Osteotomies in the Crooked Nose

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ABSTRACT

The crooked nasal pyramid and upper third of the nose can be straightened with various osteotomes. Appropriate solutions to maximize successful nasal straightening require a thorough knowledge of the anatomy, a comprehensive preoperative plan, and the appropriate osteotomy choice.

KEYWORDS: Osteotomies, lateral osteotomies, medial osteotomies, intermediate osteotomies, nasal bones, crooked nose

Most facial plastic surgeons consider rhinoplasty to be the most challenging operation they perform. Rhinoplasty is a delicate balance between the aesthetic features of the nose as a central feature of the face and the functional aspects of the nasal airway. Nowhere is this challenge more evident than in straightening a crooked nose. The surgeon works to improve the external deformities, congenital or posttraumatic, while at the same time preserving or improving the patient's nasal airway. Osteotomies are the means to straighten the osseous portion of the nasal framework.

ANATOMY

Nasal Surface Anatomy and Skin–Soft Tissue Envelope

Before discussing the underlying aspects of nasal structure, a review of external nasal anatomy is helpful. The nasofrontal angle is a soft tissue landmark whose apex marks the most posterior point of the nasal dorsum. This point is different from the nasion, which represents the bony nasofrontal suture line. The nasion may actually be located a few millimeters superior to the deepest part of the nasofrontal angle. The root of the nose, or radix, describes the junction of the frontal and nasal bones as well. Another external landmark is the rhinion, the location where the nasal bones meet the cephalic portions of the upper lateral cartilages.

The skin and soft tissue overlying the bone and cartilage framework play a vital role in nasal appearance. Nasal skin thickness varies over the different portions of the nasal bones and cartilages. Superiorly, the nasal skin is thick in the region of the nasion, thinnest over the rhinion, thickens in the supratip region, and then may thin again in the area of the nasal infratip.[1] These differences play important roles not only in profile management but also when correcting deviations of the middle and lower thirds of the nose.

The nasal mimetic muscles lie deep to the skin and soft tissue, ensheathed in the superficial musculoaponeurotic system (SMAS). The "bloodless" plane of rhinoplasty dissection occurs just deep to the nasal SMAS. The vessels and nerves that help supply the nose lie in and on the undersurface of this layer, as well. The nasal periosteum lies deep to the SMAS. The periosteum provides support and nourishment to the underlying nasal bones.[2]

Osseocartilaginous Framework

The bony nose is comprised of paired nasal bones that attach superiorly to the frontal bone at the nasion, superolaterally to the lacrimal bones and inferolaterally

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The Crooked Nose; Guest Editor, Stephen A. Goldstein, M.D., F.A.C.S.

Facial Plast Surg 2011;27:456–466. Copyright © 2011 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA. Tel: +1(212) 584-4662.
DOI: http://dx.doi.org/10.1055/s-0031-1288927.
ISSN 0736-6825.

with the paired ascending or frontal processes of the maxilla. The bony nasal pyramid meets the perpendicular plate of the ethmoid bone on its undersurface in the midline. The nasal bones are thickest superiorly where they meet the frontal bone and thinnest at their caudal edges by the pyriform margin.[3]

The nasal bones intimately articulate with the cephalic edges of the upper lateral cartilages bilaterally, forming the sidewalls of the nose. The upper lateral cartilages attach to the undersurface of the nasal bones. Maintaining the integrity of these attachments is vital to the strength of the cartilaginous vault after osteotomies. Accidental dislocation of the upper lateral cartilages may lead to middle vault collapse and an inverted V deformity. The caudal nasal bones integrate to the widened aspect of the cartilaginous dorsal septum at the "keystone region" of the nasal bridge.[4] The upper lateral cartilages fuse to the cartilaginous septum medially in the middle vault forming the cartilaginous nasal dorsum.

Further caudally, the upper lateral cartilages are overlapped by the lower lateral cartilages at the scroll. The scroll is formed by an inward curving to the cephalic edge of the lower lateral cartilages, which relates to an outward curving caudal border of the upper lateral cartilages. The lower lateral cartilages provide support to the nasal lobule and attach laterally to the pyriform aperture through a series of accessory cartilages and fibrous connections known as the *pyriform ligament*.[5] The pyriform aperture is the entrance to the nasal cavity and represents the narrowest, most anterior bony aspect of the nasal airway. Slightly further inside the nose and just inferior to the opening of the pyriform aperture, the inferior turbinate head inserts on the lateral nasal wall.

The upper lateral cartilage, inferior turbinate, nasal septum, and bony pyriform aperture form the internal nasal valve (INV). The INV is the site of greatest resistance to air flow along the entire airway, playing a large role in nasal function. The INV angle is formed by the nasal septum with the upper lateral cartilage and is normally 10 to 15 degrees in the Caucasian nose; it is more obtuse in platyrrhine African-American and Asian noses.

