REVIEW

Current updates in nasal bone reshaping

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Purpose of review
To review recent studies on nasal osseocartilaginous anatomy, osteotomy techniques and contemporary methods of nasal bone reshaping carried out under direct vision.

Recent findings
Current cadaver studies on osseocartilaginous vault anatomy, osteotomy techniques provide valuable information that can reduce outcome variability and increase reliability of osteotomies. Nevertheless, osteotomes have limitations and contemporary approaches – namely, piezoelectric instrumentations, osteoectomy, and osteotomy carried out under direct vision – can provide valuable solutions to certain shortcomings. Contrary to widespread understanding, extended wide periosteal dissection is the common thread in newly introduced methods which claim enhanced control, reduced soft tissue trauma, and reproducible results. Comparative and cadaver studies show promising results regarding protection of underlying mucosa, reduced comminuted fractures, reduced postoperative ecchymosis, and edema.

Summary
Improvements in nasal bone reshaping are promising for better esthetic and functional outcomes. Nevertheless, these approaches need to be validated by randomized controlled trials and test of time before being incorporated in routine surgical practice.

Keywords
nasal bone reshaping, osteotomy, powered instrumentation, rhinoplasty

INTRODUCTION

Principles of nasal bone reshaping have not changed much since its first description: the 'ideal osteotomy' is to make a precise and controlled cut in nasal bones in order to obtain consistently pleasing results with low complication rates. Certain shortcomings of conventional osteotomy, current understanding of nasal osseocartilaginous anatomy and dorsal reduction, quest for better technique and sequencing of osteotomy are reviewed in this article. Finally, contemporary methods of nasal bone reshaping carried out under direct vision are reviewed in detail.

CERTAIN LIMITATIONS OF CONVENTIONAL OSTEOTOMY

Conventional osteotomes are used successfully by many surgeons with optimal results; nevertheless, it is considered an unpredictable part of rhinoplasty by some surgeons. Although simple in theory, undesired esthetic and functional results are possible with this high-impact tool at the operating theatre:

(1) Osteotomy is carried out 'blindly' under tactile and auditory feedback. Even with precise technique, it can result in overresection, underresection, or uneven resection of the dorsal hump.
(2) Although the intention is cutting the nasal bone, soft tissue trauma is unavoidable. Osteotomy has been shown to damage the overlying periosteum and tear underlying mucosa [1]. Although narrow endonasal and perforating osteotomies decrease the likelihood of mucosal tearing, they do not avoid it completely [2–5]. Innovative surgical methods [6] and more delicate surgical tools (2-mm osteotomes) [7] were introduced but they come at a trade-off: reduced intraoperative control. There is no way to ensure osteotomy will spare the branches of angular artery, avoid intraoperative bleeding,

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KEY POINTS

- Quest for ideal osteotomy sequencing and technique continues.
- Current cadaver studies on anatomy and technique provide valuable insight.
- Osteotomy is carried out 'blindly' and has particular limitations.
- Contemporary methods focus on solutions carried out under direct vision.

and consequent postoperative ecchymosis and edema.

(3) Desired cutting patterns and complete mobilization cannot always be achieved. Inadequate mobilization of bony vault will necessitate excessive digital pressure and undesired fracture patterns can occur [8■■]. Even with the accomplishment of desired cut patterns and adequate mobilization, the simple act of medialization is a limited maneuver that does not address intrinsic morphologic asymmetries of the nasal bones.

(4) High-impact hammer strokes can potentially result in comminuted fractures, particularly in traumatized, osteoporotic, brittle, and short nasal bones [9]. Postosteotomy irregularities and fragmented bone pieces can be hard to address.

CURRENT OPINION IN NASAL ANATOMY AND DORSAL REDUCTION

Dorsal reduction is generally the primary step of nasal bone reshaping. Anatomical cadaver study conducted by Palhazi *et al.* [10■■] introduced the concept of osseocartilaginous vault (OCV; cap): all dorsal humps are composed of a variable ratio of bone to cartilage but a thin contour bony vault overlaps the cartilaginous vault dorsally. Palhazi *et al.* advocate reduction of the bony cap either manually or with powered rasps. Following bony vault removal, upper lateral cartilages (ULCs) were undamaged in all (9/9) cadavers; ULCs can be subsequently removed with precise 'component' reduction to desired level. Our experience is similar, we prefer rasps for a controlled and consistent dorsal reduction, but in our hands not all ULCs can be protected from the shear forces of the rasps. Alternatively, an osteotomy can also be used for this purpose, but even with superb surgical tools and experience cannot avoid the possibility of undesired over-resection or uneven resection.

