynx, and (4) x-ray examination including a lateral and base view of the nasopharynx after instillation of radiopaque material into the nasal cavity with the patient in the supine position.

**Surgical Treatment of Unilateral Choanal Atresia**

The surgical repair of unilateral choanal atresia is usually made when the patient is an adult. The simplest method consists in removal of the posterior portion of the nasal septum. This is accomplished by making a vertical incision in the mucous membrane of the septum, on the side of the atresia, approximately 1.5 cm anterior to the site of the atresia. The incision is best made with a right-angle knife. It is continued through the perpendicular plate of the ethmoid bone and the mucous membrane of the opposite side of the nasal septum. With ring punch forceps, the nasal septum posterior to the incision is totally removed. Following this a horizontal incision is made through the mucous membrane on the superior and inferior aspect of the atresia; the mucous membrane is then elevated and based laterally. The bony choanal atresia, with the mucous membrane on its posterior surface, is resected with Kerrison forceps. The laterally based mucous membrane flap is then reflected posteriorly and packed in place with one large finger-cot. The packing is left in place for 2 or 3 days. This intranasal procedure usually enjoys a high incidence of success, and therefore a transpalatal approach for repair of unilateral choanal atresia is rarely necessary.

**Surgical Treatment of Bilateral Choanal Atresia**

Some surgeons prefer to treat bilateral membranous choanal atresia by simply breaking through the obstructing membrane with an instrument such as a long, curved hemostat and inserting rubber or plastic tubing into the nasopharynx. The tubes are anchored anteriorly, just behind the columnella, with a suture. Of course, this procedure is impossible for correction of a bony atresia.

**Transpalatal Approach to the Nasopharynx.** The transpalatal approach is the preferred method for repairing either a membranous or a bony bilateral choanal atresia, since it provides a direct route, thus permitting an exacting reconstruction. It also is used for the removal of nasopharyngeal tumors such as juvenile angiofibrous and mixed tumors.

There are a number of palatal incisions for this approach to the nasopharynx. The midline incision is the simplest, and if properly executed, is rarely complicated. The anterior palatal flap approach is also widely used.
For repair of bilateral choanal atresia the operation may be performed in the immediate neonatal period, as soon as the infant is able to withstand general anesthesia. McGovern states that the use of his specially designed nipple permits delay of the operation for one year when the operative field is doubled in size as compared with that at birth. A tracheostomy is not necessary when the McGovern procedure is employed.

**Technique of Operation.** The patient is placed in the supine position with the head extended. The surgeon sits at the head of the operating table working with the palate “in his lap”. Exposure is acquired with a McIver or Brown-Davis self-retaining retractor.

Infiltration of a local anesthetic with added epinephrine along the line of incision may be used for hemostatic purposes and to supplement the general anesthesia. The incision is made in the midline along the entire length of the hard and soft palate, to the base of the uvula. The incision over the hard palate is made down to the bone, whereas the incision in the soft palate is made only to the muscular layer. The mucosa and periosteum over the hard palate are readily elevated with right and left palatal dissectors. A plane of cleavage is established between the mucosal and muscular layers of the soft palate.

The mucosal flaps are reflected laterally by using #00 chromic catgut sutures for retraction. These sutures are either anchored around a molar tooth or weighed with heavy hemostats. The dissection proceeds with care in the region of the greater palatine foramina. It is most important that the blood supply not be disturbed after the flaps have been reflected laterally. A horizontal incision is made at the junction of the hard and soft palates. The soft palate retracts slightly in a posterior direction, exposing the nasopharynx and the choanal atresia. The posterior aspect of the hard palate extends in a postero-superior direction forming the choanal atresia. If the atresia is not bony, the reflected tissue will, of course, be mucous membrane. The dashed lines represent the area of bone to be removed. The area of bony atresia is removed with a mallet and chisel, Kerrison and Citelli forceps. When this has been accomplished, the posterior aspect of the nasal septum can be seen along with the membranous atresia. Then the incisions for relief of the obstruction and the formation of the mucous membrane flaps are made.

The mucosal flaps are elevated and tubing is inserted into the nasopharynx from the anterior nares. This tubing should be of a soft material such as Portex, polyvinyl acetate, or silicone.

At this point the operation has been completed with the exception of the initial incision. A tube has been inserted through each choana and the mucosal flaps are placed on the inferior surfaces of the tubes.

The midline palatal incision is closed with #3-0 chromic catgut, and the tubes are anchored in place by a postcolumellar suture of #4-0 silk or polyethylene.

**Postoperative Care.** No intranasal care is required other than keeping the tubes patent. This can be done with a flexible cotton-tipped applicator saturated with hydrogen peroxide solution. Oral hygiene is important during the first postoperative week to prevent contamination of the palatal incision. After a few days, the tubes are well tolerated. They should remain in place for approximately 4 weeks following operation. If the operation has
been performed after infancy, there may be some disturbance of speech and reflux of liquids into the nasal cavities for a short period following removal of the tubes. The parents can be reassured that this phenomenon is transient.

**Velopharyngeal Insufficiency**

Velopharyngeal incompetence renders a person incapable of speaking without a noticeable nasality. The emission of excessive air by way of the nasal cavity during speech results in a disturbance in quality and articulatory accuracy of the voice. Velopharyngeal closure is necessary to prevent regurgitation of liquids from the oropharynx into the nasopharynx during deglutition.

Closure of the oropharynx and the nasopharynx is accomplished by a rather complex coordinated contraction of both the palatal and pharyngeal muscles. The elevator palatine muscle contracts to pull the soft palate upward and backward. The superior constrictor muscle contracts to narrow the pharynx. The posterior wall of the pharynx is also displaced anteriorly during this contraction, especially in the region of Passavant's ridge.

**Etiology.** The most common causes for velopharyngeal insufficiency are listed below:

1. Cleft palate.
2. Paralysis of the palate.
3. Congenital shortening of the palate or excessive depth of the pharyngeal vault due to basilar skull deformities.
5. Defects in the soft palate resulting from injury or from surgical procedures, as well as scarring of the soft palate.

It is gratifying that the improved techniques for repair of cleft palate have reduced the incidence of velopharyngeal insufficiency. Hypernasality, however, persists in nearly 40% of patients who have undergone cleft palate repair.

**Diagnosis.** A thorough ear, nose, and throat examination and an audiometric evaluation are, of course, essential. The patient is also tested for level of speech maturity. His speech is recorded on tape and evaluated as to articulation and nasality. The degree of velopharyngeal insufficiency is also measured by comparing air pressure obtained when the nasal cavity is open with those obtained when the nares are closed.

Lateral x rays of the pharynx and nasopharynx are secured both while the patient is at rest and while he is speaking. The vocalization of the letters U and S is done. If the apparatus for determining pressure readings is not available, a simple comparison can be made by having the patient blow an easily inflatable balloon with and without the nares occluded. Cinefluorographic study of velopharyngeal function during speech, blowing against pressure with and without the nares occluded, and swallowing are sometimes necessary for an accurate evaluation of the velopharyngeal incompetency. The incompetency during swallowing can be most accurately evaluated by making the contrast study with the patient in the supine position.
Treatment. *Speech Therapy*. Speech therapy is the treatment of choice if the velopharyngeal incompetence is minimal. Surgery may not be necessary.

*Dental Prosthesis*. A dental prosthesis in the form of an obturator or an elevator is effective in some adult patients with velopharyngeal insufficiency.

*Injections*. Injections of the posterior pharyngeal wall are often adequate for restoration of normal speech when there is a minimal velopharyngeal insufficiency.

Liquid Silastic can be injected into the posterior pharyngeal wall. According to Blocksm's experience in a series of cases, its use appears quite promising. The liquid Silastic (4 to 8 cc) is injected after either a local or general anesthetic has been administered. Immediately prior to its injection, three drops of Stennous Octoate catalyst are added to 10 cc of the fluid Silastic. The material is agitated briefly and rapidly poured into a 10-cc Luer lock syringe to which is attached a #15-gauge needle with a curved end. It is injected beneath the mucosa of the posterior pharyngeal wall, just above the protuberance of the atlas. The material vulcanizes in 10 minutes into an inert rubber mass. To prevent it from migrating caudally as it vulcanizes, a tongue depressor is pressed into the posterior pharyngeal wall, just below the site of injection.

