Chapter 46: The Nasal Septum

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The nasal septum has long been of considerable interest to the otolaryngologist - head and neck surgeon. Attempts to alter septal deviations probably were first made in 1757 with Quelmaltz's advocacy of daily digital pressure for gradual correction. A century later, Adams (1875) advocated fracture and splinting of the nasal septum. Ingals initiated bolder methods in 1882 by removing a small triangular piece of cartilage (Hinderer, 1971). Krieg (1889) and Boeninghaus (1900) advocated removing the deformity and the nasal mucosa. In 1899 Asch (1899) suggested actually altering the spring of the cartilage with full-thickness cruciate incisions. Freer (1902) and Killian (1904) should be credited with the concepts of submucous resection (SMR) that to this day form the basis of most techniques. In 1903 Jackson attributed failure of septal surgery to turbinate hypertrophy, and in 1907 Mosher added notable work on the premaxilla to the literature (Hinderer, (1971). Metzenbaum (1929), along with Peer, Galloway, and Foman (Hinderer, 1971) designed techniques to deal with the caudal septum, and Metzenbaum's "swinging door" technique ushered in an era of special interest in this branch of septal surgery.

The era of the modern septoplasty began with Cottle (Cottle and Loring, 1947) and, in the ensuing years, he and others (Cottle, 1960; Goldman, 1956; Smith, 1957) decried the disadvantages of SMR and extolled the virtues of septoplasty methods. Borg et al (1957), Stoksted (1969), Pearson and Goodman (1973), Edwards (1974), and Maran (1974) all attempted to analyze the incidence and timing of the complications associated with SMR. Despite the lengthy development of a large body of knowledge favoring septoplasty over SMR techniques, many surgeons continue to prefer the latter to the former (Peacock, 1981).

Embryology

The development of the nose begins in the third week of fetal development when the sensory epithelium originating within the cranial ectoderm thickens. This is the precursor of the paired olfactory placodes that are lateral to the frontal prominence just above the stomodeum. During the fifth week, the lateral and medial nasal swellings appear as ridges. They surround the placodes, which become depressed to form the nasal pits (Moore, 1973). Deepening of these pits separates the frontonasal process into medial and lateral components. The medial component ultimately fuses to form the primitive nasal septum. Inferiorly, the paired maxillary processes of the first branchial arches grow anteriorly and medially to fuse with the medial nasal processes.

During the sixth week of development the slitlike epithelium-lined nasal pits begin to extend posteriorly. These thin out to form the bucconasal membrane separating the nasal from the oral cavities. Subsequent membrane rupture forms the early choanae, which are ultimately located more posteriorly as a result of palatal development. Palatal growth and rupture of the bucconasal membrane facilitates the development of the definitive nasal septum, which grows simultaneously toward the sphenoidal process in a posterior direction.

By the third fetal month, mesenchymal condensation begins and cartilage grows in from the sphenoid to form two adjacent plates. These plates fuse not only with one another but also ventrally with the lateral nasal walls to form the nasal capsule. During the sixth fetal month, ingrowth of connective tissue divides the capsule into lower and upper lateral cartilages as well as septal cartilage.

By the middle of the fifth fetal month, and extending well into adolescence, ossification of the posterior part of the cartilaginous capsule begins. The cribriform portion of the perpendicular plate remains fibrous until the third year, when it ossifies, thereby stabilizing the ethmoidal complex. The anterior extent of the perpendicular plate varies between individuals, ranging from the nasal spine of the frontal bone to the caudal end of the nasal bones.

The vomer, on the other hand, does not develop by ossification of cartilage but rather from connective tissue that exists on both sides of the septal cartilage. The cartilage between the lamellae of the vomer is absorbed, thereby allowing fusion of the vomerine plates. These plates grow upward to meet the perpendicular plate of the ethmoid and the posterior portion of the septal cartilage in the groove on top of the plates of the vomer.

Anatomy

The nose is a prominent appendage with both aesthetic and functional significance, and the nasal septum is an integral part of this structure (Bernstein, 1973; Clark and Wallace, 1970; Cottle, 1951). To discuss the septum alone when dealing with development, anatomy, or physiology is virtually impossible; any such discussion must emphasize the interrelation between the nasal and septal parts.

The nasal septum is composed of cartilage and bone that are covered predominantly by respiratory mucosa. The septum separates the columns of the nose, contributes to dorsal support (especially in the rhinion area), and provides a protective shock-absorbing mechanism for the floor of the frontal fossa from various forces presented to the normal, upright face. The anatomic orientation of the septum relates to the head in the upright position; thus there are anterior, posterior, inferior, and superior parts. The spatial or body orientation of the nose is referred to as *cephalic, caudal, dorsal,* and *ventral* (Fig. 46-1).

The nasal septum consists of parts of the maxillary, palatine, vomerine, and ethmoid bones as well as cartilage. Some texts also include the nasal spine of the frontal bone, the premaxilla, the upper lateral cartilages, the membranous septum, and the columella (Hinderer, 1971). Perpendicular projections from the maxilla and the palatine bone form the maxillary crest. Its upper edge is characterized by a spine that extends almost the entire length of the palate. In this groove lies the quadrilateral cartilage anteriorly and the vomer posteriorly. Cartilage does not articulate directly with bone, but through fibrous attachments between the respective perichondrial and periosteal compartments (Fig. 46-2); occasionally, fat is interposed between the two. With trauma, separation of the two compartments occurs more often than does fracture of the contents of the individual compartments. The articulation between the vomer and maxillary crest is unique. This union is fibrous early in life, yet becomes bony after both structures have ossified (Clark and Wallace, 1970).