PREOPERATIVE EVALUATION AND ANALYSIS OF THE NASAL FRAMEWORK

Preoperative analysis begins with an accurate and complete history, focusing on any breathing complaints, prior nasal or facial trauma, or previous nasal surgeries. It is helpful to elicit the direction, mechanism, and force of impact with a history of nasal trauma. This may assist to focus the examination.[6]

The nose can be divided horizontally into thirds for analysis, with the upper third representing the bony nasal vault, the middle third the cartilaginous vault, and the lower third the nasal tip and alae. The upper two-thirds of the nose are the most relevant to the topic of osteotomies for the crooked nose. A vertical line transecting the glabella, philtrum, central maxillary incisors, and mentum can be used as reference to the midline. Each nasal third's components are then assessed independently to determine the symmetry and alignment of the nasal dorsum.

From the frontal view, the width of the bony nasal vault and the brow-tip aesthetic lines are evaluated. The brow-tip aesthetic lines should display a subtle curvature on either side of the nose without pinching, excessive width, or irregularities. The gentle curve is symmetric and ideally suggests some width in the region of the bony vault, narrowing at the cartilaginous middle vault and then widening to the domes of the nasal tip.[6] This frontal view is also best for evaluating the width of the bony nasal vault. The bony vault can be again divided into the dorsal width and the ventral width, the latter representing where the ascending process of the maxilla meets the body of the maxilla.[7] The ventral width normally is 75 to 80% of the width of the alar base in a Caucasian nose.[8]

During physical evaluation, palpation of the nose identifies any nasal bone fracture, contour irregularity, deviation of the bony or cartilaginous vaults, and the length of the nasal bones. An intranasal exam is always necessary to assess the position and shape of the septum, position of the nasal bones, patency of the nasal valves, and status of the inferior turbinates. Large concha bullosa are identified during endoscopic rhinoscopy because they can sometimes interfere with septal and nasal straightening.

TYPES OF OSTEOTOMIES

Osteotomies are performed to correct deformities of the nasal bones during rhinoplasty. They can be used to: (1) straighten a deviation within the bony nasal vault; (2) close the open roof following dorsal hump reduction; and/or (3) narrow the bony nasal dorsum or sidewalls.[8] The four common osteotomies, in order of clinical use, are lateral, medial, intermediate, and cross-root. There are several different osteotomes and other bone-cutting instruments that the surgeon may utilize to produce these precise osteotomies, as described previously (Fig. 1).

Lateral Osteotomies

Lateral osteotomies are a routine part of most rhinoplasties. They play a central role in correcting both functional and aesthetic deformities. Although there continues to be controversy among surgeons as to the optimal technique, there is less debate over the indications for performing these osteotomies. From a functional standpoint, the surgeon must consider the possible

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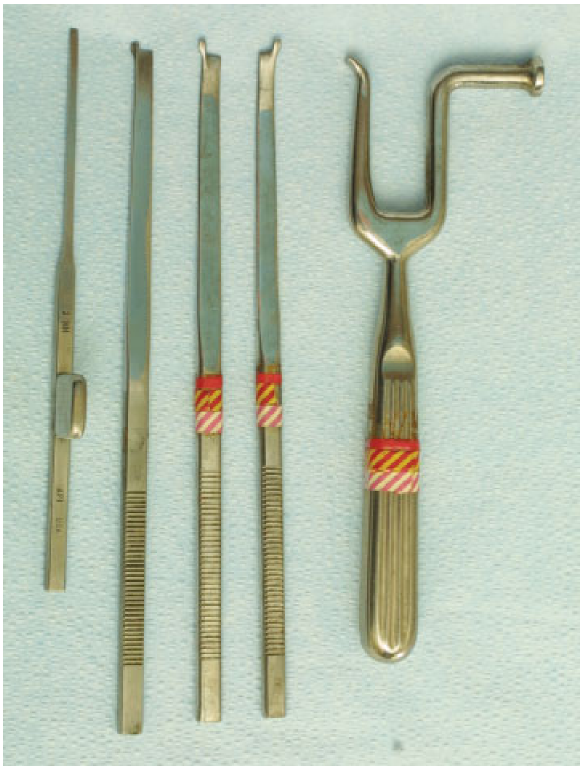

Figure 1 Multiple osteotomes that are used for straightening a crooked nose. From left to right, they are a 2-mm osteotome, Anderson-Neivert straight guarded osteotome, right and left Anderson-Neivert curved guarded osteotomes, and a Rubin nasofrontal osteotome.