Teflon paste (Ethicon PTFE Paste) has also been used for augmentation of the posterior pharyngeal wall. The paste is placed in a 10-cc Luer lock syringe, to which is attached an #18-gauge needle with a curved end. The needle is inserted just above the prominence caused by the tubercle of the atlas, and the paste is injected until an adequate prominence can be seen. The material is placed in the submucosal layer. Caudal spread can be prevented by applying pressure, with a tongue depressor, just below the site of injection. The amount of Teflon paste necessary to effect an adequate closure is usually 5 to 10 cc. In some cases, additional amounts can be injected at a later date. The velopharyngeal space can be closed further by injecting 1 or 2 cc of Teflon paste into each side of the posterior margins of the palate.

**Implants.** In the treatment of velopharyngeal insufficiency, implants of cartilage, adipose tissue, and fascia into the posterior pharyngeal wall were for a time reported to be quite promising. However, the long-range results are unpredictable because of varying degrees of resorption. The use of solid implants of silicone rubber has been pretty much abandoned because of migration or extrusion of the implant. Possibly a soft, solid implant will be developed that will neither extrude through the mucous membrane nor migrate from its site of implantation.

**Lengthening of the Soft Palate (Palatal Pushback).** The soft palate can be lengthened by making a simple U-shaped mucosal incision or executing a V-Y Wardill pushback over the hard palate. A mucoperiosteal flap is elevated and displaced posteriorly after the nasal mucosa at the junction of the hard and soft palates has been incised.

**Posterior Pharyngeal Mucosal Flap.** The pharyngeal flap procedure is indicated for those patients with moderate to severe velopharyngeal insufficiency for whom procedures designed for augmentation of the posterior pharyngeal wall are not suited. This group
especially includes those with a congenitally short soft palate or paralysis of the soft palate, as well as those having various defects of the soft palate.

The posterior pharyngeal mucosal flap operation should not be performed on children under 7 years of age because of the frequency with which tracheotomy is required for these patients. The optimal age for patients undergoing this procedure is between 7 and 9 years.

The operation is performed with the patient under general endotracheal anesthesia and in the Rose position. The palate and pharynx are exposed with the aid of a Brown-Davis mouth gag as for a tonsillectomy. A soft palate retractor or traction sutures applied to the soft palate are used to expose the posterior epipharyngeal wall. Submucosal infiltration of a local anesthetic agent with epinephrine added, supplements the general anesthesia, reduces the amount of bleeding during the procedure, and facilitates the dissection in a plane between the constrictor muscle and the prevertebral fascia. A vertical incision is made on each side of the posterior pharyngeal wall. This should include most of the width of the wall. Dissection is carried through the mucosa, pharyngeal fascia, and constrictor muscle. The prevertebral fascia is identified, and a plane of cleavage is established with either curved or right-angled scissors. It is most important to acquire a flap of adequate length. The inferior horizontal incision connecting the two vertical incisions is thus made just at the level of the superior aspect of the epiglottis. The flap retracts superiorly as this dissection is completed. A moist gauze pack is placed against the posterior pharyngeal wall and also in the nasopharynx to control bleeding, while the soft palate is prepared to receive the inferior margin of the pedicled flap.

The uvula is grasped with atraumatic forceps, or secured with three traction sutures of #2-0 chromic catgut, and retracted anteriorly. This exposes the immediate posterior aspect of the soft palate and the palatal pharyngeal fold. A horizontal incision is made on the posterior aspect of the soft palate between bases of the palatal pharyngeal folds. The soft palate is then split horizontally, creating a bed for the inferior aspect of the posterior pharyngeal flap. Three sutures of #2-0 chromic catgut are placed at the end of the pharyngeal flap. All three are passed through the soft palate by way of the bed created, before they are tied. The end of the pharyngeal flap is then drawn onto the bed by pulling on the sutures. The knots are tied loosely so that they will not cut through mucous membrane when postoperative edema occurs.

The superiorly based posterior pharyngeal flap is far superior to the inferiorly based flap, for dissection is simpler. It is much more suitable for patients in whom the distance between the palate and the posterior pharyngeal wall is great, and in whom the flap can be sutured without tension and the posterior pharyngeal defect can be at least partially closed.

The lateral edges of the posterior pharyngeal defect are undermined, and the defect is at least partially closed by suturing the lateral margins to underlying fascia. By this technique not only is the postoperative discomfort reduced, but also the superior pharynx is narrowed, thus assisting with the velopharyngeal closure.

Complications of this operation are infrequent. Postoperative bleeding may occur. This can be avoided by careful dissection and either ligating or cauterizing bleeding vessels. If persistent bleeding does occur, it may be necessary to perform a tracheotomy and insert a pharyngeal pack. On occasion, the flap may become detached from the palate. This usually
occurs within one week after the operation, and it is, of course, essential that it be re-attached
to the soft palate. If nasal respiration is inadequate following this procedure, revision of the
lateral gutters must be undertaken at a later date. A late complication of this operation is
shrinkage of the pharyngeal flap due to scar-tissue contraction, resulting in an insufficient
velopharyngeal closure. This can often be remedied by tissue augmentation such as with the
injection of Teflon paste.

**Combined Procedures.** A combination of palatal pushback and the posterior pharyngeal
flap is necessary for the treatment of moderate to severe velopharyngeal insufficiency. Either
a U-shaped or V-Y pushback procedure is accomplished as has been described. The result is
a mucosal defect on the nasopharyngeal surface of the palate. The posterior pharyngeal flap
is elevated and sutured to this defect.

**Repair of Palatal Defects.** Defects of the soft palate are a cause of velopharyngeal
incompetency. They may be congenital or the result of neoplasm, surgical procedure, or
trauma.

**Stenosis of the Nasopharynx**

The most common cause of nasopharyngeal stenosis is the ingestion of caustic
material. Other possible causes are trauma, severe infection, and sequelae of surgical
procedures. The stenosis, which involves adherence of the soft palate to the epipharyngeal
wall, may be partial or complete. The patient complains of hyponasality or hypernasality.
There may be a conductive hearing loss due to interference with eustachian tube function.
Simple excision of the adhesions or the use of electrocautery is usually ineffective. Skin
grafting and the use of stents often results in gradually recurring stenosis.

**Technique of Repair.** The operation for repair of stenosis between the oropharynx and
nasopharynx is performed with the patient in the Rose position. Exposure is obtained with a
Brown-Davis mouth gag with a ring attachment for an endotracheal tube.

A mucosal incision is made on the oral surface of the soft palate to fashion a mucous
membrane flap which is to be reflected into the nasopharynx to cover the denuded posterior
epipharyngeal wall. The incision for the construction of a buccal mucosal flap which is to
cover the defect on the oral surface of the palate is outlined.

The mucous membrane flap has been elevated from the oral surface of the soft palate
and reflected inferiorly. This leaves a denuded area on the oral surface of the soft palate.

The newly formed opening into the nasopharynx is now apparent. The mucosal flap
has been reflected into the nasopharynx to cover the denuded area on the posterior
epipharyngeal wall. This flap is sutured in place with #4-0 chromic catgut as the margin of
the soft palate is reflected anteriorly. The mucous membrane flap has been elevated from the
inside of the cheek in preparation for its rotation to cover the denuded oral surface of the soft
palate.

The buccal mucosal flap has been further dissected and the palatal flap sutured in
place.
The buccal mucous membrane flap has been rotated into place and sutured with #3-0 or #4-0 chromic catgut. The defect inside of the cheek is closed by first undermining the surrounding buccal mucosa and closing it in a straight line.

**Adenoidectomy and Tonsillectomy**

The decision to perform a tonsillectomy and/or adenoidectomy can be quite perplexing. With local and general nasal decongestants, biochemotherapy, and minor procedures such as myringotomy for serous otitis media, the surgeon can procrastinate and play for time. Each case must be individualized, reviewing a carefully taken history and the physical findings. At times it is difficult to overrule the persistence of the parent or referring physician who insists that the tonsils and adenoids be removed.

The following are a few positive indications which can be used as ground rules.

**Indications for Adenoidectomy:**

1. Large adenoids obstructing the eustachian tubes and causing repeated or persistent ear disease and hearing loss.
2. Sufficient obstruction from the adenoids to cause chronic sinus infection.
3. Obstruction of the nasopharynx associated with chronic mouth-breathing and "adenoidal" abnormal facial appearance.

**Indications for Tonsillectomy:**

1. Repeated episodes of acute tonsillitis.
2. Peritonsillar abscess and a history of past tonsillitis.
3. Unusual tonsil hypertrophy that interferes with swallowing and respiration. The tonsils at times can become so large that they meet in the midline.
4. Should the tonsils be removed when there is only indication for an adenoidectomy? As a rule the answer is no, for only a small percentage of these patients will require a subsequent tonsillectomy. The postoperative course following an adenoidectomy is quite benign as compared to that following a tonsillectomy.