The septal cartilage has four borders: dorsal, ventral, caudal, and cephalic (see Fig. 46-1). It does not extend to the floor of the nose but ends at the maxillary crest. The most caudal portion of the cartilage usually extends beyond (anterior to) the nasal spine, a structure to which its perichondrium has substantial fibrous attachments. The ventral border of the septal cartilage slants upward as it extends cephalically in the trough of the vomer. The most cephalic extension of the septal cartilage varies according to the general development of the whole structure; it reaches more posteriorly in noses with firm and substantial cartilage development. No relationship seems to exist between the thickness of the septal cartilage and that of the perpendicular plate of the ethmoid bone. On numerous occasions, a thin or dehiscent perpendicular plate has been observed, even in the presence of a septal cartilage of substantial thickness (Sessions and Wenig, 1986).

The caudal border of the septal cartilage is exposed to environmental forces. That portion of cartilage extending beyond the nasal spine can be subjected to forces that cause either dislocation of its nasal spine attachment or vertically oriented cartilage fractures. Although thickness and strength vary, the septal cartilages that have greater extensions beyond the nasal spine are more vulnerable to this form of injury. The caudal border of the cartilaginous septum is insinuated into the posterior aspect of the columella, between the two medial crura of the lower lateral cartilages. This arrangement offers some protection because movement of the highly mobile membranous septum provides some absorption of force.

Under the stress of direct trauma to the nasal tip, two major anatomic relationships influence the resultant injury: (1) the attachment of the septal cartilage to he vomerine sulcus, and (2) the relationship of the septal cartilage to the upper lateral cartilages. If the sulcus is deep and the septal cartilage well entrenched, the cartilage bends with the blow and, depending on the magnitude of the force, may fracture. If, on the other hand, the vomerine sulcus is shallow, as is often the case in children, the cartilage subluxes into one or the other nasal fossae (Metzenbaum, 1929). The length of the upper lateral cartilages influences the location and direction of septal fracture lines. In the past, the upper lateral cartilages and the septum were thought to function as one unit (Forman et al, 1952), but more recent cadaver studies have clearly shown that the two structures are not only separate cartilages, but are housed in their own respective compartments (Fig. 46-3). This anatomic fact probably provides additional shock absorption and mobility to this area, while attachment to the upper lateral cartilages lends more strength to the dorsal edge of the septal cartilage. Consequently, septal fractures are usually confined to the free nasal tip and are vertically oriented. However, in noses with short upper lateral cartilages (those that do not extend far caudally), and thus with no support of the dorsal septum, fractures may occur in an oblique fashion and can extend from the nasal spine toward the rhinion area (Metzenbaum, 1929). The cephalic border of the cartilaginous septum where it lies against the ethmoid perpendicular plate is usually the thickest (5-7 mm) portion of the septal cartilage (Clark and Wallace, 1970) (Fig. 46-3). This end-to-end relationship between bone and cartilage can actually be disrupted with cartilage telescoping over the bony perpendicular plate. The cephalic extent of the septal cartilage varies considerably, and, in some noses, can reach beyond the midpoint of the nasal bones.

The septal cartilage articulates with the upper lateral cartilages in the area of the rhinion dorsally (Fig. 46-4). When the caudal ends of the upper lateral cartilages diverge (as is often the case), caudal attachment may not exist. The compartmental separation of the septal cartilage from the upper lateral cartilages is another anatomic feature of structural mobility for the absorption of various forces in traumatic events. Additionally, the compartmentalization tends to retard the dissection of subperichondrial bleeding from one area of the nose to another. Diffuse hematoma is more likely to be of submucosal or subcutaneous origin rather than subperichondrial or subperiosteal. In effect, compartmentalization serves to tamponade and localize bleeding within the framework of the nose.

On the dorsal edge of the septal cartilage is a groove that cephalically accepts the nasal spine of the frontal bone, and just caudally, the keel-like undersurface of the nasal bones (Fig. 46-4). Together, these form a structure of substantial strength that has been referred to as the keystone area of nasal support (Hinderer, 1971).

Any discussion of nasal septal anatomy must pay special attention to the perpendicular plate of the ethmoid bone (perpendicular lamina). This polygonal structure descends downward from the cribriform plate and usually makes up a large part of the nasal septum. Its contribution to nasal support is, however, minimal. Its thickness is variable in children and may be vestigial in an otherwise normal nose (Hinderer, 1976). The chief significance of the perpendicular plate is related to its presumed role in shock absorption. The anterior border is grooved to receive the nasal process of the frontal bone and the V shape of the undercarriage of the joined nasal bones. Its caudal edge is often thickened where it lies against the septal cartilage. The lower edge curves around sharply as it lies in the groove on the superior surface of the vomer. In effect, articulations between the perpendicular plate and septal cartilage and between the perpendicular plate and vomer form the shape of an arch, with the anterior leg based in the root of the nose and the posterior leg in the basisphenoid area. If force is directed onto the end of the nose, theoretically it would pass onto the arch, through its legs and onto the thicker parts of the cranium, and thus be diverted away from the delicate cribriform area of the frontal fossa (Unger, 1965) (Fig. 46-4).

The mucoperiosteal and mucoperichondrial lining of the septum contains its blood and nerve supply. As is true with cartilage elsewhere, blood vessels do not actually penetrate the underlying cartilage, but are contained between he perichondrium and the overlying mucosa. This depth relationship is important from a surgical standpoint, for between the cartilage and perichondrium the surgeon finds an avascular tissue plane for dissection during septoplasty. The vessels run in an anteroposterior direction along the septum, which is important in the planning of surgical incisions, lest the septal blood supply be interrupted unnecessarily.

Pathologic Anatomy of Cartilage

Intrinsic factors

In circumstances in which the cartilage itself is crooked, the defect is usually related to one of two causes: congenital disproportion, with the cartilaginous component being too large for the housing in which it must grow; or (the more common cause) the long-term results of trauma sustained earlier in life. In the former circumstance, such a cartilage may bend, and in so doing probably generates intrinsic tension. Septal cartilage successfully resists many episodes of trauma because of its elasticity. However, even relatively minor trauma to the developing nose can have significant effects on subsequent development. Hinderer (1971) states that there are three distinct periods in the early development of the nose: the first period lasts for 5 years and is distinguished by rapid growth, the next 5 years are noted for relative quiescence, and the last 5-year period is associated with another acceleration of growth. Injuries during periods of growth are more likely to result in long-term deformities.

