

Original Investigation

Identifying Septal Support Reconstructions for Saddle Nose Deformity

The Cakmak Algorithm

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IMPORTANCE The saddle nose deformity is one of the most challenging problems in nasal surgery with a less predictable and reproducible result than other nasal procedures. The main feature of this deformity is loss of septal support with both functional and aesthetic implications. Most reports on saddle nose have focused on aesthetic improvement and neglected the reestablishment of septal support to improve airway.

OBJECTIVES To explain how the Cakmak algorithm, an algorithm that describes various fixation techniques and grafts in different types of saddle nose deformities, aids in identifying saddle nose reconstructions that restore supportive nasal framework and provide the aesthetic improvements typically associated with procedures to correct saddle nose deformities.

DESIGN, SETTING, AND PARTICIPANTS This algorithm presents septal support reconstruction of patients with saddle nose deformity based on the experience of the senior author in 206 patients with saddle nose deformity. Preoperative examination, intraoperative assessment, reconstruction techniques, graft materials, and patient evaluation of aesthetic success were documented, and 4 different types of saddle nose deformities were defined.

MAIN OUTCOMES AND MEASURES The Cakmak algorithm classifies varying degrees of saddle nose deformity from type 0 to type 4 and helps identify the most appropriate surgical procedure to restore the supportive nasal framework and aesthetic dorsum.

RESULTS Among the 206 patients, 110 women and 96 men, mean (range) age was 39.7 years (15-68 years), and mean (range) of follow-up was 32 months (6-148 months). All but 12 patients had a history of previous nasal surgeries. Application of the Cakmak algorithm resulted in 36 patients categorized with type 0 saddle nose deformities; 79, type 1; 50, type 2; 20, type 3a; 7, type 3b; and 14, type 4. Postoperative photographs showed improvement of deformities, and patient surveys revealed aesthetic improvement in 201 patients and improvement in nasal breathing in 195 patients. Three patients developed postoperative infection and 21 patients underwent revision septal surgery.

CONCLUSIONS AND RELEVANCE The goal of saddle nose reconstruction should be not only to restore an aesthetic dorsum but also to restore the supportive nasal framework. The surgeon should provide more projected and strengthened septal support before augmentation of saddle nose deformity to improve breathing and achieve a stable long-term result. The Cakmak algorithm is a mechanism that helps surgeons identify the most effective way to maximize septal support and aesthetic appeal.

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The saddle nose is the loss of structural integrity of the lower two-thirds of the nose that results in both functional and aesthetic impairment. The loss of septal support coupled with the disruption of the septum, upper lateral cartilages, the nasal bone-septal cartilage complex, and the contraction of the skin soft tissue envelope and internal mucosal lining, lead to a deficiency of the middle nasal vault, that impairs internal nasal valve function.¹ The saddle nose not only is an aesthetic problem but also has the potential to create functional deficits. Poor function may arise due to a widened nasal septum, collapsed upper and lower lateral cartilages, an acute nasal valve angle, or a down-rotated nasal tip.² Previous studies focusing on the aesthetic feature of this deformity have contended the need for onlay grafts to restore the normal appearance of the nasal dorsum. Although different materials and the fixation techniques have their own advantages and disadvantages,³⁻⁶ the absence of addressing septal support has been a major pitfall.

Recent studies have revolved around the role the septum plays in the formation of this complex abnormality.⁷⁻¹² We believe that the goal of saddle nose reconstruction should be not only to restore an aesthetic dorsum but also to restore the supportive nasal framework to improve breathing and achieve a stable long-term result. An algorithm, the *Cakmak algorithm*, developed by the senior author (O.C.) describing the reconstruction of septal support, various fixation techniques and grafts in different saddle nose deformities is presented (Figure 1 and Figure 2).

Methods

The medical records of 216 patients with saddle nose deformity undergoing septorhinoplasty were reviewed. These records were selected from a total of 2686 rhinoplasty procedures performed by the senior author between August 1, 1998, and August 1, 2014. Ten patients having less than 6 months of follow-up were excluded from the study.

For each patient, a standard rhinoplasty series of photographs, subjective nasal symptoms, anterior rhinoscopic examination, intraoperative findings, reconstruction techniques, graft materials, complications, and revisions were documented. Aesthetic outcome of each patient was evaluated as improved, remained the same, or became worse by comparing the preoperative and postoperative photographs by an independent facial plastic surgeon and assessing the patient's responses regarding self-assessment of their postoperative nasal appearance. The functional outcome of each patient was evaluated by similar grading for anterior rhinoscopy findings and patient's responses regarding self-assessment of their nasal breathing. The septal support test was used to demonstrate the need for reconstructing septal support and was performed by applying digital pressure to the nasal tip and noting the presence and amount of depression. If the tip remains supported, it is a negative septal support test finding, and compression toward the premaxilla is a positive test finding.