**Technique of Surgery**

The adenoidectomy and tonsillectomy are best performed with the patient in a supine position with his head extended (Rose position). The surgeon can sit comfortably at the head of the table during the operation. Excellent exposure of the pharynx can be acquired by use of a Brown-Davis mouth gag which has a ring attachment for the endotracheal tube. The McIver mouth gag is used with the ring attachment if the incisor teeth are either very loose or absent. An endotracheal tube is used to give the anesthesiologist better control of the airway and to facilitate the administration of the anesthetic. With an endotracheal tube in place, there is very little chance for aspiration of blood or other substances.

If both adenoidectomy and tonsillectomy are to be performed, the adenoidectomy is carried out before the tonsillectomy because bleeding from the site of the adenoids is more difficult to control than that from the tonsil area. Keeping a nasopharyngeal pack in place
until the completion of the tonsillectomy is usually all that is necessary to control bleeding from this location. The nasopharynx is exposed with a soft palate retractor in order to determine the amount of adenoid tissue present. The instruments used to remove adenoid tissue include various-sized adenotomes, ring punches of varied shape, and adenoid curettes.

**Adenoidectomy.** If the patient's head is in hyperextension, it is slightly flexed so that the bodies of the cervical vertebrae and prevertebral fascia will not be too convex. An adenotome, with a width slightly less than the distance between the eustachian tube orifices, is inserted, pressed slightly in a posterior direction, and closed to remove the main mass of adenoid tissue. Before closing the blade of the adenotome, the position of the uvula must be determined so that it will not be resected. Even though the absence of a uvula usually causes no dysfunction, it can cause considerable apprehension to both the parents and the patient.

The soft palate is again retracted and the nasopharynx suctioned with a Yankauer suction tip. If any of the main mass of the adenoid in the lower nasopharynx is still present, it is removed by a second application of the large adenotome. The surgeon's index finger is inserted into the vault of the nasopharynx, palpating first one choana, the posterior margin of the nasal septum and then the opposite choana. Quite often a mass of adenoid tissue will be palpated just below the choana. A smaller adenotome with closed blade is inserted with the index finger still in place. The adenotome is guided by this finger to the mass of tissue, the blade is opened, slight posterior pressure is exerted, and the blade is closed. Multiple bites with the adenotome may be necessary to removed the mass.

With the patient's head in hyperextension, the soft palate is again retracted in order to obtain a view of the torus tubarius and eustachian tube orifices. Lymphoid tissue in these areas is removed with ring punches having both rounded and flat ends.

When the operator is satisfied that all adenoid tissue has been removed, the nasopharynx is packed with two or more dental rolls previously moistened with saline solution to which has been attached black silk suture material. The black silk suture is essential, for it is very easy to inadvertently leave a packing in the nasopharynx.

The nasopharyngeal packing remains in place until the completion of the tonsillectomy. As soon as the tonsillectomy is completed and the tonsillar fossae are packed with dental rolls, the nasopharyngeal packing is removed, and the nasopharynx inspected with the soft palate retracted. If bleeding is absent, the nasopharynx is left undisturbed. A bleeding vessel high in the nasopharynx can be detected by flexing the patient's head so that the nasopharynx is no longer dependent. The site of the bleeding will become obvious as blood trickles down the posterior pharyngeal wall. Bleeding points in the nasopharynx can be cauterized with a silver nitrate stick or electrocoagulated with an insulated suction tip. The exposure for this cautery is acquired by either retracting the soft palate or inserting a Yankauer nasopharyngoscope.

If there is any question that there may be bleeding from the nasopharynx in the immediate postoperative period, a nasal-oral string is inserted in case a nasopharyngeal pack is needed. To accomplish this a catheter is inserted into the pharynx by way of the nasal cavity. The tip of the catheter is grasped as it appears in the pharynx and a silk suture (#0)
is tied to this end. The catheter is removed from the nose and both ends of the string are tied externally. The string is cut and removed after a few hours if no bleeding has occurred.

**Tonsillectomy.** The upper medial aspect of the tonsil is grasped with an instrument such as an Allis forceps. It is pulled downward and forward, thus tenting out the mucous membrane superior to the tonsil between the anterior and posterior pillars. A small incision is made in this mucous membrane with the spade-shaped end of a tonsillectomy knife. The instrument is reversed and the right-angled end of the tonsil knife is inserted through the incision, under the mucous membrane just anterior to the posterior pillar. This mucous membrane is incised along the entire length of the posterior pillar. With the tonsil retracted slightly in a posterior direction, the right-angled knife is inserted beneath the mucous membrane immediately posterior to the anterior pillar by way of the same initial incision. This anterior incision is not performed first, for the resulting blood flow would obstruct a view of the posterior pillar.

The Allis clamp is re-applied so that it may be used to grasp the superior aspect of the tonsil. The superior pole of the tonsil is then carefully dissected in the plane between the fibrous layer of the tonsil and the underlying muscles. A tonsil dissector or curved scissors is used for this dissection. As soon as the superior pole is in clear view it is grasped by the Allis forceps so that the tonsil can be more readily retracted inferiorly. The remainder of the tonsil, with the exception of the detachment of the inferior pole, is easily dissected, by using the index finger, tonsil dissector, and curved scissors.

A wire snare is placed around the tonsil. As the snare is tightened, it is pushed slightly inferiorly as the tonsil is being retracted superiorly. In so doing the inferior pole is completely excised.

Large vessels in the tonsillar fossae should be suture ligated with #2-0 or #3-0 catgut. If there is no significant bleeding, the tonsillar fossa is packed with a moist dental roll which remains untouched for at least 3 minutes. Providing a nonexplosive anesthetic agent is being used, the insulated suction tip with electrocautery is an excellent way to obtain hemostasis in the tonsillar fossa.

With the exposure acquired by using a pillar retractor, the bleeding vessel is grasped with a hemostat. The needle is inserted in a postero-anterior direction, first below the hemostat and then above the hemostat. The hemostat is removed the suture ligature tied. This type of suture ligate (Figure "8") is much more effective and secure than a slip tie placed around the vessel.

The patient is placed in a sitting position if the tonsillectomy is to be performed with local anesthesia. A metal tongue depressor is used in place of a mouth gag. The local anesthetic solution is injected into the tonsillar side of the pillars. The tonsil is grasped and pulled medially so that the anesthetic agent can be infiltrated posterior to the tonsil. The operative procedure is identical to that described above.
Surgery of the Upper Respiratory System

William W. Montgomery

Chapter 11: Surgery of the Ear

Surgery for Acoustic Neurinoma

Recently otolaryngologists have become interested in the operation pioneered by William F. House, for the removal of acoustic tumors.

A small acoustic neurinoma (2 cm), without coexisting loss of serviceable auditory function, is best removed by way of the translabyrinthine route. The operation is performed in a relatively short time and is attended with low morbidity and mortality rate.

A total resection of a small acoustic neurinoma can be accomplished through the translabyrinthine route with a 75% chance for preservation of facial nerve function. This is in contrast to a figure which is usually reported as below 20% when the tumor is approached from the posterior route. The intrameatal portion and petrous extensions of the tumor can be resected only through the translabyrinthine route. The importance of total removal cannot be overemphasized, for the mortality rate in patients with recurrent acoustic neurinomas rises sharply.

Total removal of a larger acoustic neurinoma (4 cm and larger) by way of the translabyrinthine route may not be practical, for the exposure of that portion of the tumor adherent to the brain stem and the exposure of vital arteries and cranial nerves may be difficult and hazardous. When the tumor is large the translabyrinthine approach may be used for resection of the intrapetrous portion of the tumor, dissection of the intrapetrous and intracranial portions of the facial nerve, decompression of the tumor, and resection of the posterior surface of the petrous pyramid to the sigmoid portion of the lateral sinus in order to facilitate the suboccipital approach.

To complete the removal of the tumor the suboccipital craniotomy is performed 1 to 2 weeks following the translabyrinthine procedure. This two-stage resection for large acoustic neurinomas is the safest and offers the patient the best chance for survival, preservation of the facial nerve, and complete removal of the tumor.