Fry (1973) applied the principles of cartilage infrastructure described by Gibson and Davis (1967) to explain these clinical observations. In vitro studies have shown that cartilage has a definable intrinsic stress system that, when disturbed by fractures, develops an imbalance that can lead to warping or bending. Histologically, chondrocytes are concentrated at the periphery of cartilage, whereas the central portion is relatively acellular. It is believed that this histologic lamination maximizes the intrinsic stress. When one side of cartilage is interrupted with partial-thickness cuts, the opposite side assumes dominance, causing the cartilage to warp in that direction (Fig. 46-5). Microfractures sustained early in life simulate such partial-thickness cuts. Bowing of cartilage to the opposite side can follow such an injury. As fibrous ingrowth fills the microfracture, permanence is established (Fig. 46-6). Such a scenario may be the underlying cause of many crooked septal cartilages. During septoplasty, close inspection of the cartilage with magnification often reveals previously unsuspected microfractures. Murakami et al (1982) studied this problem and concluded that the theoretic norm is probably more complex than the work of Fry (1973) or Gibson and Davis (1967) suggests. In general, the internal stresses of the septal cartilage are determined at a molecular and cellular level, and although the intrinsic stress system in any given cartilage does determine its shape, the arrangement, distribution, and magnitude of the stresses vary in different areas of the septum, as well as between different individual septums. Murakami et al (1982) showed that because of these variations this theory cannot be used as the sole basis for the correction of septal deformities. Instead, he demonstrated that full-thickness incisions through cartilage are probably a more effective means for correcting deviation. In fact, we have frequently observed that cartilage fails to behave as Gibson and Davis or Fry theorized, thus clinically substantiating Murakami's doubts. Probably these principles of intrinsic stress and its alteration by partial cuts are applicable in some areas of septal cartilage but not in others. Furthermore, contralateral partial-thickness cuts may be all that is needed to neutralize the bowing in the septal cartilages that is caused solely because of old microfractures.

It appears that many patients who ultimately develop deviated septal cartilages have sustained trauma in the neonatal period. Many physicians tend to attribute a nasal deformity in a newborn to congenital factors, but unless other deformities exist, this is not usually the case. Most nasal deformities in newborns can be traced to trauma either during labor or birth (Gibson, 1977; Gray, 1974; Steiner, 1959). That such nasal injury occurs should not be surprising considering the compressional and rotational forces on the fetal head during passage through the birth canal. The cartilaginous nasal tip is the most prominent facial structure by 2 to 3 cm, and the nose is subjected to extraordinary forces during the birth process. These stresses, of course, vary according to the head-pelvic outlet ratio.

As early as 1929 Metzenbaum addressed the general subject of birth trauma to the nose. Since then many others have contributed to our knowledge of this subject (Gray, 1974; Jazbi, 1977; Kirchner, 1955; Klaff, 1956; Olsen, 1980; Steiner, 1959). Parturition itself is only one of the causes of neonatal deformity; additional stresses occur during pregnancy. Kirchner (1955) stated that lateral nasal displacement in the newborn is the consequence of trauma that is either the result of forces applied to the nose during the late months of intrauterine life or during birth. He felt that the latter variety of injury usually consists of a dislocation of the septal cartilage from the vomer. Steiner (1959) stated that nasal trauma may occur at any time after the fourth month of gestation and discussed the continuous pressure on the nose from the intrauterine growth of fetal limbs, among other causative factors. Cottle (1951) made a distinction between the temporary flattening of the nose from delivery and permanent damage occurring in utero. He based the existence of intrauterine trauma on the fact that nasal septal deformities are sometimes noted in neonates born by cesarean section. Regarding pelvic delivery trauma, the direction of nasal deviation in neonates seems to correlate with the presentation of the fetal head in the pelvis. Most vertex presentations are positioned in the left occipitoanterior position (Danforth, 1982), and with rotation into the normal position, the nasal septum can be pushed to the left of the vomer and the external nose to the vomer's right (Jazbi, 1977). With all of these forces being brought to bear on the neonatal septum, it is not surprising that microfractures and dislocations of cartilage occur frequently.

When early life trauma to the septum results in a gradual bowing and deviation of the cartilage, there is asymmetric growth of the nose, septal membranes, and underlying skeletal parts as the child develops. This fact becomes important later in life if one attempts to correct the problem. At that time, the surgeon must deal with a "short" and a "long" membrane (Fig. 46-7). Adequate elevation, realignment, and trimming of such membranes are essential to prevent the initially straight nasal septum from returning gradually to its preoperative deviated state. Finally, our impression is that the majority of microfractures occurring early in life are vertically oriented and result in classic deformities, as is seen in the example of Fig. 46-8.

Extrinsic factors

Factors extrinsic to the septal cartilage itself may also be responsible for nasal septal deviation. For instance, an abnormally large or lateralized premaxillary spine can cause the displacement of the base of the caudal septal cartilage, and in so doing, distort the symmetry of the nasal tip (Fig. 46-9).

Abnormalities of the maxillary crest-vomer relationship also can cause displacement of the nasal septum. The different deformities encountered in this area are to some extent influenced by the developmental time at which the disturbance occurred. A lateral deflection of the septum caused by dislodgment of the vomer from the maxillary crest, and in which the vomer-septal cartilage relationship is undisturbed, indicates that the causative agent occurred before ossification of the area. Because of the elasticity of youthful cartilage, such a circumstance is often associated with a fracture-free cartilage, and appropriate realignment techniques need deal only with the bony component that is out of the normal groove. Examination of such a nose is characterized by varying degrees of shift of the base of the septum. Inspection of the contralateral side of the nose usually reveals an unoccupied maxillary trough. Often such abnormalities are labeled spurs, whereas in reality the bulge is the distorted appearance of normal bony anatomy. Another type of derangement of these structures exists when the vomer is actually fractured, leaving its lower edge lying in the groove of the maxillary crest. In this circumstance, the fracture causes a prominence of the septum (ie, a spur). This situation reflects injury after ossification.

