The Keystone: Consistency in Restoring the Aesthetic Dorsum in Rhinoplasty

Paul N. Afrooz, M.D.
Rod J. Rohrich, M.D.
Dallas, Texas

Summary: The keystone represents the union of six distinct anatomical structures between the bony vault and the cartilaginous midvault. In reshaping the nasal dorsum, the individual components of the nose respond variably as the fusion points of the keystone are released. In restoring the nasal dorsum, meticulous effort is made to equalize the width between the bony vault and the cartilaginous midvault. Techniques used for width equalization will yield gratifying long-term results and avoid common pitfalls such as the inverted-V deformity. (Plast. Reconstr. Surg. 141: 355, 2018.)

The keystone represents the union of the bony and cartilaginous framework of the nose. Anatomically, this unique triangular union consists of the paired nasal bones, the perpendicular plate of the ethmoid, and their fusion with the cartilaginous midvault, including the upper lateral cartilages and the cartilaginous septum. The nature of this transition from bone to cartilage has significant implications for aesthetics of the dorsum. As such, imperfections at the keystone can lead to a number of common dorsal nasal deformities and pitfalls in rhinoplasty. This article aims to describe and carefully delineate strategies to preserve, restore, and maintain the integrity of the keystone to achieve consistently gratifying results in reshaping the dorsum in rhinoplasty.

ANATOMY

The keystone is composed of three distinct bones from the upper bony vault, including the paired nasal bones and the perpendicular plate of the ethmoid (Fig. 1). Anteriorly, these three bones fuse and constitute the triangular architecture of the bony dorsum. At the caudal edge of this fusion of three bones, the paired nasal bones diverge and extend in an inverted-V pattern laterally, caudally, and posteriorly, where they articulate with the maxilla at the pyriform rim.

The cartilaginous midvault is analogous in its triangular architecture, composed of three individual structures including the paired upper lateral cartilages and the cartilaginous septum (Fig. 2). The keystone represents the region of the union between the three structures of the bony vault and the three structures of the cartilaginous midvault (Fig. 3). The cephalic portion of the upper lateral cartilages is fused to the undersurface of the caudal portion of the nasal bones (Fig. 4). The nature of this overlapping relationship allows the nasal bones to largely dictate the position of the upper lateral cartilages, particularly at the keystone, where the relatively flimsy upper lateral cartilages fuse with the firm, static nasal bones. The perpendicular plate of the ethmoid fuses with the cartilaginous septum at the level of the keystone, and further distinguishes this union of bone and cartilage.

Deformities and Cause

When considering deformities or manipulation of the keystone, one must understand the supplemental digital content is available for this article. Direct URL citations appear in the text; simply type the URL address into any Web browser to access this content. Clickable links to the material are provided in the HTML text of this article on the Journal's website (www.PRSJournal.com).

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variability in skin thickness over the nasal dorsum. Skin and soft tissues are thickest overlying the radix, which consists of subcutaneous fat and muscle, whereas skin at the keystone is thinnest because of minimal subcutaneous fat and the transition of the transverse nasalis muscles into a thin aponeurosis in this region. The thin composition of skin overlying the keystone inherently lacks the ability to camouflage irregularities, thereby leaving little to no margin for error in achieving clinically gratifying results.

The overlapping relationship between the nasal bones and the upper lateral cartilages creates a smooth and undifferentiated transition from bone to cartilage at the keystone, thereby masking the caudal edge of the nasal bones. In reshaping or reducing the nasal dorsum at the keystone, consideration of the intrinsic triangular architecture of the bone and cartilage is mandatory. Specifically, as the roof of the triangular bony vault is removed in a dorsal reduction, the apex of the bony dorsum widens. The upper lateral cartilages remain soft and relatively flimsy. Therefore, the width of their union to the cartilaginous septum is suddenly narrower than the apex of the bony vault. In other words, the roof of the firm bony vault has widened, but the width of the cartilaginous midvault remains unchanged, thereby creating a significant width discrepancy (Fig. 5). To maintain the imperceptibility of the transition from bone to cartilage, these widths must be equalized. (See Video, Supplemental Digital Content 1, which demonstrates the component dorsal reduction: separation of the upper lateral cartilages from the cartilaginous septum and incremental reduction of the cartilaginous septum, available in the “Related Videos” section of the full-text article on PRSJournal.com or, for Ovid users, at http://links.lww.com/PRS/C567.) Failure to do so increases the likelihood of visibility of the caudal edge of the nasal bones, otherwise known as the inverted-V deformity (Fig. 6).