The diagnosis and successful resection of an acoustic neurinoma is dependent upon a team effort. The team should include an audiologist, roentgenologist, otoneurologist, neurosurgeon, and otolaryngologist. Once the diagnostic procedures have been completed, the case should be reviewed at a meeting of all members of the team. It is my experience and that of my colleagues that all acoustic neurinomas should be approached first by the translabyrinthine route. The neurosurgeon should be present for the intracranial portion of this operation, or at least to inspect the field following the total resection of a small acoustic tumor. If the suboccipital approach is required as a second-stage procedure, the otolaryngologist should be present for that portion of the operation having to do with the facial nerve. Often he can be of valuable assistance with the identification and dissection of the lateral portion of this nerve.
Advances in audiology have contributed considerably to the diagnosis of acoustic neurinomas. Since there is no specific pattern of audiological findings, complete testing is necessary. For the most part this evaluation will either exclude the possibility of the presence of an acoustic tumor or present evidence which should initiate the stimulus to embark upon other diagnostic studies.

**Audiologic Testing.** For proper organization and simplicity it is best to divide the audiolologic testing into six categories. Approximately 50% of patients with acoustic tumors will present positive findings in all of them. These categories are as follows:

1. *Testing with whispered and spoken voice.* With the patient's unaffected ear masked with a Barany noise apparatus, phonetically balanced words are spoken at a distance of 1 foot from the patient. A moderate or marked loss of discrimination will be quite apparent. If the hearing loss is great, the use of a speaking tube is of value in detecting discrimination loss.

2. *Testing with a tuning fork.* If an acoustic neurinoma is present, it is obvious that the Weber test will show lateralization to the uninvolved ear. The reaction to the Rinne test should be positive, but should show a reduced bone and air conduction time. A marked increase of the bone conduction time is indicative of tone decay. The Bing test, which is performed by placing the tuning fork over the mastoid process and intermittently occluding the external auditory canal, is of value. With a conductive hearing loss the patient notices very little or no difference in the hearing with the canal occluded, but with a sensorineural hearing loss he will usually state that bone conduction is louder when the ear canal is occluded. The tuning forks often give an excellent indication as to the presence of recruitment. This test is performed by lightly brushing 512, 1024, and 2048 tuning forks. With any significant hearing loss the patient will usually not hear one or all of these tuning forks. Unless the hearing loss is very severe, the patient will hear a tuning fork which has been moderately tapped with a rubber hammer. A positive reaction for recruitment is evident if the patient withdraws from the sound or states it is too loud or uncomfortable when the tuning fork, which has been struck by a sharp blow with the rubber hammer, is placed next to his ear.

3. *Audiogram.* Johnson and House, in their evaluation of pure-tone air-conduction threshold tests, in a series of 46 patients with acoustic neurinoma, found that there was no specific pattern associated with the tumor; 67.4% of the patients demonstrated a high-tone hearing loss, 24% a flat-tone loss, 4.38% a low-tone loss, and 4.3% a trough-shaped loss. Seventy-five percent of patients with acoustic neurinomas will have a type 3 or 4 Bekesy tracing. In a large series of these patients, at least 5% will have normal hearing. This is understandable, for the tumor does not involve or exert pressure on the cochlear nerve, nor does it interfere with the blood supply to the cochlea. Normal hearing or a slight hearing loss is not necessarily indicative of a small tumor.

4. *Recruitment.* Recruitment (determined by the alternate binaural loudness balanced test), which may or may not be present, is useful in differentiating cochlear from retrocochlear disease. As a general rule there is no recruitment when a neural lesion is present. Approximately 10% of patients with acoustic neurinomas, however, will have complete
recruitment. Many others will demonstrate partial recruitment. This is quite understandable since an acoustic tumor may interfere with hearing, either by pressure on, or with involvement of, the cochlear nerve producing a neuro-type loss. On the other hand, the tumor may interfere with the blood supply to the cochlea and thus produce an end-organ lesion.

5. **SISI (short increment sensitivity index) test.** This should be performed in all patients suspected of having an acoustic tumor. In the test a steady ring is administered at 20 decibels above the threshold and increased at 1 decibel increments. As a rule a cochlear lesion will respond to a 1-decibel increase in loudness. On the other hand, approximately 70% of patients with acoustic tumors will not respond and have a low (0 to 20%) Sisi score.

6. **Discrimination score.** A speech test should be conducted using the standard Spondee and PB words. In approximately 70% of acoustic neurinoma patients the discrimination score will be at a 30% or lower level. Approximately 20% of the patients will show fairly good discrimination (60 to 100%). The remaining 10% will demonstrate a discrimination score between 30 and 60%.

**Vestibular Testing.** Approximately 95% of patients with acoustic neurinoma will show some evidence of vestibular dysfunction. Vertigo is usually not the presenting complaint associated with an acoustic neurinoma. Some symptoms suggestive of vestibular dysfunction can be elicited in approximately 80% of the patients; the remaining 20% will have no history of vertigo. A small percentage of patients will give a history of episodic vertigo. At least 6% of the patient's with a positive history of vestibular dysfunction will admit only to a sensation of unsteadiness rather than that of true vertigo.

**Caloric Test.** The minimal caloric test is the first test used to determine vestibular function, for it is less apt to produce side effects than are the others. If the results of this testing show no abnormality on either side and equal response on both sides, additional testing is not indicated. The minimal caloric test is performed with the patient's head inclined backward at an angle of 60 degrees; 20 cc of water (at a temperature of 80°F) are instilled into the external auditory canal in 20 seconds. If there is no response to this test, then an icewater (Kobrak) test is performed. Icewater (5 cc) is instilled into the external auditory canal with the patients head inclined backward at a 60-degree angle. If there is no response, then 10 cc and finally 20 cc of icewater are instilled into the ear canal. No response to 20 cc of icewater is indicative of nonfunction.

**Electronystagmography.** Electronystagmography is of some value, but there are no consistent characteristic findings for localization of lesions. It will more readily demonstrate spontaneous nystagmus. Tracings are obtained after irrigating the ear canal with water both above and below the normal body temperature. The degree and type of response is recorded. The greatest value of electronystagmography is that it produces a permanent record which can be referred to, especially for comparison with future testing.

**Trigeminal Nerve.** The corneal reflexes are said to be absent in approximately 60% of patients with acoustic neurinoma. With careful testing, at least some slight degree of decreased facial sensation can be elicited in 30% of the patients. As a general rule there is normal fifth nerve function when the size of the tumor is less than 2 cm.
**Facial Nerve.** Less than 10% of patients with acoustic neurinomas will show either decreased function or irritability of the facial nerve. A loss of sensation in the posterior wall of the external auditory canal is rather difficult to evaluate. When pronounced, it should increase the index of suspicion that there is a lesion involving or compressing the facial nerve.

Hyperacusis is not a common finding. This may be confused with positive recruitment.

Pulec and House report that two thirds of patients with confirmed acoustic tumors had decreased taste function as determined by the electric taste-tester. Most of these patients were not aware of this loss, and only 8% showed a noticeable decreased taste.

The tear test (Schirmer) provides an evaluation of the parasympathetic fibers which accompany the facial nerve from the superior salivary nucleus. The test is performed (Pulec) with two strips of filter paper 1 cm in width. Each is folded 5 mm from one end and placed over a lower lid. Normally 2 cm of filter paper will be saturated with tears in 1 minute. The unaffected side, of course, serves as a good control. Approximately 60% of the patients will show decreased tearing on the side of the lesion.

**Other Cranial Nerves.** Involvement of the ninth and tenth cranial nerves will be manifested by a decreased palatal or pharyngeal reflex and a vocal cord paralysis on the side of the lesion. Weakness or paralysis of the tongue musculature represents an involvement of the twelfth cranial nerve.

Involvement of the ninth, tenth, eleventh, and twelfth cranial nerves is evidence that the tumor has increased in size in an inferior and posterior direction and in the region of the jugular foramen. Cerebellar signs are rare; when manifest they signify the presence of a large tumor. The signs usually associated with cerebellar compression are past-pointing, a disturbance in the gait, or dysdiadochokinesia. As the size of the lesion increases, there may be signs of brain-stem compression, herniation of the cerebellar tonsils into the foramen magnum, increased cerebrospinal fluid pressure with resultant papilledema, and visual disturbance.

**Spinal Fluid and Perilymph Protein Determination.** An acoustic neurinoma does not necessarily cause a rise in the protein level of the spinal fluid. In 25% of the patients the spinal fluid protein value is less than 50 mg per 100 cc of fluid. Usually a normal protein level in a patient with an acoustic neurinoma denotes a relatively small tumor.