According to Palhazi *et al.*, dorsal lines – from the radix to the alar cartilages – in the nonoperated Nasal Obstruction Symptom Evaluation (nose) are predominantly determined by the cartilaginous vault. Following osteotomy, medial and caudal borders of the nasal bones become primary determinants of dorsal lines.

The authors stress on the importance of subperichondrial/subperiosteal plane because the soft-tissue envelope overlying the rhinion is the thinnest tissue in the nose with virtually no subcutaneous fat. In our perspective, extra time and effort is worth spending to avoid irregularities of this area which are very common, particularly in thin-skinned patients. Lower cartilaginous part of the rhinion should remain more projected at the end of the operation to avoid uneven contour or depression and inverted-V deformity that can develop months later.

CURRENT UPDATES IN OSTEOTOMY TECHNIQUE

The quest for better technique and sequencing continues for nasal osteotomies [11,12]. OCV anatomy following hump removal dictates the individualized decision of osteotomy.

According to Gruber *et al.* [13■,14], the decision of osteotomy is based mainly on two parameters: nasal dorsum and nasal base width. There are three types of noses in terms of nasal bone width: broad nasal dorsum; broad nasal base; broad nasal dorsum and base. Mainly lateral osteotomy addresses the width of the nasal base, medial osteotomy addresses the width of the nasal dorsum, and osteotomy choice should be tailored based on what the nasal deformity requires. In addition to these two parameters, Ghanaatpisheh *et al.* [15■■] stress the importance of addressing individualized needs of the patient including the presence of lateral wall convexities and morphologic asymmetries.

In accordance with Gruber, Ghanaatpisheh *et al.* advocate the use of lateralized medial oblique osteotomy (LMOO) for narrowing of the wide dorsum as described in the study by Harshbarger and Sullivan [16]. This step is carried out subsequent to hump reduction and precedes lateral osteotomy; LMOO starts 2–3 mm lateral to the apex of the open roof and fades about 15° off the midline. LMOO narrows the bony dorsum irrespective of the lateral base osteotomy. When further narrowing of the dorsum is required, intermediate osteotomes can be performed following LMOO. Sequencing of lateral osteotomy can either be performed as the final step of bone reshaping or avoided when nasal bones are vertically oriented and further nasal base narrowing is not required. In particular cases, this approach allows adequate narrowing of bony dorsum and closure of open roof deformity without unwanted additional medialization.

The cadaver study by Gabra *et al.* conducted on 20 heminoses adds knowledge to continuous debate on the ideal sequencing and technique to obtain desired results [8■■]. The study evaluates three parameters: achieving desired cutting pattern, completeness of mobilization of the osteotomized nasal fragment, and whether a continuous cut was obtained. This cadaver study has three main conclusions, which are as follows:

(1) Without prior paramedian osteotomy, high-low-high osteotomy can result in a greenstick fracture superiorly and incomplete mobilization of the bony nasal sidewall. Necessary digital pressure does not always conclude with a 'reliable and controlled' cut and can cause nasal bone collapse consequent to mucosal tearing.
(2) When high-low-low osteotomy is planned, suggested osteotomy sequencing is as follows: paramedian osteotomy followed by percutaneous transverse osteotomy, and, finally, the lateral osteotomy. Without transverse osteotomy, cutting line tends to deviate into a higher pattern as the osteotomy approaches the medial canthus.
(3) In seriously crooked noses – when upper one-third bony part of the nose is deviated, transverse osteotomy of the central segment (the nasal bone portion between the paramedian osteotomies) does not result in collapse of the nasal pyramid and is considered reliable in order to replace the nose into midline.

Although current updates research offers solutions to drawbacks of osteotomy, osteotomes – when solely used – are limited tools for nasal bone reshaping.

BONE RESHAPING UNDER DIRECT VISION

Contemporary techniques and current research mainly focus on solutions that are carried out under direct visualization. They are worth considering and might have potential solutions to drawbacks of conventional osteotomy.