Figure 1. Cakmak Algorithm

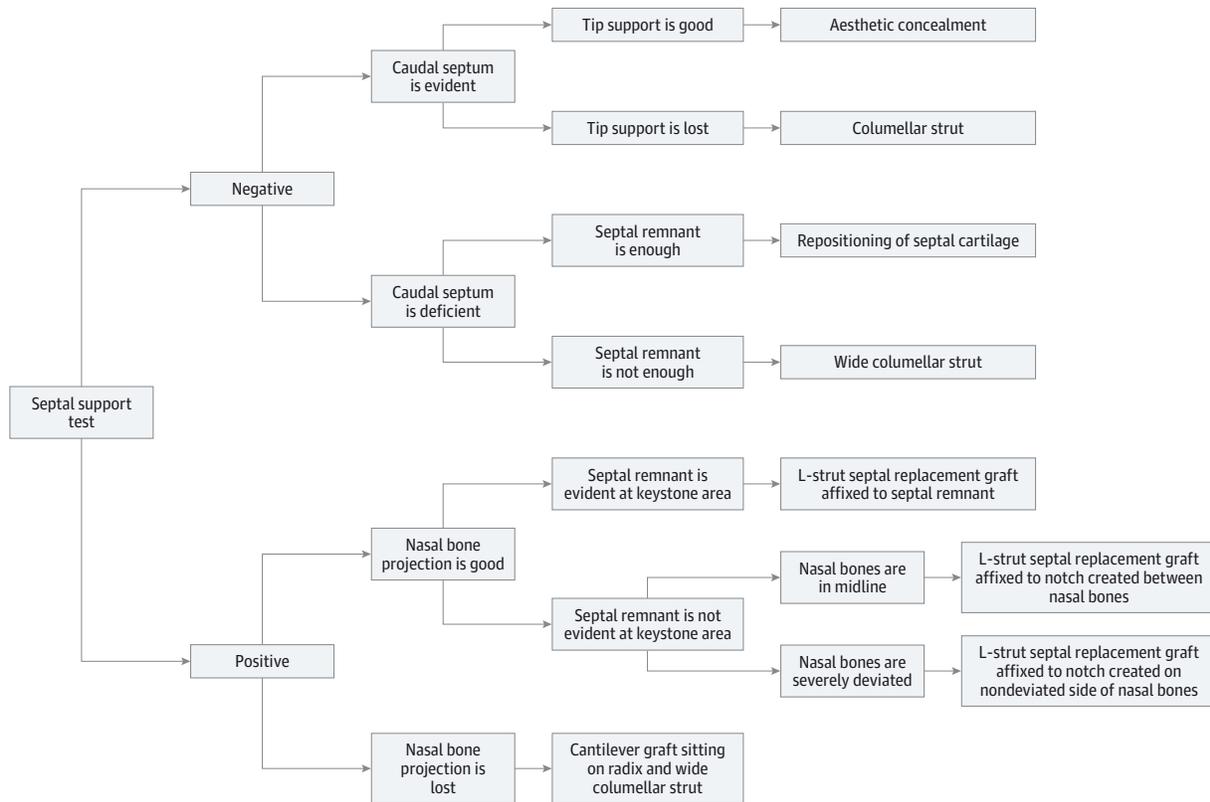
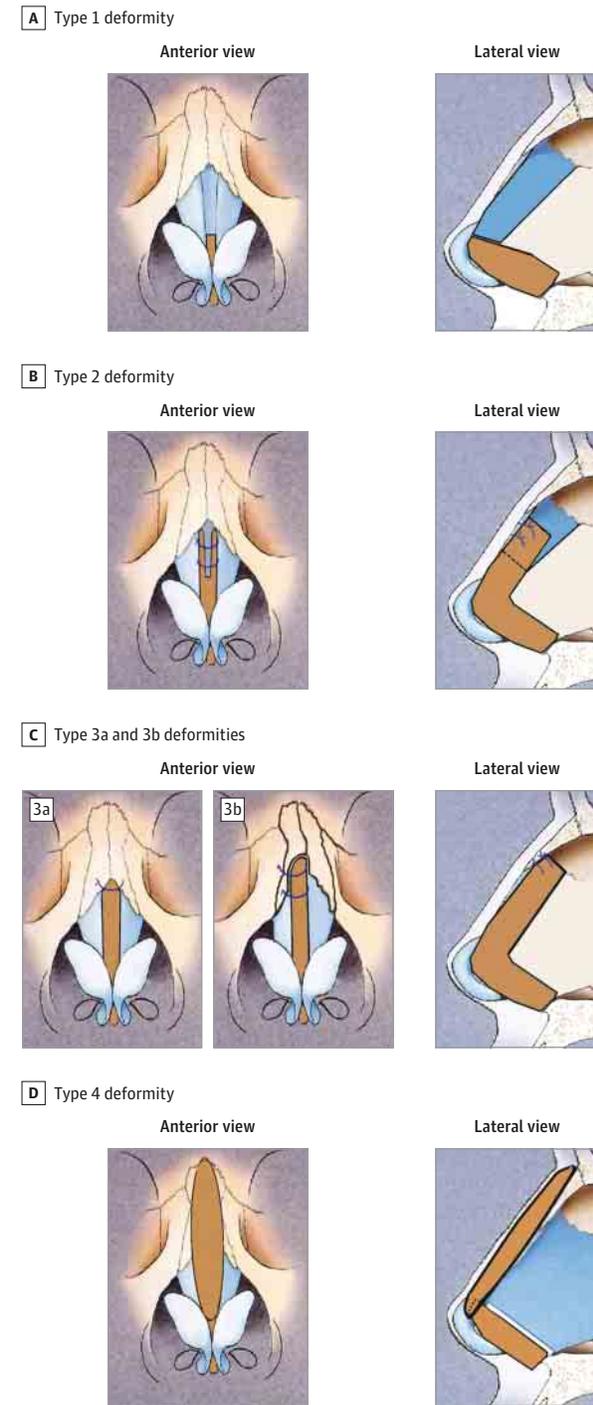