For perilymph protein determination, perilymph fluid is aspirated through a perforation made in the foot plate of the stapes. This test should not be performed if other evidence points to a positive diagnosis of an acoustic tumor or when the hearing is normal or slightly decreased. In a patient with an acoustic neurinoma the perilymph protein level is usually well in excess of 1000 mg per 100 cc.

**X-ray Study.** Of all the diagnostic procedures, radiographic evaluation is the most valuable. Routine x rays of the petrous bone should be taken if there is even a slight degree of suspicion that the patient has an acoustic tumor. These should include petrous views by way of the orbits, views at right angle to the long axis (Stenvers views), and 30-degree angle fronto-occipital projections (Chamberlain-Towne views). Normally the diameter fox the
internal auditory canal is quite variable (2.5 to 11 mm), and there may be a 1- to 2-mm variation between the right and left sides. On the other hand, asymmetry between the two sides in a normal person is uncommon, and thus a 1-mm difference between the diameter of one internal auditory meatus and that of the other is significant, providing there is clinical evidence of the presence of an acoustic tumor. When a difference exists, laminograms or polytomography of the petrous bone are indicated. These will outline more clearly the differences in the diameters of the internal auditory canals and the areas of bone destruction.

If the index of suspicion of the presence of an acoustic tumor is high, contrast studies are indicated. This is especially true since the internal auditory canals are normal in 5% of persons with acoustic tumors. The myelography of the posterior fossa is by far the preferable contrast study. A pneumoencephalogram is indicated when the tumors are large.

**Treatment**

**Middle Cranial Fossa Approach.** This approach is similar to that used to approach the trigeminal ganglion. A window, approximately 4 cm square, is made in the squamous portion of the temporal bone. The temporal lobe dura is retracted superiorly after reducing the spinal fluid pressure. The greater superficial petrosal nerve is identified as it exists from the hiatus facialis on the anterior surface of the petrous pyramid. The bone over this nerve is removed by using a diamond bur and constant suction irrigation. The dissection is continued in a posterior direction, until the geniculate ganglion is identified. The bone superior to the facial nerve, medial to the geniculate ganglion, is removed in a similar fashion, until the internal auditory canal is identified. The roof of the internal auditory canal is removed, exposing the tumor.

This operation is technically difficult, for there is a fair chance of injury to the facial nerve as it is unroofed. The bony dissection is accomplished in an area between and very close to both the cochlea and the labyrinth. Injury to the internal auditory artery is another hazard and will result in loss of both auditory and vestibular function.

**Translabyrinthine Approach to the Cerebellopontine Angle.** **Anatomy.** The key to the translabyrinthine operation is a thorough knowledge of the anatomy of the petrous bone and its surrounding structures.

The figure shows the anatomic relationships after the mastoid, middle ear, and labyrinth have been dissected. The important landmarks indicating the location of the horizontal portion of the facial nerve are the cochleariform process, incudal fossa, and the horizontal semicircular canal.

The ampullar ends of the horizontal and superior semicircular canals are close neighbors. The superior semicircular canal often extends above the level of the tegmen mastoideum. The common crus is deep and elusive. The posterior semicircular canal is found just posterior and at right angles to the horizontal semicircular canal.

The vertical portion of the facial nerve is found by a careful and thorough dissection of the superficial group of antero-inferior mastoid cells. The incudal fossa and digastric ridge are also useful landmarks.
The position of the sigmoid portion of the lateral sinus in relation to the labyrinth is variable. An anteriorly positioned sinus usually indicates underdevelopment of the mastoid cells and adds to the complexity of the operation.

The sinodural angle must be dissected. The tegmen over the dura of the posterior and middle fossae is identified. Citelli’s angle, at the junction of the dural plates of the posterior and middle fossae is the landmark, in the mastoidectomy defect, for the superior petrosal sinus.

The superficial and deep groups of the antero-inferior mastoid cells are carefully dissected to determine the level of the jugular bulb and for location of the digastric crest.

A view of the posterior and middle cranial fossae is seen in the figure. Of note are the branches of the middle meningeal artery, the sigmoid portion of the lateral sinus with the beginning of the jugular bulb, the superior and inferior petrosal sinuses, the anterior and posterior surfaces of the petrous pyramid, and the internal auditory meatus.

The translabyrinthine approach for small tumors is through the triangle bound by the superior petrosal sinus, the lateral sinus, and the jugular bulb.

The surgeon should have a clear mental picture of the components of the internal auditory meatus. A simple method of doing this is to visualize the internal auditory meatus as being divided into an upper and lower half by the horizontal crest (crista transversa).

The antero-inferior quadrant is occupied by the cochlear nerve. As would be expected from the middle ear anatomy, the facial nerve enters the meatus directly above in the antero-superior quadrant.

Behind the facial nerve, in the postero-superior quadrant, is the superior vestibular nerve with its branches to the utricle and horizontal and superior semicircular canals. There is a vertical crest between the superior vestibular nerve and the facial nerve.

The inferior vestibular nerve enters the meatus in the postero-inferior quadrant. It supplies the utricle. The nerve to the posterior semicircular canal usually enters behind the inferior vestibular nerve in a separate foramen.

**Technique of Operation.** The incision is similar to that for any postauricular mastoidectomy. Inferior and superior extensions over the mastoid tip and squamous portion of the temporal bone are made in accord with the pneumatization of the mastoid.

It is imperative to obtain wide exposure of the root of the zygomatic portion of the temporal bone and the superior wall of the external auditory canal.

A simple mastoidectomy should include exposure of the entire tegmen mastoideum, lateral sinus plate, sinodural angle, mastoid tip with digastric ridge, horizontal semicircular canal, and short process of the incus.
The superficial group of antero-inferior mastoid cells usually leads directly to the facial nerve. Other landmarks for identification of the vertical portion of the facial nerve are the incudal fossa, horizontal semicircular canal, and the digastric ridge.

At this point a small fenestra is made in the horizontal semicircular canal in order to obtain perilymph for a protein determination.

The superior and posterior semicircular canals are identified and entered. Whether or not to remove the incus at this point is controversial. Some surgeons prefer to leave it in place to protect the horizontal portion of the facial nerve. Others remove it in order to keep an eye on the nerve and also to identify the cochleariform process. As the semicircular canals are dissected the vestibule is encountered.

While dissecting the medial aspect of the labyrinth and vestibule, the peristeum lining the posterior wall of the internal auditory canal is encountered. This is followed laterally and slightly anteriorly until the posterior end of the horizontal crest is identified. This important landmark positively identifies the superior and inferior vestibular nerves. Above and slightly anterior to the superior vestibular nerve is a triangular projection of bone which has been mentioned previously. This provides differentiation of the facial nerve in relation to the superior vestibular nerve.

The remaining bone is carefully removed from the dura of the posterior fossa. This dissection is somewhat tedious and is best done with a diamond bur and constant irrigation-suction.

Quite often the tumor can be seen before the dura is incised. It is of a yellowish, fatty consistency and may be accompanied by cysts of various sizes. The dura is carefully incised with angulated dural knives. A biopsy specimen is taken for frozen-section diagnosis.

The capsule of the small tumor is dissected posteriorly, superiorly, and inferiorly, by using various elevators, forceps, middle-ear scissors, and small cottonoids.

Prior to dissecting the tumor anteriorly, the vestibular nerve concerned (usually the superior) is sectioned laterally. The facial nerve must be positively identified before dissecting the anterior aspect of the tumor. The identity of the facial nerve is confirmed by the use of an electrical nerve stimulator (Richards Manufacturing Co).

The vestibular nerve is sectioned medially and the tumor removed. The antero-superior cerebellar artery is often seen and should not be disturbed. Bleeding from the internal auditory artery and other small vessels may at times be troublesome. This is treated by packing with absorbable gelatin sponge (Gelfoam) or oxidized cellulose gauze (Oxygauze), cottonoids saturated with thrombin solution, or by cauterization, using a #20 insulated suction tip.

Prior to closure of the wound, the dural defect is temporarily packed with cottonoids and the bony mastoid labyrinthectomy defect irrigated with bacitracin solution (50,000 units of bacitracin in 200 cc of normal saline) to remove all debris and bony fragments. Hemostasis is imperative.
The mastoid labyrinthectomy defect is obliterated with subcutaneous adipose tissue obtained from the left side of the abdomen. The mastoid incision is closed with drainage. The adipose tissue serves to prevent postoperative contamination and leakage of spinal fluid. This tissue rapidly revascularizes.