The perpendicular plate of the ethmoid is often deformed, presumably because of a flaw in the developmental process. This can cause marked deviation of the junction area with the septal cartilage. The cause of the deformity is frequently recognized as soon as the cartilage and bone are separated during surgery. At this time, the cartilage can be seen to move to a more normal midline position, revealing the significant bony deformity. In such a nose, purely cartilaginous septal reconstruction cannot rectify the obstruction; the bony portion of the septum must be dealt with as well.

A previously depressed nasal bone can be responsible for a substantial degree of anterior septal deformity (Fig. 46-10), and one must "outfracture" such a bone before permanent correction of the cartilage can be achieved. The earlier in the development of the nose such an injury occurs, the more significant the septal deformity will be. The parts in this keystone area are integrated in such a manner that the alteration of one part affects the whole complex.

Under normal circumstances, the upper lateral cartilages attach to the dorsal aspect of the nasal septum in a symmetric manner, creating an equal amount of stress from each side. In cases of dorsal septal cartilage deflections that have existed throughout life, the upper lateral cartilages and their respective membranes are of unequal length. This affects the corrections of such dorsal septal deviations because failure to deal with the asymmetry of the upper lateral cartilages is invariably associated with a recurrence of the septal deformity. If, on the other hand, the upper lateral cartilages and their overlying membranes are separated from the dorsal septum and the appropriate adjustments to their length are made, the newly created symmetry helps to stabilize the dorsal cartilage in its newly corrected position.

Finally, other extrinsic factors can affect the nasal septum. Any lateral nasal structure (eg, a turbinate) can disproportionally impinge on the nasal septum to result in a deflection of the septum. The narrow, high nose also can be responsible for compromise of lateral intranasal dimensions and consequent airway obstruction.

Indications for Nasal Septal Surgery

As with many other elective surgical procedures, there are no absolute indications for septoplasty. Indications are relative, having to do with the priorities of the patient's life, and such priorities are influenced by age, economic status, and social and environmental needs. In general, septal surgery has become a refined skill and has minimal morbidity. Improved anesthetic techniques, a greater appreciation for intranasal tissue integrity, newer methods of intranasal suturing, and shorter hospital stays have all made septal surgery less burdensome.

The two general categories of indications for septal correction are procedures done because of primary abnormalities and those done for reasons associated with rhinoplasty.

Septal surgery for primary septal pathology

Alteration of nasal physiology

Assessment of the symptoms of nasal airway insufficiency or alteration is at best an imprecise art. Nasal obstruction is a relative and subjective sensation. What represents difficulty in breathing to one individual may be the norm to another person who has had nasal problems since childhood and who has never experienced nasal patency. On the other hand, a person who had normal nasal breathing throughout life may find even moderate alteration of nasal breathing produced by a recent event (such as a fracture) extremely bothersome. Rhinomanometry can be used to quantify the nasal airflow, but as yet its role in preoperative evaluation of nasal obstruction needs further definition.

Watching the patent breathe, inquiring about snoring, mouth breathing, dryness of the pharynx, and subjective nasal obstruction are important. All data derived from questioning are subject to extreme variations in patient tolerance. The older person who begins to complain of difficulty with nasal breathing may actually be verbalizing the discomforts and physiologic alterations associated with chronic lung disease. On the other hand, the absorption of subcutaneous fatty tissue, loss of dentition, relaxation of the facial muscles, and loss of skin turgor can initiate a nasal-tip droop typical of older people; this condition results in a substantial alteration in nasal breathing (Fig. 46-11). To address this particular problem as purely septal rather than nasal usually produces results that are less than optimal.

Nasal respiration

To think that the nasal septum alone is responsible for nasal respiratory compromise is grossly inaccurate. Other intranasal structures are of great importance and their relationship to the septum must be weighed in any appraisal of nasal respiration. The nasal "valve" (Mink, 1903) is defined as the space between the most caudal margin of the upper lateral cartilage and the nasal septum. This angle is usually about 10 to 15 degrees. This value controls the "shape" of inspired air currents, changing them from a column to a sheet of air. In so doing, the valve controls the level of resistance and the velocity of the air stream.

Nasal resistance

The resistance of the nasal valve results in a greater depth of respiration (Hinderer, 1971). The valve controls velocity of airflow and keeps it within a critical zone; if airflow is too fast or too slow, the valve collapses against the septum.

A certain degree of nasal resistance is necessary for the nose to function as a variable resistor, air conditioner, and filter. In quiet respiration the nose accounts for 47% of total airway resistance (Butler, 1960), and the nasal valves make up a significant part of this. The nasal valve area can be disturbed either by deviation of the nasal septum or by the bowing effect created by a broad, flattened nose. In such circumstances the angle between the upper lateral cartilages and septum is greater than the usual 15 degrees. Inspiratory air flow control is to some extent lost, so that alterations in resistance and other normal nasal reflex mechanisms are impaired (Fig. 46-12). In a similar manner, an excessively high septum that stretches the upper lateral cartilages into a narrowed angle with the septum predisposes the cartilage to collapse on inspiration, resulting in the sensation of nasal obstruction.