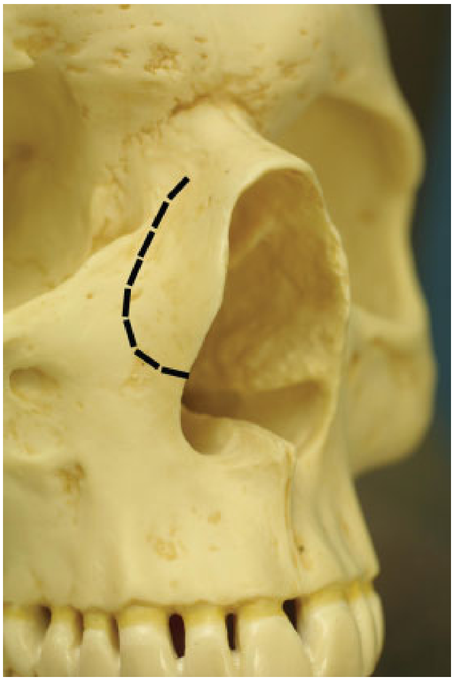

Figure 2 The pathway for microperforating lateral osteotomies is demonstrated along a high-low-high trajectory to help completely mobilize the nasal bones.

effects of the osteotomy on the patient's nasal airway. Using acoustic rhinometry (AR), Grymer et al have shown that lateral osteotomies severely limit the nasal valve area.[9]

Lateral osteotomy techniques have evolved over the years. The earliest technique was popularized by Joseph, who used a saw osteotomy method.[1,2,10] The path of his osteotomy extended from the inferior aspect of the pyriform aperture into the nasal process of the frontal bone (low to low). Although aesthetically pleasing, this aggressive mobilization of nasal bones resulted in high rates of postoperative nasal airway obstruction.[1,2,10–12] In the 1970s, Webster et al introduced the curved "high to low to high" lateral osteotomy[11] (Fig. 2). This advancement better protected the nasal airway and maintained the airway's cross-sectional area by preserving a small triangle of bone, known as *Webster's triangle*, at the inferior portion of the pyriform aperture during lateral osteotomies (Fig. 3). Starting high on the pyriform aperture also prevents the medialization of the head of the inferior turbinate and lateral nasal wall, which could cause a narrowing of the nasal valve area and impending nasal airway obstruction.[13] In addition, this technique preserves the lateral attachments of the alar suspensory ligaments and leaves the soft tissue attachments intact, further stabilizing the nasal airway.[1,2,12]

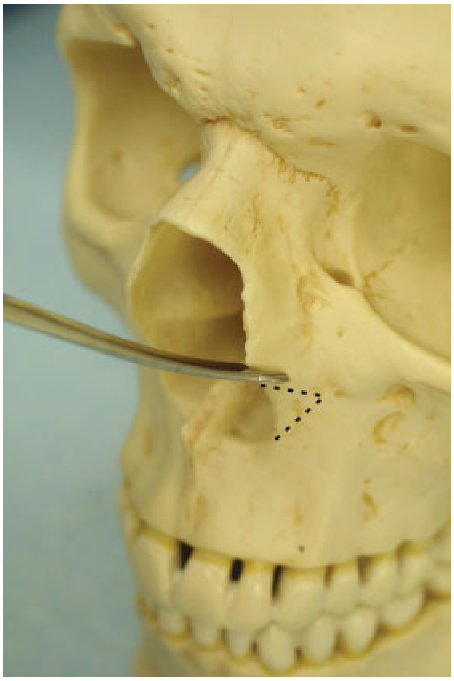

Figure 3 The curved osteotome is seated in the pyriform aperture at its ''high'' starting point about the head of the inferior turbinate. The wedge of bone that prevents collapse of the lateral nasal wall and inferior turbinate head is known as *Webster's triangle*.

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From this evolution, two basic techniques for performing lateral osteotomies have evolved: continuous and perforating. The ideal lateral osteotomy should not only be precise, reproducible, safe, with maximum aesthetic and functional results, but should also limit postoperative sequelae such as edema, ecchymosis, and nasal bone instability.

The continuous internal lateral osteotomy is performed endonasally and creates a single fracture along the lateral portion of the ascending process of the maxilla and nasal bones. An important surgical consideration is that the lateral osteotomies are guided through the thick bone of the ascending process of the maxilla and not the lateral aspect of the thin nasal bones.[2] The continuous lateral osteotomy begins with anesthesia and vasoconstriction. A 27-gauge needle is used to inject lidocaine, 1% with 1:100,000 epinephrine, buffered 10:1 with sodium bicarbonate. The needle is inserted intranasally, and the periosteum external and internal to the bony pyriform aperture is injected, beginning at a level just superior to the lateral attachment of the anterior head of the inferior turbinate. Ten minutes are allowed for vasoconstriction. A 3-mm stab incision is made transversely above the lateral insertion of the inferior turbinate, making sure to stay anterior to the mucocutaneous junction in the vestibular skin to minimize mucosal trauma.