*Postoperative Course.* The postoperative course is similar to that of a mastoidectomy. The patient should be carefully observed for early signs of central nervous system complications. The usual duration of hospitalization is one week.

**Suboccipital Translabyrinthine Approach.** Resection of large acoustic neurinomas, in excess of 4 cm in diameter, is rather difficult and hazardous by way of the translabyrinthine route. It is difficult to identify the antero-inferior cerebellar artery, and that portion of the tumor attached to the brain stem must be approached at right angles. Therefore, injury to the lower cranial nerves is likely. As a result, my colleagues and I have adopted a two-stage technique for resection of large tumors.

The first-stage operation consists of a dissection and tagging of the facial nerve, decompression of the posterior fossa, and partial resection of the acoustic neurinoma. Of prime importance is the identification of the facial nerve. This is sometimes difficult when the tumor is large, for the nerve can be displaced and may be broadened and thinned by pressure from the tumor. The tumor is carefully resected from the posterior aspect of the facial nerve, both in the internal auditory canal and intracranially. As much of the tumor is removed as is necessary for decompression of the posterior fossa. This is for the most part an intracapsular resection. It is important to remove as much bone as is possible on the posterior surface of the petrous pyramid in order to facilitate the dissection during the second-stage operation.

At the termination of the translabyrinthine operation, a narrow strip of *blue* rayon is placed on the posterior surface of the facial nerve. This is extremely useful as a "tag" for identification of the facial nerve during the second-stage procedure. The labyrinthectomy and mastoidectomy defects are obliterated with an adipose autograft, and the mastoid incision is closed without drainage.

The second-stage suboccipital operation should be performed as soon as the patient has recovered from the first-stage procedure. An interval of 1 to 2 weeks is usually required. During the second operation, the remainder of the tumor is dissected from its attachment to the lower cranial nerves, cerebellum, and brain stem. The rayon strip is identified and removed from the posterior surface of the facial nerve. The nerve stimulator, with a long insulated probe, is invaluable when outlining the course of the facial nerve from the brain stem to the internal auditory meatus. Once the course has been ascertained that portion of the tumor, which may extend forward and be attached to the fifth cranial nerve, can be readily resected.

A temporary facial paralysis may follow the resection of a large tumor. Anesthesia of the cornea is often present with large tumors. The cornea is thus in great danger of injury. The administration of antibiotic eye ointment is essential, beginning with the immediate postoperative period. If there is no evidence of return of facial nerve function in 3 to 5 days, a lateral tarsorrhaphy is indicated.
Surgery of the Auricle

Congenital Lop Ears

The term "congenital lop ears" covers a variety of anomalies of the external ear. Attempts to classify these various types of ear problems are confusing because one deformity may differ slightly from another and yet shade ever so slightly into still another category. There are, however, five basic defects, each with variations, which the surgeon will observe when analyzing congenital lop ear. These are:

1. Poor definition or absence of a component part of an ear, most often the anthelix.
2. An excess of cartilage in the concha either uniformly, superiorly, or inferiorly.
3. Abnormally small ears (microtia).
4. Excessive size of the ears (macrotia) or of a component part of the ears.
5. Disparity in the size or shape of one ear as compared with the other.

Many surgical techniques have been devised and advocated for the correction of these defects. That no one surgical procedure is a "cure-all" can be attested by the number available. Each surgeon, therefore, should have a workable knowledge of a few basic procedures which he can vary to correct the unique defects of any particular ear.

The minimum age for surgical correction of lop ears should be around 4 to 5 years. Prior to this age, most children are not conscious of any deformity. At any earlier age the auricular cartilage may not be mature enough to make the procedure technically feasible.

Preoperative Preparation. Unless the patient is in his late teens, general anesthesia will prove invaluable. Local anesthesia can be used with older patients. Xylocaine with epinephrine is infiltrated circumferentially around the ear and around the external auditory meatus. This works quite nicely with a well-premedicated patient.

After the patient is "prepped," he is draped so that contamination of an ear, either prior to the operation or following it, is avoided. This can be accomplished by placing a sterile stockinette, with holes cut for the ears, over the patient's head. A sterile sheet is placed under the head. After one ear has been operated upon, sterile batting applied while working on the second. Many surgeons now prefer to use sterile adhesive drapes which are applied easily and provide a view of the patient's features.

Various Surgical Techniques. Space does not permit mention of the many procedures that have been devised for correction of the numerous auricular defects. Three widely used techniques will be described. A variation of one of these techniques will usually suffice to correct most cases of lop ears adequately. The surgeon's ability to use the right procedure for the right case and his own innovations will make the difference between mediocre and good results.

Mattress Suture Otoplasty (Mustarde Technique). This is a simple method which has recently become quite popular.
The ear is folded into the desired position and straight needles are passed through the apex of the "new" anthelix. The needles are tipped with methylene blue and withdrawn, leaving a series of dots along the posterior surface of the apex of the new anthelix. An elliptical excision of skin is made on the posterior aspect of the ear down to perichondrium. The skin is undermined 5 to 10 mm in all directions.

Using #4-0 white silk or braided dacron, with an atraumatic needle, at least four mattress sutures are placed in position to bridge a gap in the cartilage. These are tied when all the sutures are in place. The degree of tightening of the sutures determines the contour of the anthelix. The skin is closed with interrupted sutures of #5-0 nylon.

This is a simple procedure which will correct a poorly developed anthelix, but other techniques or variations of this technique may be necessary in patients with abnormalities of the conchal cartilage, grossly enlarged ears, or disparity of ear size.

Cutting, Thinning, and Tubing the Cartilage. This technique was described by Converse and associates in 1955. An elliptical piece of postauricular skin is excised to expose the auricular cartilage posteriorly. The anthelix is outlined with straight needles introduced anteriorly when the ear is positioned into proper alignment. The needles are tipped with ink and withdrawn. The cartilage is incised along the inked lines provided by this maneuver. It should be noted that the superior incision does not joint the lateral incision. Another incision is also made along the lateral border of the conchal cartilage. The auricular cartilage between these incisions is thinned with a wire brush, then folded back and sutured to the proper width. This technique can be combined with the excision of conchal cartilage when necessary.

Linear Incisions and Fish-Scaling. Luckett, in 1910, advocated "breaking the spring" of the cartilage with a single linear incision to help form a new anthelix. This procedure is seldom used today for occasionally it produces a sharp crease in the ear rather than the natural-appearing, rounded anthelix desired. This method was modified later by others who preferred multiple partial-thickness incisions parallel to the new anthelix. Those experienced with this technique can produce a normal-appearing anthelix.

Another method for "breaking the spring" of the auricular cartilage, involving multiple gouges in the posterior aspect of the cartilage, was introduced by Holmes in 1966. This operation is performed by making rows of interdigitating pieces of cartilage with only partial thickness. According to Holmes, this adequately breaks the spring and forms a surface area for fibrosis to occur so that the ear will remain in this position, once the stay sutures are removed.

Surgery of the Lobule. Excessive lobule size may be decreased by a simple wedge incision. The protruding lobule may be corrected at the time of an otoplasty by a "W" excision of postauricular skin.

Dressing and Postoperative Case. Dressing and packing of the ear is most important to prevent the formation of hematomas and to hold the ears relatively immobile during the initial healing phase. Cotton, impregnated with either an antibiotic ointment or tincture of benzoin, is packed into the convolutions of the ear and covered carefully with cotton fluff. The postauricular incision is covered with petrolatum gauze and the proper amount of cotton
fluff. Cotton pads are then placed over the ears and a mild compression dressing is taped into place to remain for 5 to 7 days. The ear should be examined for hematomas the day following the operation.

**Excision of Auricular Lesions**

A natural-appearing or cosmetically acceptable external ear following trauma or surgical removal of a tumor is the result of a gentle surgical technique plus a basic knowledge of flaps, grafts, and pedicles.

The most commonly excised tumors of the external ear and auricle are squamous cell and basal cell carcinomas. Excision of these lesions is usually performed with the area locally anesthetized. A small tumor presents no difficulty since it may be excised by a simple V incision which is closed primarily. As the size of the lesion increases it becomes more difficult to approximate the edges of the helix; when closure is difficult two additional small V incisions are most helpful. A 1-cm margin should be obtained around the lesion. The results of a frozen section should be checked before the wound is closed.

In some instances up to one third of the auricle may be excised in this manner without disturbing the contour of the ear.