The normal cyclic alteration of turbinate size is involved in the production of nasal resistance. This is involuntary and is intimately involved in nasal resistance. Despite a relatively high resistance, nasal breathing is deemed preferable to mouth breathing. People commonly feel short of breath when the nose is occluded by an upper respiratory infection. Athletes frequently note better performance with functional nasal breathing rather than with oral breathing only. Nasal obstruction has been associated with hypoxia, decreased pulmonary function, sudden death, and sleep apnea (Cassissi et al, 1971; Cook and Komorn, 1973; Hady et al, 1983; Ogura, 1970; Ogura and Harvey, 1971). In fact, an increasing amount of data shows the profound effect that nasal obstruction has on sleep (Olsen et al, 1981). Exercise-induced asthma is related to pulmonary ambient temperature and humidity; consequently, improvement in nasal breathing secondary to septoplasty has been shown to improve this condition markedly (Shturman-Ellstein et al, 1978).

Nasal septal deformity

Even in a normal environment, the process of breathing exposes the nasal mucosa to all types of irritants such as temperature extremes, humidity, dust, chemical fumes, and smoke. The geometric design of the intranasal structures takes these factors into account. The nasal septum is the initial contact point in creating air turbulence and ideally should divide the inspired air column precisely. When the caudal septum is substantially deviated (see Fig. 46-8) alterations in the airflow currents result. This can result in drying, crusting, and metaplastic changes of the mucosa on the side with increased flow. Nasal septal deformity can also be responsible for the loss of normal mucosal reflex mechanisms and can result in atrophic rhinitis, a condition that causes nasal congestion despite a patent airway.

Air cooling and filtering

Because the nose serves as both an air conditioner and a filter, one of its most important functions is the preparation of air for the lower respiratory tract. Because of the nose, the air in the nasopharynx is maintained at a temperature of 30° to 37°C with 75% or greater relative humidity, despite wide environmental fluctuations in temperature and humidity. Approximately one third of this heat and water is recovered in expiration. It would seem reasonable that improving nasal physiology in the patient with chronic pulmonary problems would be beneficial. This is not to suggest that all patients with chronic lung disease should have a septoplasty, but rather that serious consideration should be given to improving the nasal airway surgically in patients with chronic lung disease who have identifiable nasal abnormalities (Sessions and Wenig, 1986).

Bleeding

In some patients abnormal air turbulence that is secondary to an intranasal deformity can cause excessive drying and crusting of the mucosa, which can lead to recurrent bleeding. In such circumstances a septoplasty decreases the frequency of epistaxis. More commonly, nasal bleeding may be an indication for septal surgery because the deviated septum prevents the adequate management (ie, packing) of a bleeding vessel in the posterior nasal vault, and a septoplasty is necessary to allow access to the bleeding site.

Sinus drainage

Finally, in those circumstances in which the deviated nasal septum impinges on the infundibular region of the lateral nasal wall, a problem with sinus toilet can result with recurring sinusitis. Such a circumstance should be corrected with appropriate septal surgery and functional endoscopic sinus surgery, if indicated (Rice, 1990).

Septal surgery as part of functional rhinoplasty

Septorhinoplasty is sometimes indicated solely for functional reasons. A majority of such noses have been damaged by trauma earlier in life. The high-septum or tension nose, on the other hand, is a congenital problem often associated with a straight septum. Rhinoplastic techniques are used to lower the high nasal dorsum with osteotomies to close the "open dorsum" that hump removal creates; thus the internal nasal angles and nasal physiology are improved.

A depressed nasal bone is frequently associated with a dorsal septal deformity, and if not corrected along with the septum, can result in an inadequate functional result. The classic C-shaped dorsal deformity that occurs in this situation is usually managed by outfracture of the depressed bone before any attempt is made to mobilize the opposite site or straighten the septum (see Fig. 46-10).

Finally, asymmetry of the upper lateral cartilages is often associated with dorsal septal deformities (see Fig. 46-10). Achieving a straight nose may require detaching the cartilages from the septum and trimming them until they are symmetric.

Septal surgery as part of cosmetic rhinoplasty

An understanding of the nasal septum is important in obtaining consistently good results with cosmetic rhinoplasty. Alterations in nasal dimensions that are invariably associated with rhinoplasty can increase nasal obstruction if the septum is not straightened at the time of rhinoplasty. This can be done by intranasal or external rhinoplasty approaches (Ries, 1990). A compromise in nasal physiology should not be considered an acceptable part of cosmetic rhinoplasty. In fact, the nose should function at least as well, if not better, after surgery.

Techniques of Septal Surgery

Contemporary methods of septal surgery tend to favor a conservative approach, with emphasis on straightening the septal cartilage rather than removing it. Surgical techniques such as partial- or full-thickness gridding, morselization, crosshatching, and excision with suture reapproximation of cartilage parts all reflect an emphasis on preservation of cartilaginous tissue. With such techniques, careful preservation of extramembraneous support and reapproximation of septal membranes take on added importance.

Postoperative packing

When the surgeon has completed the cartilage-weakening techniques, the septum should stand straight in the midline on the maxillary crest without reliance on packing for stabilization during the healing period. In the past, surgeons have routinely packed both sides of the nose following septoplasty to prevent development of a hematoma between the septal flaps and to hold the septum in the midline. Even with packing, however, firm pressure on the septal membranes can be difficult to maintain, and when one does pack extensively, one risks lateral displacement of the freshly operated and mobile septum. With membrane-approximation sutures (Sessions, 1984), the need for postoperative packing is virtually eliminated. The desired result of membrane approximation is enhanced, and a thinner septum is achieved sooner. Less morbidity occurs without packing, and the period of postoperative nasal congestion is shortened. The risk of intramembranous hematoma is minimal with suturing. An additional benefit gained with such a suture technique is that mucous membrane lacerations occurring during septal surgery can be reapproximated with more precision and ease.