The inverted-V deformity is nothing more than the caudal edge of the nasal bones becoming visible through the thin skin at the keystone. This is simply because of cartilaginous structures of the midvault falling away from the overlying bone, or becoming narrower than the bony vault, thereby allowing the outline of the caudal edge of the nasal bones to become perceptible. This can be caused by a discrepancy in width, dorsal height, or both. This type of defect ranges from subtle contour irregularities to severe deformities.

Further potential causes of deformities at the keystone are the result of disruption or avulsion of the upper lateral cartilages from the nasal bones. This may be intrinsic, posttraumatic, or secondary to surgical manipulation. Inadvertent avulsion of the upper lateral cartilages from the undersurface of the nasal bones can occur during a number of maneuvers, such as rasping or performing osteotomies if the upper lateral cartilages are not adequately protected.

Dorsal height discrepancies at the keystone between the bony and cartilaginous septum may also occur and manifest as contour deformities in the anterior and profile views. This deformity usually presents as an inverted-V deformity or depression in the anterior view, and a step-off,
pseudo-hump, or depression of the cartilaginous dorsum on profile. This is often caused by disruption or suboptimal transition at the junction of the bony and cartilaginous dorsum at the keystone. Once again, this may be intrinsic, or secondary to trauma or surgical manipulation. Failure to maintain adequate dorsal support by means of a strut 10 to 15 mm wide anteriorly and 10 mm caudally may also lead to immediate or gradual posterior recession of the dorsal septum. At the keystone,

this leads to perceptibility of the junction of bone and cartilage and results in a step-off between the bony and cartilaginous dorsum, creating a pseudo-hump. In addition, excessive trimming of the dorsal height of the upper lateral cartilages may render them shorter than the height of the bony dorsum. This may further contribute to a dorsal height discrepancy between the bony and cartilaginous dorsum.

**Strategies to Avoid and Correct Deformities**

Establishing and maintaining equal height and width between the bony and cartilaginous midvault are fundamental to long-term success in dorsal reshaping. If a dorsal hump is to be corrected, we advocate the component dorsal reduction to facilitate accurate and incremental reduction of the individual components of the dorsum. Following mucoperichondrial elevation and subsequent separation of the upper lateral cartilages from the dorsal septum, the upper lateral cartilages are retracted and protected while the bony dorsum is rasped incrementally, followed by the incremental, sharp resection of the dorsal cartilaginous septum. (See Video, Supplemental Digital Content 1, http://links.lww.com/PRS/C567. See Video, Supplemental Digital Content 2, which demonstrates reduction of the bony dorsum, available in the “Related Videos” section of the full-text article on PRSJournal.com or, for Ovid users, at http://links.lww.com/PRS/C568.) Great care is taken to isolate and protect the upper lateral cartilages during dorsal reduction, as the excessive trauma of rasping may avulse the upper lateral cartilages from the undersurface of the nasal bones. Following rasping of the bony dorsum, the width of the apex of the triangular bony vault is assessed. Because of
the triangular architecture of the bony vault, the width of the roof of the dorsum will invariably be wider than the apex of the cartilaginous midvault (Fig. 5) and one must determine how these widths will be equalized. (See Video, Supplemental Digital Content 3, which demonstrates the open roof deformity and width discrepancy between the bony vault and cartilaginous midvault, available in

**Fig. 5.** Anterior (above) and basal (below) views of the bony dorsum following reduction of the bony dorsum. Following reduction of the bony dorsum, the apex of the dorsum widens.