Traditionally, surgical principles suggest wide dissection of periosteum overlying nasal bones laterally to be strictly avoided because of possible collapse of the nasal bone and nasal airway compromise following lateral osteotomy. On the contrary, below-mentioned approaches do not abide by this rule, and work on this principle: as long as mucosa underlying the bone is preserved, the bones do not collapse and compromise the airway following extended periosteum dissection (Fig. 1). All of the below-mentioned methods are carried out under direct vision and claim precise and reproducible results that are not hampered by limited visualization (Fig. 2).

PIEZOELECTRIC INSTRUMENTATION AND ITS EXTENDED APPLICATIONS

Powered instruments have been long introduced to rhinoplasty, are used commonly, but have

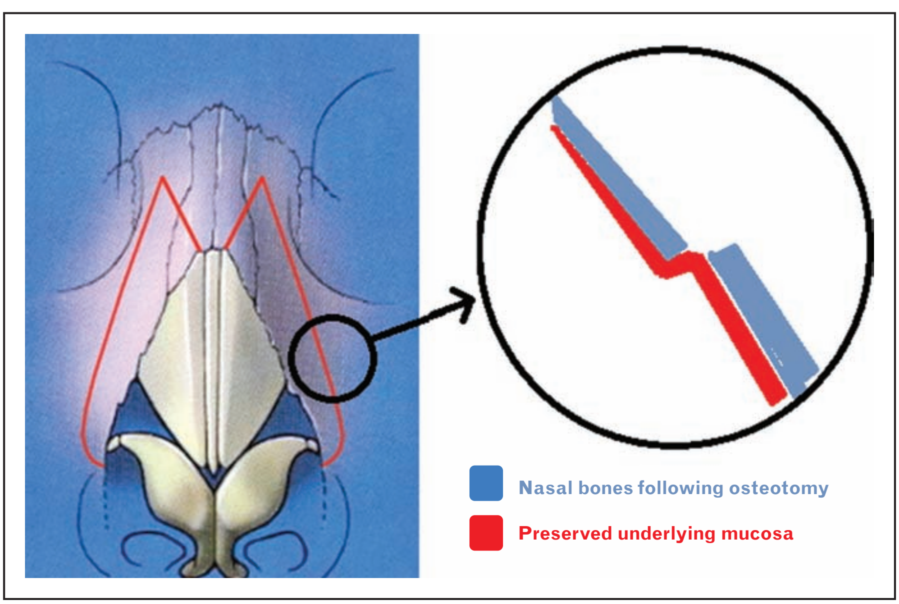

FIGURE 1. Preserving internal mucosal lining. Source: Illustrated by Berke Ozucer, MD.

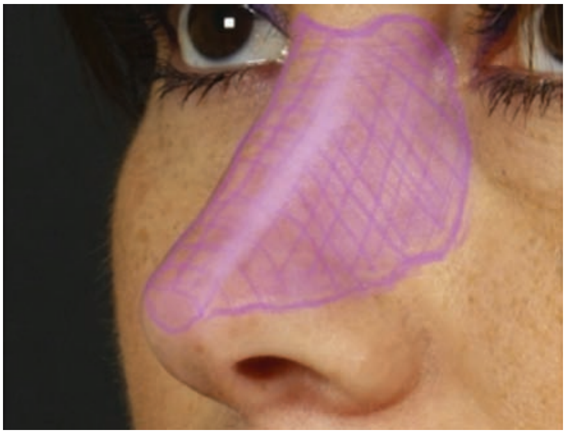

FIGURE 2. Extended dorsal dissection of bony framework is required compared to conventional osteotomy. Source: Reproduced by courtesy of Dr Barış Çakır, Springer, Switzerland.

particular shortcomings: they do not provide good visualization; powered burrs with the rotating tip can cause soft tissue injury – to the forehead or nasal skin; irregularities or asymmetries in the mobile nasal bones after osteotomies are difficult to address with traditional methods such as rasps or drills, which may avulse the bone fragments.