When preparing for osteotomies, some surgeons prefer to elevate the periosteum in a narrow tunnel with a Joseph elevator to protect it from being injured by the guarded osteotome. The surgeon must weigh the benefits of elevating the periosteum off of the nasal bones to protect this layer from damage, with the problems associated with extensive elevation of this layer, which may leave the bony fragments destabilized and without any support. Minimal elevation of the periosteum over the nasal bones should be performed in cases of nasal trauma and revision rhinoplasty where osteotomies have previously been executed. In these situations, wide elevation of the periosteum, especially in the event that it has already been disrupted, can completely destabilize the nasal bones and lead to collapse if the bones are osteotomized again.

Next, a 4-mm curved, guarded osteotome is inserted into the incision, perpendicular to the bony rim of the ascending process of the maxilla (Fig. 3). The guard is palpated transcutaneously and is used to monitor the trajectory of the osteotome course. The osteotome is tapped toward the face of the maxilla with a mallet in a high-to-low direction until it reaches the nasofacial groove. A helpful landmark is to point the handle of the osteotome toward the ipsilateral lateral canthus. It is then turned cephalad to cut the ascending process of the maxilla from the body of the maxilla in a low-to-high direction. Once it reaches the level of the nasal bones near the medial canthus, it is directed anteriorly to cut the nasal bone from the nasal process of the frontal bones. The bony nasal sidewall is then in-fractured with digital pressure or by rotating the osteotome medially.[14] Advantages of the continuous technique include increased mobility of the bony nasal vault, consistent narrowing of nasal pyramid, and ease of palpation of the trajectory via the guard. Disadvantages include constriction of the pyriform aperture leading to airway compromise, significant soft tissue displacement, creation of an air pocket, and increased hemorrhage, ecchymosis, and edema due to lacerations of the intranasal lining and soft tissue trauma.[15] Although increased mobility of the bony nasal vault is an advantage, it can also be problematic because the mobilized segment may be more likely to collapse.[12]

The perforating lateral osteotomy technique creates a series of postage stamp–type perforations along the same line as the continuous osteotomy. These perforations are then connected by a digital in-fracture to mobilize the nasal bones. The perforating technique may be performed through a percutaneous external or an internal transnasal approach. The perforating internal transnasal lateral osteotomy (the senior author's preferred lateral osteotomy technique) begins with the same injection technique as the continuous lateral osteotomy. A small incision is then made in the same location as the lateral intranasal continuous osteotomy with the point of a 2-mm unguarded, straight osteotome. The 2-mm osteotome is seated onto the lateral face of the pyriform aperture perpendicular to the bone and then punched into the bone with the tap of a mallet. As the osteotomy is performed, the bone cracks several millimeters ahead of the osteotome. The surgeon palpates the end of this crack with the osteotome, and the next punch is then made, creating a series of punch, postage stamp, high-to-low-to-high osteotomies. Usually, no percutaneous osteotomy is required. Care is taken to punch only as deeply as necessary to cut the bone, minimizing injury to the tightly adherent underlying nasal mucosa. After the series of punches are created in the nasal sidewall, lateral digital pressure allows for in-fracture of the nasal bone (Fig. 4).

The benefits, as described in the literature, of the perforated lateral osteotomy technique are that it produces a more controlled, precise, and direct fracture with consistent results. It has also been reported that this technique routinely leads to less intranasal trauma and may minimize associated patient morbidity (hemorrhage, edema, and ecchymosis).[15–17] Other advantages include preserved periosteal support, limited nasal bone subluxation, reduced lateral nasal wall collapse, and prevention of nasal airway compromise.[10,12,15,18] In addition, this technique may be used for the delayed refracture method in patients with nasal bone fractures who present far removed from the initial event, even up to 6 weeks after trauma.[19] Disadvantages of this

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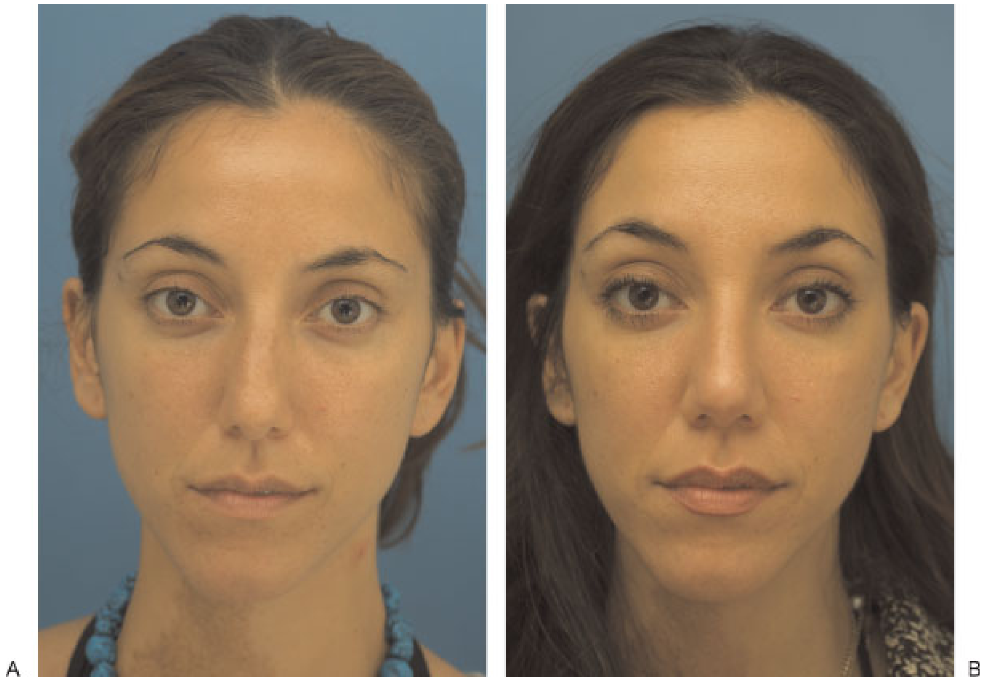