**Video 1.** Supplemental Digital Content 1, which demonstrates the component dorsal reduction: separation of the upper lateral cartilages from the cartilaginous septum and incremental reduction of the cartilaginous septum, is available in the “Related Videos” section of the full-text article on PRSJournal.com or, for Ovid users, at [http://links.lww.com/PRS/C567](http://links.lww.com/PRS/C567).
Equalization of width can be achieved by narrowing the bony vault (Fig. 7), widening the cartilaginous midvault, or a combination of both. (See Video, Supplemental Digital Content 4, which demonstrates achieving width equalization between the bony vault and cartilaginous midvault, available in the “Related Videos” section of the full-text article on PRSJournal.com or, for Ovid users, at http://links.lww.com/PRS/C568.) Narrowing the bony vault can be achieved by way of osteotomies, whereas widening the cartilaginous midvault can be accomplished with spreader grafts or autologous spreader flaps (autospreader flaps).4,5 (See Video, Supplemental Digital Content 5, which demonstrates bilateral nasal bone osteotomies to close the open roof and equalize the width of the bony vault and cartilaginous midvault, is available in the “Related Videos” section of the full-text article on PRSJournal.com or, for
Frequently, there is utility for autospreader flaps and, therefore, the upper lateral cartilages are not trimmed until after reducing the bony dorsum, performing osteotomies, and determining how width equalization should be achieved based on the desired width. If necessary, the upper lateral cartilages are trimmed conservatively only after the method for width equalization is determined and autospreader flaps are deemed to be unnecessary. This is performed judiciously, as excessive

**Video 3.** Supplemental Digital Content 3, which demonstrates the open roof deformity and width discrepancy between the bony vault and cartilaginous midvault, is available in the “Related Videos” section of the full-text article on PRSJournal.com or, for Ovid users, available at http://links.lww.com/PRS/C569.

Ovid users, at http://links.lww.com/PRS/C571.

**Video 4.** Supplemental Digital Content 4, which demonstrates achieving width equalization between the bony vault and cartilaginous midvault, is available in the “Related Videos” section of the full-text article on PRSJournal.com or, for Ovid users, at http://links.lww.com/PRS/C570.

**Fig. 7.** (Above, left) Anterior view. (Above, right) Basal view. Open roof deformity. (Below, left) Anterior view. (Below, right) Basal view. Nasal bones following bilateral low-to-low osteotomies, demonstrating closure of the open roof and narrowing the bony vault.
trimming can contribute to dorsal height and width discrepancy relative to the adjacent bony vault.

If dorsal bony reduction is minimal and, in turn, the width discrepancy between bony and cartilaginous dorsum is minimal, the cartilaginous midvault can be restored with the upper lateral cartilage tension-spanning suture (Fig. 8). Caudal tension placed on the upper lateral cartilages pulls them taught at the keystone and eases the width transition into a gradual one that will ideally remain imperceptible. This technique is most useful if minimal bony reduction is necessary and the nasal bones are intrinsically long. An acceptable transition is constantly monitored by direct visualization and palpation through the open approach.

Correction of deformities at the keystone is achieved by reestablishing a smooth transition between bone and cartilage. This typically requires width equalization and camouflage in isolation or in combination. In establishing width equalization, the foremost principle aims to restore the upper lateral cartilages to a more intrinsic position, where they lie flush against the undersurface of the nasal bones, and flush with the height of the bony dorsum. This can also be achieved by similar strategies, including the accurate placement of spreader grafts, or autospreader flaps if available. Following placement of spreader grafts, the upper lateral cartilages can be sutured to the spreader grafts as a composite of upper lateral cartilage/spreader graft/septum, or they can be sutured to one another over the spreader graft/septal complex. In either case, the spreader flaps or grafts will routinely provide the bulk necessary to reposition and push the upper lateral cartilages flush with the nasal bones laterally and dorsally. If the bony vault requires narrowing, osteotomies can be performed. Figure 9 illustrates the algorithm that is routinely used to achieve width equalization of the dorsum.