As the last generation powered tool, piezoelectric instrumentation (PEI) was introduced to rhinoplasty by Robiony *et al.* [17] and Pribitkin *et al.* [18]. Osteotomy with PEI is carried out following extensive exposure of dorsal skin envelope, which makes it possible to make precise lateral, intermediate, and medial osteotomies. Underlying soft tissues are preserved because PEIs use different frequencies to cut bony and neurovascular tissues: therefore, PEI makes a cut in the bone without tearing the underlying mucosa and causing soft tissue damage [19▪▪,20]. Fragmented comminuted fractures can also be avoided with PEIs; this has been shown in the literature by a cadaver study [20]. As Robiony puts it 'details and advantages of the use of ultrasound osteotomies in rhinoplasty are superimposable' [21]. There are several innovative approaches that extend the application of PEI for subtle refinements during bone shaping. These applications were mentioned by Greywoode and Pribitkin *et al.* [18,22,23]:

(1) Fragmented bones, irregularities, and bony edges following osteotomy can be difficult to address with rasps and motorized tools: these may apply force/torque and avulse the bone fragments. The vibratory motion of the ultrasonic bone aspirator enables making subtle refinements, smoothing out the bony edges without damaging surrounding structures under direct visualization. (This was the most common application performed nearly in all patients.)
(2) Dorsal reduction with PEI protects the underlying cartilaginous vault.
(3) Radix reduction with specialized carbide or powered rasps and diamond drills can be a technically difficult method to achieve under poor visualization. Diamond burrs, in particular, can cause soft tissue and skin injury. PEI can be a solution that enables precise and well tolerated radix reduction under direct vision.
(4) Following wide dissection of the nasal anatomy, intrinsic morphologic asymmetries of the bone cannot always be addressed with osteotomy alone. PEI can be used to sculpt asymmetries of nasal bones that disrupt a smooth and symmetrical brow-tip esthetic line.

NEW CONCEPT: OSTEOECTOMY

Çakır *et al.* introduced a new bone chisel scraping technique for lateral and medial osteotomies [24▪▪,25]. The main principle of this technique entitled 'osteoectomy' is to thin down the maxillary-nasal bony units progressively using 8-mm curved chisels (Fig. 3). Every push–pull movement removes a thin layer of bony debris and when adequate thinning is achieved, a greenstick fracture is easily achieved with a gentle digital pressure.

On the functional aspect, this technique offers a valuable improvement in our perspective: literature has shown in-fracture of the nasal bones

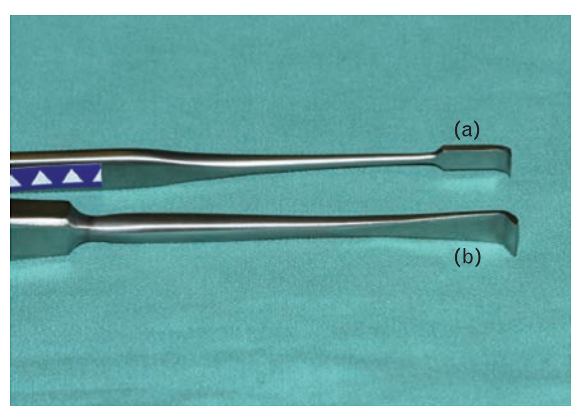

FIGURE 3. Chisels (a) Chisel used for medial osteoectomy. (b) Chisel used for lateral osteoectomy. Source: Reproduced by courtesy of Dr Barış Çakır, Springer, Switzerland.

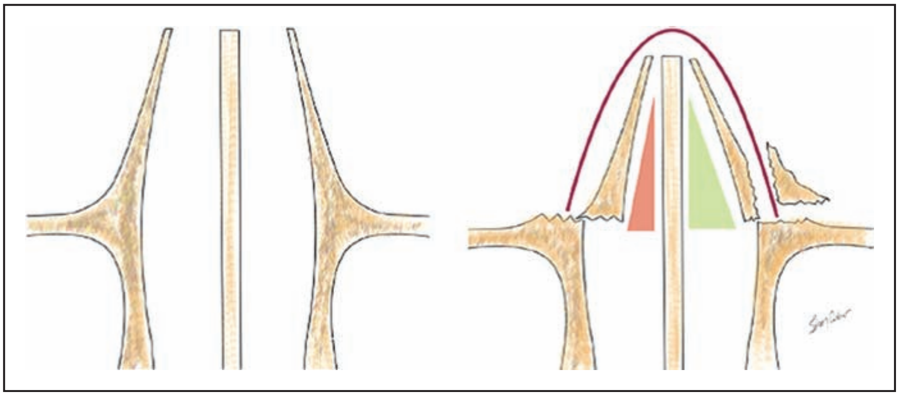

FIGURE 4. Narrowing effect of conventional osteotomy versus osteoectomy. (Left) Open-roof following dorsal reduction. (Right) Airway following closing open-roof: conventional osteotomy (gray) versus osteoectomy (light gray). Source: Reproduced by courtesy of Dr Barış Çakır, Springer, Switzerland.

compromises the airway passage; by thinning down the nasal bones, the same narrowing effect can be achieved without narrowing the airway. This is depicted in Fig. 4. Although this study stands as an observational study rather than comparative, the authors reported fewer functional problems and revisions with the mentioned method. NOSE scores of the patients improved. The advantage of osteoectomy on nasal airway compared with conventional osteotomy also needs to be investigated with randomized clinical trials.