Figure 4 (A) Preoperative photo displaying the patient's deviated nasal vault. (B) Five-month postoperative photograph showing a straight, narrow nose with an excellent brow-tip aesthetic line after bilateral high-low-high lateral and fading medial osteotomies.

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technique are potential nasal asymmetry and external scarring, when a percutaneous approach is utilized.[15]

The best method of performing lateral osteotomies has been an ongoing topic of debate. Several studies have compared continuous versus perforating osteotomy techniques with regard to airway compromise as well as postoperative bruising, ecchymosis, and perceptible scarring. Tardy and Denneny advocate a perforating endonasal "micro-osteotomy" with a 2- to 3-mm unguarded osteotome. They conclude that the micro-osteotomy perforating technique creates a more precise fracture and minimizes damage to both the supportive periosteum and the intranasal mucosa, ultimately leading to decreased bleeding and soft tissue disruption compared with the continuous technique.[20] Critics note that caution must be taken as the small osteotome may slip in less experienced hands and may require repeated passes and thus lead to mucosal injury. Additionally, Murakami and Larrabee used cadaveric skin surface dimensions to analyze the occurrence rate of lateral periosteal disruption and soft tissue injury, comparing the use of 4-mm guarded osteotomes for an endonasal approach to 2- to 3-mm unguarded osteotomes for use with the percutaneous approach. They concluded that the perforating lateral osteotomy technique results in a more irregular greenstick fracture with better soft tissue support than the continuous technique because residual strips of retained periosteum and mucosa act to stabilize the nasal bones.[10]

Rohrich et al[15] compared the internal continuous osteotomy method to the external (percutaneous) perforating technique in fresh cadaver noses using blinded endoscopic evaluation of the nasal mucosa. Although 74% of the continuous osteotomies resulted in mucosal tears, only 11% of the perforated osteotomies led to mucosal tears ($p < 0.001$). The authors concluded that the external perforating technique results in a more controlled fracture with less intranasal trauma and subsequent reduction in postoperative morbidity such as bleeding, ecchymosis, and edema. However, critics of this study note that with the internal continuous technique, the osteotome was positioned with the guard placed medially where it could more easily catch and tear the mucosa. The rhinoplasty surgeon should weigh the risks and benefits of the osteotome guard position for continuous osteotomies. Although lateral positioning of the guard is likely to result in increased mucosal trauma and intranasal bleeding because the medial periosteum or mucosa is not being protected, there is the possibility of more ecchymosis and edema from having the guard directed medially from injury to the soft tissues over the nasal bones. In addition, they did not inject the nasal mucosa prior to the osteotomies. Injection both lateral and medial to the nasal bones provides not only hemostasis but also a plane for some degree of hydrodissection to help prevent mucosal or external soft tissue trauma.

Few studies have attempted to quantify the effects of osteotomies on nasal narrowing. Kortbus et al[7] first examined the effects of continuous lateral osteotomies on aesthetic rhinoplasty changes. They concluded that continuous lateral osteotomies can narrow the ventral width of the nose significantly and yet, contrary to expectations, maintain the dorsal width. Zoumalan, Shah, and Constantinides[14] quantitatively evaluated the effects of both continuous and perforating lateral osteotomies on nasal bone narrowing. They concluded that both lateral osteotomy techniques resulted in a decrease in ventral nasal bone width, with no statistical difference in narrowing found between the two. Neither technique resulted in significant change in the dorsal width; thus, these results confirm the results of the earlier study showing that reduction rhinoplasty using lateral osteotomies can still leave the dorsum narrow despite hump reduction.