Correcting extrinsic defects

Because many septal cartilage deformities are related to the extrinsic forces, the techniques used in repairing septal deformities should address this early in the course of the dissection. Our practice is to elevate membranes, inspect the overall pathology, separate the septal cartilage from most of its bony attachments, and, by displacing the cartilage to one side, expose the posterior part of the nose (ie, the perpendicular ethmoid plate and vomer). The posterior deformities are generally managed by removing bone. The septal cartilage is then altered in a manner dictated by the problem at hand. Often the cartilage is straight, and little more is needed after management of the bony parts. To ensure a narrow septal base and allow the cartilage to seek the midline freely, a large portion of the vomer and maxillary crest is often removed. The anterior maxillary spine is almost always preserved as its periosteum provides a sturdy tissue to which the septal cartilage, which is not free, is reattached.

Steps of dissection

The entrance incision, a hemitransfixion incision, is made at the caudal rim of the septal cartilage. Next, the sharp dissection is carefully carried through the perichondrium to the cartilage because beginning the septal dissection in this relatively avascular plane facilitates the overall procedure. The hemitransfixion incision is then converted to a complete transfixion incision. If one creates a transfixion incision before establishing the subperichondrial plane of dissection, the increased mobility of the caudal end of the septum makes it more technically difficult to search for this initial tissue plane. Encountering anything other than trivial bleeding during the subperichondrial elevation of the septal membranes indicates that the dissection is probably in a plane that is too superficial.

The elevation of the mucoperichondrium is carried from the most dorsal aspect of the septum to the maxillary crest. At this point, carrying the dissection around the maxillary crest and onto the floor of the nose may be difficult because of fibrous attachments between the perichondrial and periosteal compartments (see Fig. 46-2). Sharp dissection against the bone of the crest allows the surgeon to enter the subperiosteal plane without tearing the mucosa.

Once the septal membrane is elevated onto the nasal floor, the elevation of membranes is carried into the posterior nose. The membrane overlying most of the perpendicular ethmoid plate and vomer is elevated. Maintaining the subperiosteal tissue plane posteriorly is helpful to minimize any bleeding that can interfere with visualization in this rather limited space.

Separation of the septal cartilage from bone is started in the dorsal aspect of the cartilaginous articulation with the perpendicular plate and is carried down to the vomer and forward along it to the anterior maxillary spine. A boomerang-shaped piece of cartilage is excised along the edge of the cartilage, with care taken to remove it from its attachment to the contralateral mucoperichondrium (Fig. 46-13). The subperiosteal plane is then elevated from the contralateral surface of the perpendicular plate of the ethmoid. The septal cartilage should then swing freely with the opposite mucoperichondrial flap still attached to the cartilage. This "swinging door" is displaced laterally with the nasal speculum, and the posterior and posteroinferior parts of the bony septum can be inspected (Fig. 46-14).

If present, any bony deviation is removed. A chisel is used to cut the maxillary crest along the floor, starting just posterior to the anterior maxillary spine; the bone cut is carried along the floor posteriorly well into the nose (Fig. 46-15). A bone scissors or chisel is used to cut the perpendicular plate superiorly (Fig. 46-16), thereby avoiding a fracture into the cribriform plate. The remaining portions of deviated ethmoid plate and vomer can then be removed with a Jansen-Middleton bone forceps (Fig. 46-17).

Attention is then directed to the cartilage that is the "swinging door". If it is straight, the base of the caudal septum is sutured with absorbable sutures to the periosteum of the anterior maxillary spine. This submembranous suture is designed only to ensure midline stability during the healing process and should not be used in an attempt to overpower crooked cartilage (Fig. 46-18). The removed cartilage is compressed into a flattened configuration and placed between the membranes where the perpendicular plate previously existed (Fig. 46-18). The cartilage ultimately adds stiffness to the septal membranes, much as a batten does to a sail.

Membrane-approximation sutures are applied from one side of the nasal cavity to the other (Fig. 46-190. Suturing is carried back and forth, approximating the membranes. This quilting suture is continued forward through the septal cartilage, and finally the continuous suture is terminated at the most caudal end of the septum, thus closing the transfixion incision with the same suture. Using a No. 4-0 plain catgut suture on a small straight cutting needle (SC-1; Ethicon Inc, Somerville, New Jersey) greatly simplifies this method of continuous mattress suture for membranous reapproximation. When a bayonet needle holder is employed, intranasal needle placement is greatly enhanced.

If the septal cartilage itself is deviated, various techniques are available to straighten it. As is often the case, if an obvious old fracture line filled with fibrous tissue seems to be responsible for the deviation, the fracture line is excised along with a sliver of adjacent cartilage. The excision is done in such a manner that the still-attached contralateral perichondrium is not injured (Fig. 46-20).

If, on the other hand, the deviation is more complex than a one-line fracture, any one of a variety of methods can be used. The matter of altering cartilage shape has been the subject of much experimentation. Asch (1899) was the first to refer to "breaking the spring" of the cartilage. In more contemporary writing, Gibson and Davis (1967) predicted the behavior of cartilage when cut. Fry (1973) later applied Gibson's work, suggesting the value of partial-thickness cutting of cartilage on the concave side to make it straighter. More recently, Murakami et al (1982) addressed the whole matter of altering cartilage shape. They analyzed the biomedical behavior of cartilage and showed that the most effective method for correcting bowed cartilage is to make full-thickness incisions on the concave surface of the curvature or wedge excisions on the convex surface (Figs. 46-21 and 46-22). This work demonstrated the inconsistency of results with partial-thickness cuts. Another method of straightening bowed cartilage is with morselization, as described by Rubin (1969). The morselizer is unique and is especially suited for weakening cartilage (Fig. 46-23). It does crush to some extent, however, and in so doing renders the treated cartilage vulnerable to absorption.

The method we prefer is a "checkerboard" method of gridding (Fig. 46-24), a technique that can be used only because of the attached contralateral membrane. This method consists of crossing cuts through the cartilage to, but not into, the opposite perichondrium; thus a series of cartilage islands is created. Each island is independent of the other, but each retains the nourishment of the still-intact contralateral perichondrium. The spring or bow is generally overcome, and when the membrane approximation sutures are applied, the overall strength of the septum is retained.