For larger defects, the surgeon must resort to local flaps and pedicles. For complete or nearly complete loss of the auricle there is no good method of total reconstruction. Numerous procedures have been employed, but none have given consistently good, cosmetically acceptable results in even the most skilled hands. This is a problem that remains sorely in need of a solution.

The surgeon may use one of a variety of flaps, pedicles, or grafts for reconstruction. When partial loss of the auricle does not permit primary closure.

**Postauricular Flap.** This flap, also known as an auriculomastoid flap, can be used in a number of ways. The flap can be based posteriorly and outlined to fit the defect of the auricle. It is sutured in place with a strip of cartilage graft from the opposite ear, or nasal septum, embedded to conform to the helix. After 3 weeks, the base of the flap is severed and the flap is raised and sutured in place to form the posterior surface of the auricle.

**Chondrocutaneous Flap.** For a similar lesion, Millard has described an ingenious method which employs a composite flap using cartilage from the ear being operated upon to re-form the rim of the helix. The flap is based on the anterior auricular skin and has intervening scar tissue which makes a delay imperative. After a 2-week delay, the flap is raised again, and a piece of cartilage, 0.33 cm in width, is excised and left attached to the skin. This is fashioned to form a cartilaginous support for the length of the reconstructed helix. The distal skin is sutured into place to form the posterior surface of the auricle. A split-thickness graft is needed to complete the posterior surface of the auricle and to resurface the donor site.

**Advancement of a Helical Flap for Superior Auricular Defects.** This procedure is advantageous for relatively small- to medium-sized superior marginal defects. It has a
cosmetic advantage in that duplication of the helix is not attempted. Instead, the remaining helix is advanced superiorly. A composite advancement is fashioned with the incision carried just anterior to the remaining helix and through the sides of the defect. The flap is based on the postauricular skin which must be freed from the posterior surface of the aural cartilage. It is then advanced and sutured. If the decrease in vertical height is noticeable, the height of the opposite ear may be reduced by the wedge-incision technique.

**Scalp Flap for Superior Auricular Defects.** If the hairline permits, this procedure is useful for the repair of the superior auricular defects. A local scalp flap is raised superiorly, and autogenous cartilage is embedded. The freshened edges of the auricle are sutured to the flap. After an appropriate delay (usually 3 weeks), the scalp flap is excised and sutured in place to re-form the contour of the ear. The scalp is closed primarily and a split-thickness skin graft is needed for the posterior surface of the auricle.

**Tubed Pedicle Flap.** The tubed pedicle flap can be used for subtotal or total loss of the helix. Based posteriorly near the auricle, the flap can be delayed and attached to the remaining auricle to form a helix. This procedure requires multiple steps and often the results are not entirely satisfactory.

**Preauricular Flaps.** These are superiorly based flaps which are rotated 90 degrees without delay. The donor site is closed primarily. They have proven satisfactory for correction of defects of the anterosuperior area of the auricle.

**Special Problems**

**Excision of Preauricular Cysts.** Preauricular cysts are common congenital cystic structures located anterior to the base of the helix. The small, intermittently draining sinus tract can usually be probed without difficulty. These cysts produce very few symptoms until they become infected. Prophylactic excision is indicated.

The external tract is ligated with a silk suture. A triangular flap is then raised exposing the cystic system. This conglomerate of cyst, fibrosis, and subcutaneous tissue is removed along with the duct. The triangular flap is then sutured into place.

**Chondritis Following a Burn.** The progress of a burned ear should be followed very closely. The usual time for onset of chondritis is 3 to 5 weeks following the accident. Dull pain heralds the onset; usually the pain increases in severity. The ear develops inflammation and edema causing its protrusion from the head. Fluctuance develops and drainage may occur spontaneously.

Dowling attributes a decrease of from 19 to 29% of chondritis of the auricle, occurring in association with all burns of the face, to open-air treatment and the use of Sulfamylon.

The cartilage involved with chondritis should be excised along with the overlying skin. If possible, the underlying skin, upon which a graft may be placed, should be preserved. The incidence of recurrence is high and, when this takes place, additional auricle must be excised. Chondritis of the ear usually is attended with at least some degree of auricular deformity.
**The Cauliflower Ear.** This is the "boxer's ear" in which scar contraction has occurred following trauma and hematoma formation.

Prevention is, of course, the best treatment. The blood and serum in an acute hematoma of the auricle should be evacuated as soon as feasible. A problem arises in that the hematoma may continue to re-form. To avoid this, a pressure dressing should be applied. One method is to tie through-and-through sutures over moist cotton; this will provide firm pressure and prevent the reaccumulation of serum and blood. Cotton, impregnated with tincture of benzoin, is then tucked into all the spaces of the auricle, and a pressure dressing is applied.

**Temporal Bone Resection**

Block resection of the temporal bone, with or without a radical neck dissection, as pioneered by John S. Lewis, has increased the 5-year survival rate for carcinoma involving the temporal bone. Prior to instigation of this method of therapy the treatment consisted of a radical mastoidectomy followed by radiation therapy, with a resultant 5-year cure rate of less than 10%. The osteonecrosis and injury to the intracranial structures (pons and medulla), following a full course of radiation therapy to the temporal bone, were often devastating.

Temporal bone resection, with or without preoperative radiation therapy, has increased the 5-year survival rate to approximately 30% (Lewis, 1966). The preoperative radiation therapy, however, should *not* exceed 4000 r.

**Pathology of Carcinoma Involving the Ear**

Carcinoma of the external ear and outer ear canal is most frequently of the basal cell variety (in two thirds of cases) and most often is found in the elderly white male. Basal cell carcinoma of the auricle, which is located well away from the external auditory canal, is not a serious disease and can be treated by radiation therapy or local excision as is prescribed for similar lesions in other areas of the head and neck. A lesion with 1 cm of the external auditory canal is a much more serious disease and must be treated by radical surgery. The extensive lymphatics in this region account for the seriousness of this disease (Miller).

Squamous cell carcinoma is the most common type of tumor found in the deep external auditory canal, middle ear, and mastoid. It is more prevalent among females than among males and occasionally is associated with chronic otitis media.

Adenocarcinoma of the temporal bone arising from the parotid, ceruminous glands, or middle ear mucosa, is rather rare. Numerous other malignant tumors have been reported in this area. The most common are rhabdomyosarcoma, malignant melanoma, and spindle-cell sarcoma.
**Signs and Symptoms of Carcinoma Involving the Temporal Bone**

1. *Pain* can result from secondary external otitis or otitis media, but may be due to invasion of bone by tumor.

2. *Hearing loss* is a common symptom and is due to either obstruction of the external auditory canal by the tumor, the presence of tumor or secondary infection involving the tympanic membrane or middle ear, or the extension of disease into the inner ear. It is thus important to differentiate between a conductive and perceptive hearing loss.

3. *Bleeding* from the external auditory canal can be the first and only symptom of disease. Severe hemorrhage from the external auditory canal is encountered with the rhabdomyosarcoma.

4. *Otorrhea* associated with a long history of chronic otitis media occasionally precedes the onset of carcinoma. Usually, however, the otorrhea is caused by secondary otitis externa or otitis media. A biopsy of the external auditory canal should be performed in those cases of chronic otitis externa which do not respond to the usual conservative measures, especially when granulation tissue is present.

5. A *facial nerve paralysis* may occur when the disease extends to the middle ear and beyond. Rather extensive disease can be expected when facial nerve paralysis complicates a malignant lesion in this region.

6. *Vertigo* is usually indicative of extension of disease to the inner ear, but may be the result of secondary infection.

7. *External swelling* can be present and is due to extension of disease into the parotid gland or the sternocleidomastoid muscle.

**Diagnosis of Carcinoma Involving the Temporal Bone**

Routine x-rays of the mastoid bone will show evidence of bone destruction in approximately 40% of the cases. Polytomography of the temporal bone has somewhat increased this percentage. It must be kept in mind that the exact extent of disease cannot be determined until the time of operation.

The functions of the facial, auditory, and vestibular nerves should be carefully studied. Any evidence of extension of disease beyond the confines of the temporal bone must be evaluated. The surgeon should search carefully for enlarged cervical lymph nodes.

The diagnostician must be careful not to be fooled by a pathologic report indicating no malignant disease as ascertained from a study of granulation tissue or of a polyp overlying the lesion itself. A repeat biopsy is indicated if there is any suspicion of malignant tumor.

It can be assumed that there is disease in the middle ear if the lesion in the external auditory canal has extended to the region of the tympanic membrane. The tympanic
membrane may remain entirely normal when the tumor extends around the annular ligament to the middle ear.