Research looking at lateral osteotomy techniques has also included different imaging modalities, such as computed tomography (CT). Ford et al compared the effects of a percutaneous osteotomy on one side and an internal continuous osteotomy on the other side of four cadaver specimens. Using CT scans, the percutaneous technique showed more stability, less tissue trauma, and less airway compromise.[18] Furthermore, Helal et al[21] sought to quantify changes in the INV area after internal continuous and external perforating osteotomies. They measured the nasal valve cross-sectional area using both AR and CT in the pre- and postoperative setting. The results showed that an internal continuous osteotomy and an external perforating osteotomy resulted in a statistically significant decrease in INV cross-sectional area, as measured by both AR and CT. However, there was no statistically significant difference to conclude which technique caused more narrowing of the nasal airway.

Further studies have evaluated the postoperative sequelae of lateral osteotomy techniques. Gryskiewicz and Gryskiewicz,[22] in a prospective, randomized, partially blinded study, compared perforating, both internal and external, techniques to the continuous internal method. They demonstrated that internal perforating osteotomies with a 2-mm osteotome significantly reduced postoperative swelling and ecchymosis compared with the internal continuous osteotomies with a 4-mm guarded osteotome. In addition, internal perforating osteotomies gave better results than the external (percutaneous) perforating technique with regard to postoperative swelling and bruising. They concluded that perforating (internal or external) osteotomies with a 2-mm straight osteotome reduced postoperative ecchymosis and edema in rhinoplasty patients compared with the continuous osteotomy (4-mm curved, guarded osteotome).

When comparing external and internal techniques using micro-osteotomes in both methods, Yücel et al[23] concluded that both techniques had almost the same results in terms of edema and ecchymosis on postoperative day 7, but the internal continuous techniques shows a tendency to produce less ecchymosis on the second postoperative day. This is contradictory to the results of both Gryskiewicz and Gryskiewicz[22] and Rohrich,[15] as stated previously. Additionally, Becker et al[24] evaluated the effect of different-sized osteotomes on early postoperative edema and ecchymosis when using the internal continuous technique. They concluded that early postoperative edema and ecchymosis were comparable among different groups using the continuous technique with osteotomes of different sizes. Yet, the large, curved 4-mm osteotome caused the most mucosal injury (95%), whereas the 3-mm or the 2.5-mm low-profile guarded osteotome produced significantly less intranasal mucosal tears (34% and 4%, respectively) and did not result in any postoperative nasal airway narrowing. It should be noted that many factors contribute to the appearance of postoperative edema and ecchymosis. Osteotomy technique and type of instrument are just two of the contributing factors that are surgeon dependent, but these are not the only factors.

Additional studies specifically assessed the validity that perforating lateral osteotomies result in perceptible cutaneous scarring. In a prospective, randomized, blinded study, Gryskiewicz[25] tested the hypothesis that percutaneous perforating osteotomies may cause noticeable scars. Fifty patients requiring bilateral lateral osteotomies were included and each received a percutaneous external skin puncture perforating osteotomy on one side and an internal continuous lateral osteotomy on the other control side. All patients were evaluated for scarring. The external percutaneous approach caused a visible scar in three patients (6%), one of which required a scar revision (2%). A black traumatic tattoo resulted from methods used to sharpen the osteotome; thus, care must be taken to cleanse the osteotome before each use. They concluded that overall, percutaneous osteotomies generally produce an imperceptible scar. Hinton et al[19] also studied the validity that external lateral osteotomies leave visible scars. Eighty-one postoperative photographs were reviewed by three blinded otolaryngologists at 3 and 6 months and scar visibility was assessed. The percutaneous site was visible in 3% of the osteotomies performed at 3 months and 0% at 6 months. Thus, they concluded that puncture sites after the percutaneous lateral osteotomy technique are not visible.

Furthermore, in reviewing the literature it became apparent that not all lateral osteotomy methods are performed the same way. Some authors describe various techniques for performing these osteotomies. The "inside-out" lateral osteotomy, as described by Murakami and Larrabee[10] and further studied by Byrne et al,[12] is an ideal technique for revision rhinoplasty or after trauma when the bony nasal vault needs lateralization. When compared with the internal continuous osteotomy, the

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inside-out method appears to provide greater support, stability, and improvement of the nasal airway for the excessively narrow nasal pyramid. It is an effective, accurate, and reproducible technique to laterally reposition the bony lateral sidewall of the nose.[12]

Medial Osteotomies

A medial osteotomy is a cut in a nasal bone that separates it from the midline bony septum medially and the superior aspect of the bony nasal vault laterally. This osteotomy creates a controlled back-fracture in the superior aspect of the nasal bones at a precise location chosen by the surgeon. Medial osteotomies are most commonly performed as fading, but may also be straight, oblique, or perforating osteotomies. The medial osteotomy allows the surgeon to completely mobilize the nasal bone, either by directly intersecting the superior aspect of the lateral osteotomy path or by creating a small, predictable fracture of the nasal bone that communicates with the lateral osteotomy.[13] This osteotomy is performed when there is a significant bony deviation or a wide nasal dorsum and the bones must be mobilized completely. When the nasal bones are thick or when little or no dorsal hump has been removed, medial osteotomies allow for mobilization of the nasal bones and controlled narrowing of the dorsal nasal width.