On occasion, it is necessary to elevate both mucoperichondrial membranes so as to deal with deviated cartilage adequately. This approach is especially necessary in situations in which deviated growth followed an injury early in life, resulting in the membranes overlying all of the deviated parts being significantly asymmetric. If such membranes are not elevated and their length is not appropriately altered, the short membrane pulls the newly straightened cartilage back into a deviated position (see Fig. 46-7). It should be emphasized that elevation of both membranes totally deprives the cartilage of its blood supply; consequently, if adequate measures are not taken to ensure the reapproximation of this relationship, cartilage absorption can occur. In this regard, the membrane-approximation sutures are substantially more reliable than packing and consistently prevent postoperative hematoma, a complication that often means death to cartilage because it is completely separated from its blood supply.

The surgeon should avoid elevating the contralateral membrane in situations in which checkerboard cartilage cuts have been used, lest a series of unsupported cartilage squares remain that are not deprived of a blood supply. If this occurs, meticulous replacement of cartilage parts should be followed by transmembranous sutures, designed to reapproximate the reconstructed cartilage components. If the need for bilateral membrane elevation is anticipated, cartilage-straightening techniques that avoid freely separated parts should be chosen.

Cartilage has historically been used as grafting material in the practice of surgery. Heterologous cartilage grafts have been used in the reconstruction of the septum as well as in other parts of the head and neck. Currently, with the advent of immunodeficiency diseases and concerns about the transmission of the viruses associated with them, the Centers for Disease Control have made the recommendation that contact with the tissues of subjects diagnosed or suspected of having AIDS or AIDS-related complex (ARC) should be avoided (CDC, 1982). Because of the uncertainty of incubation times and the difficulty of detecting such viruses, heterologous cartilage grafts should not be used in elective procedures such as septal or nasal reconstruction.

Any or all of these techniques are applicable on different occasions. Because no one method is foolproof, versatile nasal surgeons should have a full range of methods at their disposal. We do not favor the techniques that merely excise the septal cartilage because their long-term sequelae are often destructive both cosmetically and physiologically.

Sequence of Techniques in Septorhinoplasty

In an effort to prevent nasal dorsal collapse, staged procedures were often recommended in the past when septal surgery was needed with rhinoplasty. However, contemporary techniques allow the surgeon to avoid such time-consuming and costly methods, and, except in extraordinary circumstances, septoplasty and rhinoplasty are accomplished simultaneously. If dorsal nasal support is questionable after the surgeon has completed an extensive septoplasty, the procedure should be terminated and rhinoplastic techniques delayed until a future time. It follows then that the anticipation of such a problem dictates to some extent the sequence in which the various steps of a septorhinoplasty are performed. For example, the nose characterized by an extreme dorsal septal prominence requires a specific sequencing of the septorhinoplastic steps (Fig. 46-25). In the management of such a nose, the dorsal "profileplasty" is best accomplished before the septoplasty. If one does septal work initially in this situation, the excision line of the hump removal can blend with the septal work, leading to a failure of nasal dorsal support and saddle deformity. Except in circumstances such as this, it is unimportant whether the rhinoplasty is performed before or after the septoplasty. In the event that the septoplasty is performed first, we recommend completing the previously described septal membrane approximation sutures before instituting rhinoplastic techniques. The added stability of the newly aligned septum thus facilitates the remainder of the surgical procedure.

Many surgeons prefer the external-approach rhinoplasty. A septoplasty performed through such an approach (Ries, 1990) has all the advantages of enabling the visualizing of external nasal components directly as well as providing unparalleled exposure of the nasal base and septum; thus teaching is enhanced.

Complications of Septal Surgery

Hematoma

Although it is infrequently encountered, a postoperative septal hematoma is a potentially serious complication. Cartilage that is deprived of its blood supply can be absorbed, even though the medium surrounding it remains uninfected. A diminution in the metabolic activity of cartilage begins promptly after separation from its blood supply. However, unless infection sets in, there is a grace period during which the metabolism of such devascularized cartilage is reversible (Converse, 1977). Cartilage is unique in this regard; even cartilage that is harvested from a recently dead donor is still viable, as demonstrated by in vitro uptake of 35S (Curran and Gibson, 1956). Clinically, when a voluminous hematoma exists, avascular septal cartilage stays alive for about 3 days at body temperature, but eventually chondrocyte death results (Fry, 1969). Chondrocyte is responsible for making chondromucoprotein, collagen, elastin, and the matrix around it (Converse, 1977); therefore its death invariably heralds absorption.

Whether pressure from an expanding hematoma that is confined within a perichondrial pocket has a role in the enhancement of septal cartilage absorption is uncertain. It is known, however, that infection certainly does put the cartilage at increased risk for resorption. Even under aseptic conditions, partial absorption can occur in circumstances that are less than voluminous. Fry (1969) reported two cases in which the nasal septum was partially absorbed despite the unilaterality of the septal hematoma. If the hematoma that surrounds septal cartilage remains uninfected, the clot proceeds to liquefaction. Partial or complete resorption of the hematoma ensues regardless of the status of the associated cartilage. However, fibrosis may occur and result in permanent thickening of the septum.

If the septal hematoma becomes infected, substantial if not total cartilaginous absorption follows. The classic saddle deformity results not only from the loss of septal structure but more crucially from the ensuing scar contracture in the empty perichondrial compartment (Fig. 46-26).

Failure to adequately obliterate the intramembranous dead space created by septoplasty contributes to hematoma formation. To a large extent, intramembranous suture fixation has eliminated much of the risk of this complication, but the surgeon must continue to be alert to the possibility. Bleeding from the bone edges in the floor of the nose can cause troublesome bleeding during and after surgery.