**Radiation Therapy of Carcinoma Involving the Temporal Bone**

It is the considered opinion of most radiotherapists that any form of radiation therapy to a carcinoma which has invaded the bone is of little value. Most reports in the literature indicate a 5-year survival rate of less than 10% for patients with carcinoma of the temporal bone treated by radiation therapy. The complications of a full course of radiation therapy for temporal bone carcinoma have been mentioned.

Postoperative radiation therapy is indicated for those patients who had had one or more surgical procedures prior to the temporal bone resection. The amount of postoperative supravoltage radiation should not exceed 4500 r.

Preoperative radiation therapy is indicated for patients with more advanced disease in whom the cancer extends to the dura. These patients have severe pain that is difficult to control, even with narcotics. The amount of preoperative supravoltage radiation should not exceed 4000 r.

**Indications for Temporal Bone Resection**

Positive indications for temporal bone resections are:

1. Disease of recent onset.
2. Evidence of slight bone destruction.
3. More advanced disease in a patient who has received preoperative radiation therapy.

**Preoperative Care**

At least six units of whole blood should be in readiness prior to this extensive operation. The patient's scalp is shaved completely if the entire auricle is to be removed, otherwise the shaved area can be limited to the preauricular region, the scalp over the squamous portion of the temporal bone, and the region behind the mastoid bone.

**Anatomic Considerations**

The surgeon must have a thorough knowledge of the vascularity surrounding the temporal bone. The sigmoid portion of the lateral sinus lies posteromedial to the mastoid bone and extends inferiorly to the jugular bulb at the base of the skull. The superior and inferior petrosal venous sinuses are also important landmarks during this dissection. Medial to the petrosal bone is the cavernous sinus. The carotid artery is located inferior, anterior, and medial in the petrous pyramid and fortunately is less vulnerable to injury during a temporal bone resection that are the other vascular structures.

It is usually necessary to sacrifice the facial nerve when the temporal bone is resected. The condylar process of the mandible and parotid gland are also included in the resection. The cochlea and semicircular canals are transected or resected during the procedure. A radical
neck dissection is performed if there is evidence of cervical metastasis or if evidence of carcinoma in the inframastoid lymph nodes is found on frozen section at the time of the operation.

The location of the hypoglossal and vagus nerves at the base of the skull should be kept in mind during the operation in order to avoid their injury.

**Surgical Technique**

In general there are two variations of the primary incisions, depending upon whether or not there is to be partial preservation of the auricle. The peripheral auricle can be preserved when the tumor lies deep in the external auditory canal.

The entire auricle must be sacrificed when the tumor is present in the region of the concha.

After elevating the flap over the tip of the mastoid bone and the sternocleidomastoid muscle, a careful search for lymph nodes is conducted. The nodes are removed and sent to the pathology department for frozen-section diagnosis. A radical neck dissection is included with the operation if the lymph nodes show evidence of tumor involvement. Skin flaps are elevated anteriorly over the parotid gland, superiorly over the squamous portion of the temporal bone, posteriorly over and behind the mastoid bone, and inferiorly to expose the sternocleidomastoid and digastric muscles. The incisions for rotation and advancement of the flaps, to be used for repair of the defect when the entire auricle is removed, are not made until the temporal bone resection has been completed.

The squamous portion of the temporal bone is carefully inspected for evidence of bone destruction. The bone incision in this area is made with a rotating cutting bur. This incision begins anteriorly over the root of the zygomatic portion of the temporal bone, and extends superiorly to a point at least 4 cm above the level of the temporal line. The posterior limit of the bone incision, which extends across the squamous bone superiorly, is continued to a vertical line drawn from behind the mastoid bone. The posterior bone incision is made along this vertical line. The squamous bone can be removed, either piecemeal with a rongeur or in one piece by making a bone incision above the temporal line.

It is not uncommon for carcinoma to involve a portion of the dura in the region over the roof of the epitympanum. The area of involvement is excised with a wide margin and repaired with temporal fascia.

The attachments of the sternocleidomastoid and digastric muscles to the mastoid bone are severed. The jugular vein, carotid artery, and vagus, hypoglossal and facial nerves are exposed. A ligature is placed around both the internal carotid artery and the internal jugular vein to be tightened if either vessel is inadvertently opened during the temporal bone resection.

The beginning of the sigmoid portion of the lateral sinus is identified by additional bone removal in the postero-inferior aspect of the defect made by resection of the squamous portion of the temporal bone. The entire sigmoid portion of the lateral sinus is exposed and
dissected posteriorly, away from the temporal bone, so that it will not be injured as the temporal bone is removed.

The head and neck of the condylar process of the mandible are exposed and an incision is made through the neck of the mandible with a Stryker or Gigli saw. The condylar process above this incision is resected, exposing the glenoid fossa. Beginning in the antero-inferior aspect of the defect made by resecting the squamous portion of the temporal bone, an incision is made through the root of the zygomatic portion of the temporal bone with a rotating cutting bur, Kerrison forceps, or Stryker saw. The middle meningeal artery, or one of its branches, is usually present in this location and must be carefully avoided. The bone dissection is continued inferiorly across the glenoid fossa exposing the eustachian tube. There then remains a thin segment of bone between the line of dissection and the carotid canal.

The parotid gland, along with the facial nerve, is resected at this point. On occasion, when the tumor involves only the outer half of the external auditory canal and the surgeon is certain that there is no extension of disease around the annular ligament into the middle ear, it may be possible to preserve the continuity of the facial nerve. In such a case the facial nerve is clearly exposed at the stylomastoid foramen and a superficial and deep lobe parotidectomy is performed.

The styloid process is identified and transected near its base. The muscles attached to the base of the styloid process and the inferior surface of the temporal bone are transected at this time. A vertical bone incision is made in the glenoid fossa, exposing the eustachian tube.

The dura of the temporal lobe is retracted medially and superiorly, exposing the petrous bone to the level of the internal auditory meatus. A curved osteotome is placed medial to the arcuate eminence and immediately lateral to the internal auditory meatus on the anterior surface of the petrous pyramid. An incision is made in a posterior and inferior direction, with extreme care, and only through bone, in order to avoid injury to the internal carotid artery.

The inferior surface of the temporal bone is exposed. A chisel is placed medial to the digastric groove and a bone incision is made in a superior direction. At this point the temporal bone should be free with the exception of a small area of bony attachment in the region of the glenoid fossa. The attachments are easily severed with a straight osteotome.

As the remaining soft tissue attachments of the temporal bone are incised and the temporal bone is removed, one or more tears may be made in the dura, resulting in spinal fluid leakage. Subcutaneous adipose tissue is obtained from the abdominal wall and used to repair the defects in the dura and also to obliterate the cavity resulting from the temporal bone
resection. The catheter is removed from the dura of the temporal bone and a purse-string suture is tied.

At this point a radical neck dissection is carried out if indicated. If available a second team of surgeons should be called in to perform this operation. A radical neck dissection is usually unnecessary with resection of a temporal bone carcinoma for metastasis to the neck occurs in only 16% of uncontrolled cases. Almost all patients die of local disease with possible extension into the brain.

The hypoglossal nerve is identified, dissected free, and transected peripherally, so that it can be re-directed and sutured to the peripheral end of the transected facial nerve. The results of hypoglossal facial anastomosis are quite gratifying, for a good facial tone is obtained and there is motion of the face when the patient attempts to move the tongue or swallow.

**Postoperative Management**

In the past, cerebral fluid leakage has been a serious complication with the additional hazards of meningitis and brain abscess. The incidence of these complications has been markedly reduced with the use of adipose autografts.

If postoperative hemorrhage occurs, the site of bleeding may be a lateral sinus or the superior petrosal sinus. Bleeding is easily detected for it will either saturate the dressing or cause swelling, as the blood infiltrates the subcutaneous spaces.

Infection is a likely complication because of the length of time required for the operation and the existing secondary infection superimposed on the carcinoma. It is wise to place the patient on intravenous antibiotic therapy to cover both gram-positive and gram-negative organisms for a period of at least 5 days following the operation.

A facial nerve paralysis is managed as has been mentioned previously.

Varying degrees of vertigo will persist for 3 to 6 weeks postoperatively unless the labyrinth was functionless prior to surgery. A careful explanation of the cause of this vertigo, along with antivertiginous medication, will be beneficial.

For a patient in whom the tumor was not completely resected, postoperative radiation therapy is instituted as soon as wound healing is complete. The use of cryosurgery for treatment of residual or recurrent disease may be of value.