Our preferred technique for performing a medial osteotomy is the "fading, abbreviated" medial osteotomy. This begins by seating a 3- to 4-mm osteotome at the caudal edge of the nasal bone in a paramedian position. Because the medial osteotomy will determine the dorsal bony width, in most cases the osteotome is placed on the bone just cephalic to the junction of the septum with the upper lateral cartilage. The osteotome is first directed entirely cephalically, but after it engages the bone, its course is altered more laterally, directing it toward a point halfway between the nasion and the medial canthus.

According to Harshbarger and Sullivan,[26] medial osteotomies performed at a 15-degree angle laterally off of midline follow the natural cleavage plane in the nasal bones; when combined with a low–low lateral osteotomy, they produce a controlled greenstick fracture of the nasal bones with no contour deformities. The fading, abbreviated medial osteotomy prevents extending the osteotomy too far superiorly into the thick part of the nasal bones at the nasofrontal suture. If excessive superior extension of the medial osteotomy occurs, a contour "rocker deformity" may result from mobilization of that thick superior midline aspect of the nasal bone.[26] Avoiding this deformity is particularly vital in this area because the nasal skin is unforgiving and will readily show irregularities of the fractured nasal bones.[26] Additionally, the narrowed

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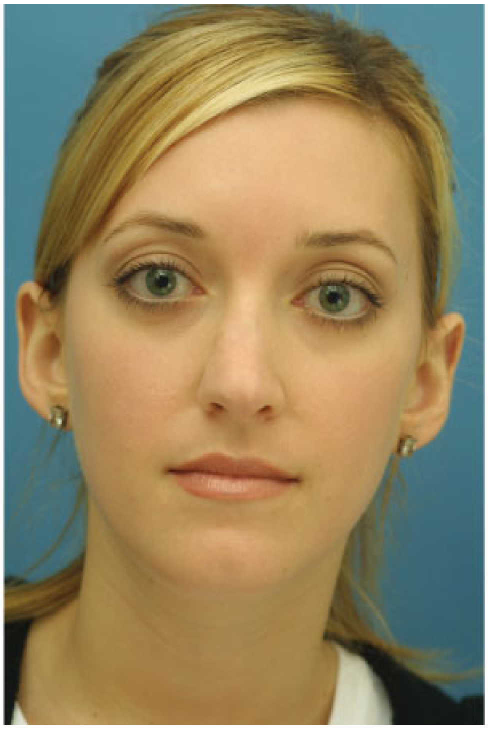

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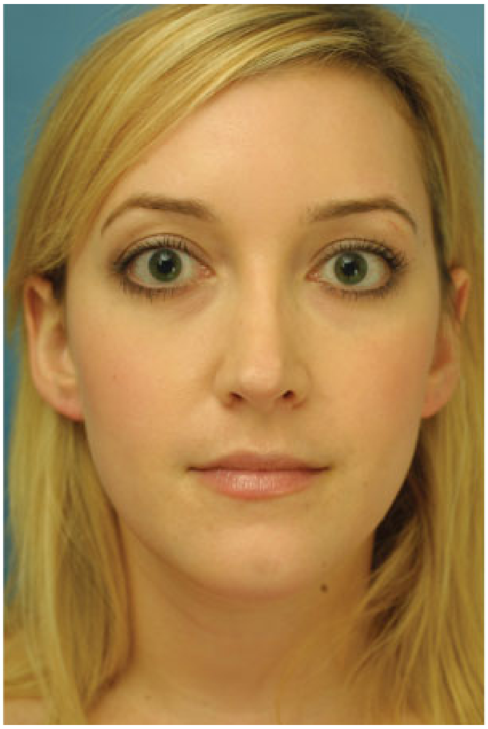

Figure 5 (A) Preoperative photo showing a persistent C-shaped nasal deformity, after a previous rhinoplasty by another surgeon, with the right nasal bone elevated and the left nasal bone depressed. The previous osteotomy was high on the right side and inadequate for upper-third narrowing. (B) Photograph 2.5 years postoperatively showing an overall straight and narrowed appearance from low lateral osteotomies bilaterally and an intermediate osteotomy on the left side. The intermediate osteotomy was performed to provide symmetry and to mirror the previous right osteotomy that was placed too high.

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A B–C D E–F

Figure 6 (A–C) Preoperative photographs of a patient with a severe nasal deviation after multiple nasal fractures. The patient was especially unhappy with the widened and flared appearance of the right nasal bone. (D, F) Six-month postoperative photographs displaying significant nasal bone narrowing an straightening after bilateral high-low-high lateral osteotomies, fading medial osteotomies, and a right intermediate osteotomy for the convexity of the right nasal bone.

bony sidewall may "rock" laterally, creating postoperative widening of the dorsal or ventral bony pyramid. It is seldom necessary to carry the medial osteotomies so far superiorly into the nasal root because that aspect of the nose rarely needs narrowing.