The cardinal signs of postoperative septal hematoma are swelling and pain. Intense pain generally does not occur after septoplasty; when it does, however, hematoma should be suspected. Also, excessive swelling of the upper lip and mucosal discoloration under the upper lip often results from intramembranous blood collection and subsequent dissection into tissues adjacent to the base of the nose. When membrane-approximation sutures are properly used during septoplasty, postoperative swelling, although still the norm, is less; therefore when complete nasal obstruction occurs after a septoplasty along with other telltale signs, hematoma should be suspected. Visible postoperative bleeding is not the rule with hematoma because the pathogenesis of the problem involves entrapment of such blood.

Management of postoperative septal hematoma should be prompt. We recommend drainage through the previously made transfixion incision. Needle aspiration of localized pockets of partially clotted blood can be adequate, but caution must be exercised lest the degree of the problem be underestimated. Occasionally, partial opening of the incision by inserting a small polyethylene tube allows ongoing bleeding to be evacuated. Following evacuation, appropriate intranasal packing should be inserted and antibiotic therapy should be begun. In the event that packing is required, care should be taken to insert the material equally on each side of the nose, otherwise the freely mobile septal base may be displaced from the midline. In the event that a potential bleeding problem is recognized during surgery, placement of a small plastic drainage tube or rubberband drain in the intramembranous space along the floor of the nose is recommended. The drain is brought out of the transfixation site, and packing is placed intranasally. Such drains can usually be removed safely the day after surgery.

Infection

Fortunately, infection following septoplasty is an unusual event. When it does occur, it probably results from the existence of intranasal pathogens that are not present normally. Preoperative antiseptic preparation is virtually impossible in the nose, and the surgeon is forced to rely on the body's own defenses. If a nasal infection is recognized preoperatively, cultures should be taken, followed by the use of the appropriate antibiotics before the surgical procedure. Delaying the surgery may also be appropriate if an infection exists. Any intramembranous hematomas resulting from septal surgery should be adequately and promptly drained to prevent infection. In the event that postoperative infection does occur, the classic principles of drainage and antimicrobial therapy should be instituted aggressively.

Hemorrhage

The free flow of blood during and after septal surgery can be troublesome and usually comes from the mucosal tears that sometimes occur during the surgery. Such an occurrence can usually be controlled during the procedure with appropriate intramembranous approximation sutures and/or by intranasal packing after completion of the procedure. Serious hemorrhage is rarely a problem following this type of surgery.

Nasal obstruction

After the routine postoperative swelling has subsided, continued nasal obstruction is usually related to either scar formation or turbinate hypertrophy. Intranasal synechiae are scar bands of varying thickness that extend from the newly operated septum to the lateral nasal parts - usually the turbinates (Fig. 46-27). Mucosal lacerations created during surgery, or even abrasions resulting from excessive packing, can be responsible. Such scar bands are usually small to moderate in size and can be corrected in the surgeon's office with local anesthesia and transection. On occasion, however, excessively dense and thick synechiae can occur, and because of the contractile force of scar maturation, can actually pull a newly straightened septum into a lateralized position. Such a situation should be treated more aggressively with the excision of the scar bands and placement of a plastic plate between the septum and lateral nose to prevent the adjacent raw mucosal edges from recreating the scar development.

In certain noses a marked preoperative septal deviation is accompanied by a compensatory hypertrophy of the inferior or middle turbinate on the concave side of the septum. If measures are not taken to lateralize or resect that turbinate during surgery, the newly straightened septum will lie against it and block that side of the nose. The sometimes archlike configuration of the inferior turbinate can preclude permanent lateralization with such a maneuver. In such circumstances, partial resection of that structure is recommended. We discourage the routine resection of the inferior turbinates during nasal surgery, although some authors propose it (Courtiss et al, 1978).

Septal perforation

Ideally, mucosal tears during septal surgery should be avoided; in practical fact they are commonplace. When they occur in one membrane, such tears are rarely serious and adequate healing usually follows reasonable reapproximation of the lacerated edges. When tears occur bilaterally and are opposite one another, the potential for postoperative septal perforation exists. Under such circumstances, the surgeon can avoid perforation by reapproximating mucosal edges with sutures on at least one side and also by placing a piece of intervening cartilage between the membranes. Membrane-approximation sutures are very helpful in repairing such membrane lacerations. Postoperative infection, excessive intranasal packing, hematoma, and membrane-approximation sutures placed too tightly all can be responsible for vascular compromise and subsequent septal perforation.

Palatal and dental anesthesia

The transection of delicate nerve endings in the area of the premaxilla during septal surgery is often followed by temporary anesthesia of the medial incisor teeth as well as the immediately adjacent palatal mucosa. This anesthesia is usually short lived.

Anosmia

Alteration in the ability to smell has also been reported following nasal septal surgery (Hinderer, 1971), but is very unusual.

Cosmetic nasal deformity

Long-term nasal deformity is predictable following excessive removal of nasal septal cartilage. The earlier techniques of submucous resection emphasized removal of a majority of this structure, leaving only a small bridge of cartilage dorsally and a strut of cartilage caudally. Generally, no replacement of cartilage was made between the membranes, and as time passed, that space became filled with scar tissue. With the inexorable and tenacious contraction of scar tissue, the inadequate perimeters of cartilage are overpowered, the dorsum sinks inward, the columella retracts, and the alar margins widen. The result is the classic horizontal orientation of the nostrils, pseudohump formation, and nasal-tip droop (Figs. 46-28 and 46-29). These sequelae are often not attributed to septal surgery because their occurrence is subtle and long-term; also, few surgeons and patients associate septal surgery with cosmetic matters. Avoiding these sequelae is accomplished by less radical septal surgery. When removal of substantial amounts of septal cartilage is necessary, every attempt should be made to place straightened cartilage back into the surgically created dead space.

Summary

Facility in dealing with the nasal septum separates the otorhinolaryngologist - head and neck surgeon from other nasal surgeons. The knowledge and skills our predecessors acquired should be enhanced by a continuing interest in nasal function, not only in training programs but also in constant educational endeavors.