Reliable uniformity of width and contour can be achieved by placing the spreader grafts in a more cephalic position underlying the nasal bones, thus spanning and controlling the transition from the bony vault to the cartilaginous midvault. This positioning allows for control of
the width of the nasal bones if they have been osteotomized, and the width of the upper lateral cartilages at the keystone. Spreader grafts can also be tailored to the appropriate thickness to avoid excessive widening. However, this must be balanced with the goal of width equalization and the repositioning of the upper lateral cartilages flush with the undersurface of the nasal bones. As an adjunctive measure to achieve a smooth transition from bone to cartilage, residual irregularities can be camouflaged with autologous fascia, crushed cartilage overlay, or thin acellular dermal matrix.

**DISCUSSION**

The keystone represents the union of six individual anatomical components of the nose: the paired nasal bones, the perpendicular plate of the ethmoid, the paired upper lateral cartilages, and the cartilaginous septum. These components are of variable character and strength in what is undoubtedly a relatively small area with remarkable aesthetic significance.

The triangular architecture of the nasal dorsum holds tremendous significance. As the apex is removed, the roof widens. Although the bony part of the roof is firm and static, the cartilaginous midvault is far less structurally stable, and therefore, a discrepancy in stability and form manifests. Stabilization of form can either be achieved by closing and restoring the apex of the stable portion, or adding structural width to the less stable portion. Depending on the desired width of the roof, a combination of these two principles may be used. The goal is to recreate the apex at the desired width without a perceptible transition.

In rhinoplasty, considerable effort is dedicated to dorsal reshaping. The smooth and appropriately contoured dorsum must be aesthetically pleasing not only on the profile view, but also on the anterior and oblique views. In the anterior view, the aesthetically pleasing nose is characterized by smooth and continuous dorsal aesthetic lines, spanning from the brow to the tip-defining points. Achieving gratifying results in rhinoplasty hinges largely on the smooth and imperceptible transition at the keystone. However, this can be

![Algorithm to achieve width equalization between the bony dorsum and cartilaginous midvault. ULC, upper lateral cartilage.](image-url)
difficult to achieve, particularly at the keystone, where the overlying skin lends very little in the way of camouflage.

Removal of a dorsal hump is often considered an “easy” task in rhinoplasty that can be executed accurately by means of an endonasal approach and an en bloc resection. However, this assumes that all remaining tissue and structures respond similarly following resection, particularly after resecting a point of structural stability at the apex where all six structures fuse. Bone is static and firm, whereas upper lateral cartilages are flimsy, and their position is dependent on their fusion to the static nasal bones. Releasing points of fusion increases the likelihood for the upper lateral cartilages to behave independent of the adjacent nasal bone. Although an en bloc dorsal reduction may appear perfect on the operating room table and in the short term, it is our opinion that the failure to appropriately equalize the width between the bony and cartilaginous mid-vault will lead to some degree of perceptibility of the caudal edge of the nasal bones in the long term, particularly as the nasal skin begins to thin with age. This further emboldens our position that the open approach facilitates precise visualization and accurate execution to achieve gratifying long-term results.

CONCLUSIONS

The keystone represents a significant anatomical region of the nose composed of the union of six distinct anatomic components. As the apex of this triangular structure is reduced in dorsal hump reduction, these anatomic components respond differently, and careful width equalization and reconstitution between the bony and cartilaginous components must be carried out. Correcting deformities in this region requires careful planning and execution of established techniques in open rhinoplasty. By way of open rhinoplasty techniques, gratifying long-term results can be achieved.

Rod J. Rohrich, M.D.
Dallas Plastic Surgery Institute
9101 North Central Expressway, Suite 600
Dallas, Texas 75231
rod.rohrich@dpsi.org

PATIENT CONSENT

The patient provided written consent for the use of her images.

REFERENCES