Intermediate Osteotomies

Because traumatic forces might cause the nasal bones to become severely comminuted or distorted, lateral and medial osteotomies alone may not sufficiently correct the bony deformity. In cases of severe concavity or convexity of the nasal bones, intermediate osteotomies can assist in the normalization of the lateral osseous contour (Fig. 5). These osteotomies also can be used to correct a deviated nose when one nasal bone is significantly wider than the other[2] (Fig. 6).

Because intermediate osteotomies are difficult to execute if the lateral aspect of the nasal bone has already been mobilized, they are best performed prior to lateral osteotomies. This osteotomy is initiated at the caudal margin of the nasal bone, at a point that will allow the osteotomy to bisect the concavity or convexity. Intermediate osteotomies are usually performed as continuous osteotomies. The continuous intermediate osteotomy begins with the osteotome at the most caudal edge of the nasal bones and movement is in a straight continuous line. The periosteum is often left undisturbed laterally, allowing soft tissue attachments overlying the nasal bones to remain intact, providing additional support.

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Figure 7 (A, B) Preoperative photographs of the patient with a large C-shaped nasal deformity, concave to the right side. (C, D) Seven-month postoperative photographs demonstrating the patient's nasal straightening after bilateral high-low-high lateral and fading medial osteotomies to completely free the nasal bones. Additionally, the patient had a percutaneous cross-root osteotomy to mobilize and straighten the root of the nose.

A variation of the intermediate osteotomy, a "double lateral osteotomy," was originally described by Parkes et al[27] and then later modified using a perforating technique by Westreich and Lawson[28] as another method to remodel the nasal pyramid. This technique addresses specific deformities that include narrowing of a wide nose, reducing the prominent frontal process of the maxilla, reshaping of the convex nasal pyramid, recreating symmetry in the traumatic deviated nose, and eliminating step-offs in primary and revision rhinoplasty. The double lateral osteotomy technique incorporates bilateral medial and low to high lateral osteotomies

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with a unilateral double osteotomy on the elongated nasal bone side. The creation of independent comminuted fractures of the maxillary process reduces the force necessary for in-fracture of the nasal bones and prevents excessive narrowing of the nasal pyramid. The double lateral osteotomy can be performed anywhere along the ascending process of the maxilla at the site of excessive convexity to equilibrate the curvature of the nasal bones. A cadaver study was performed showing that the position of the double lateral osteotomy for adequate narrowing was located approximately at the suture line between the maxilla and nasal bone in each specimen.[27]

Cross-Root (Transverse-Root) Osteotomies

Medial, lateral, and intermediate osteotomies all leave undisturbed the central root of the nose, where the medial nasal bones fuse with the nasal process of the maxilla. However, when the central root of the nose is deviated, it must be mobilized to enable adequate straightening. When the root is weak, it can often be digitally fractured. In strong nasal roots, a cross-root (or transverse-root) osteotomy is utilized. This osteotomy uses a 2-mm straight, unguarded osteotome to make a series of percutaneous perforating osteotomies horizontally across the nasal root after the lateral and medial osteotomies have been performed. The transverse-root osteotomy is positioned between the medial osteotomy sites and just inferior to the nasion or nasal "root."[29,30] Upon completion of this osteotomy, the cephalic portions of the two lateral osteotomies will be connected (Fig. 7).

Another use for this osteotomy, in addition to straightening the nasal root, is to adjust the level of the radix. Ideally, the radix should sit approximately at the height of the supratarsal crease and the nasofrontal angle, which is the intersection of the glabella-nasion line and nasion-tip lines, should be between 115 and 130 degrees.[2] This is important to understand because sometimes a shallow radix is not amenable to be deepened with rasping alone and may require a transverse cross-root osteotomy to successfully push back this area.

COMPLICATIONS OF OSTEOTOMIES

The main complication of osteotomies is malunion with subsequent deformity. Other complications of osteotomies include, but are not limited to, hemorrhage, excessive edema, infection, anosmia, canalicular trauma, skin lacerations, intracranial injury, aesthetic deformity, asymmetry, bony irregularities and instability, functional airway narrowing, synechiae, and nasal obstruction.[2,11,15,18,24] Also, collapse of the osteotomized segment can result in concomitant medial displacement of the upper lateral cartilages, narrowing the airway in the upper third as well as at the nasal valve.[12]

CONCLUSION

Nasal osteotomies will treat various deformities of the bony nasal vault effectively. To achieve optimal aesthetic and functional results, the rhinoplasty surgeon must have a fundamental knowledge of the bony and cartilaginous nasal anatomy. A complete preoperative and intraoperative anatomic analysis of the bony deformity allows the surgeon to select the best osteotomy technique. This will improve the overall contour and appearance of the nose while preserving or improving the functional internal anatomy of the nasal airway.

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