This technique also enables sculpting the convexities of the curved nasal bones to flatten the bones that disrupt a smooth brow-tip esthetic line and avoid complications associated with intermediate osteotomy. Chisels also enable radix reduction without glabellar edema. Thinning of the nasal bone was sufficient to in-fracture the nasal walls in a reliable and predictable fashion. The nasal mucosa remained intact, the lateral nasal wall split in one piece without comminuted fracture. The principle of 'thinning down' the nasal bone for a more controlled and precise fracture has been shown in the literature before. It was conducted with a 2-mm diamond surgical burr that was used to thin down the nasal bone in a cadaver study. In our perspective, the method described by Ghassemi *et al.* is disadvantaged because of requirement of an additional intraoral incision and equipment. Nevertheless, the results of the principles used in this cadaver study may also be applied to osteoectomy [9].

NEW CONCEPT: PERFORATING LATERAL OSTEOTOMY UNDER DIRECT VISION

Traditionally, osteotomies are divided into endonasal continuous osteotomies and transcutaneous perforating osteotomies. Rho *et al.* introduces this new approach carried out following extended subperiosteal dissection more laterally than the intended osteotomy line just enough to ensure visibility of the surgical field [26]. Two-millimeter straight, unguarded osteotomes were used for medial oblique osteotomy at 15–20° followed by lateralized perforating lateral osteotomies. The authors claim better control, precise and reproducible results under direct vision. In each case, preservation of underlying mucosa was ensured. Avoidance of transcutaneous scars is another advantage of the technique [27].

DISCUSSION

Above-mentioned contemporary approaches claim precise and reproducible results that are not hampered by limited visualization. Although this makes sense, there is still no evidence-based scientific proof that these will improve surgical outcomes and decrease complications.

Wide soft tissue dissection and bone reshaping under direct vision has its advantages. Prolonged ecchymosis and edema following conventional osteotomy is associated with possible damage to soft tissues and branches of angular artery. Wide periosteal dissection and direct vision enable sparing arteries and lack of soft tissue injury – in our perspective – is the main reason for early resolution of edema. In our practice, osteotomy sequencing as the last step of the operation causes lesser ecchymosis and edema, and this is in accordance with the current literature [28].

Reduced postoperative ecchymosis and edema is an advantage. Lay people's fear of 'breaking bones' with hammer and osteotomy is one of the main reasons that patients avoid rhinoplasty. Avoiding the swollen and bruised 'traumatized' appearance in the postoperative period is certainly an advantage in terms of quality-of-life and reduced surgical down time. Ilhan *et al.* [29] conducted a double-blind comparison of PEI and conventional 4-mm endonasal continuous osteotomy and the study revealed PEI is associated with significantly less edema and ecchymosis in the early postoperative period. Tirelli *et al.*[30] compared 2-mm external perforating – through transcutaneous incisions – osteotomy to PEI and results were similar.

Çakır *et al.* and Rho *et al.* also advocate their approaches provide reproducible pleasing cosmetic results and protect the nasal interlining mucosa, spare the angular artery, avoid soft tissue trauma and consequently reduce bruising and swelling compared to osteotomy. Although this is logical – and consistent with our experience for osteoectomy – randomized clinical trials are warranted to verify these observations. Other than the learning curve, operation duration is prolonged in all of the above mentioned. Expensive instruments and setup time is another disadvantage for PEI particularly.

CONCLUSION

Although a variety of surgical methods have been described in the literature, there is still no single perfect method, and the quest for consistently pleasing results will continue. New cadaver studies and contemporary techniques are worth considering for each surgeon who wants to have more 'control' during nasal bone reshaping. Although nasal bone reshaping under direct vision is promising, there is no proof that these approaches will improve surgical esthetic outcomes and lower complication rates, yet. Additional randomized clinical trials with adequate follow-up time are required to validate these new concepts.

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Conflicts of interest

There are no conflicts of interest.

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