Figure 2. Reconstruction Techniques Identified by the Cakmak Algorithm for the Type of Saddle Nose Deformity



Schematic drawings representing reconstruction techniques for the type of saddle nose deformity based on the Cakmak algorithm. A, Wide columellar strut for type 1 deformity. B, L-strut septal replacement graft affixed to septal remnant for type 2 deformity. C, L-strut septal replacement graft affixed to notch created between nasal bones for type 3a deformity, and L-strut septal replacement graft affixed to notch created on nondeviated side of nasal bones for type 3b deformity. D, Cantilever graft sitting on radix and wide columellar strut.

In line with the aforementioned evaluations, a classification showing the senior author's algorithm for 4 different types of saddle nose deformities regarding the septal support reconstruction were found and are presented in Figure 1 and Figure 2.

Type 0

Patients with type 0 saddle nose deformity present with mild depression of the middle nasal third with good residual cartilaginous septal support dorsally and caudally and a near-normal lower third and tip position. Septal support is good, and the septal support test result is negative. Usually, tip support is strong, and tip projection is normal; there is no or minimal columellar retraction. A simple onlay graft for correction of the aesthetic deformity was executed, and a columellar strut is placed if necessary.

Type 1

These patients have moderate depressions of the middle nasal third with decreased tip projections and moderate columellar retractions. Tip support and residual cartilaginous septal support is weaker than in patients with type 0 saddle nose deformity, but the septal support test result is still negative. Moderate saddling affects function due to collapse at the internal nasal valve area. The characteristic problem of this type of deformity is caudal septal deficiency: the caudal septum is either overresected, deformed, or weak and is generally not attached to the anterior nasal spine (ANS) with most cases lying posteriorly or on either side of the spine, giving no support to the middle third of the nose. Strong septal support can be accomplished with repositioning of the septal cartilage or placing a columellar strut prepared wider than a regular columellar strut to strengthen the caudal septal support and correct the columellar retraction. This wide strut is placed between the medial crus of the lower lateral cartilage, and midline fixation is accomplished by suturing it to the ANS. If septal cartilage is not sufficient, auricular cartilage is used as a double-layered columellar strut in most cases. For patients who have undergone multiple nasal surgeries and the aforementioned cartilages are not available or in cases where preferred cartilages are flimsy or weak, suturing the wide strut to costal cartilage is our choice. Additionally, spreader or extended spreader grafts are placed to restore a straight and strong dorsal septal support and sutured to the dorsal septum if necessary.

Type 2

Initial evaluation of patients in this group show moderate to severe depression of the middle third of the nose, and the septal support test result is positive. Tip support is compromised with columellar retraction, and alar support is lost, which leads to nostril widening and loss of alar rim support. Endoscopic evaluation shows mucosal loss of elasticity with severe compromise of the internal nasal valve area. Differently from type 0 and type 1, dorsal septal support is weak, and the remaining cartilage-bone junction is not strong enough and is overly pliable with loss of support value. The septum has no support value for the middle third, and mucosal retraction further distorts the upper lateral cartilages by pulling them to a more inferior position. The lower lateral cartilages are buckled, and

Figure 3. Intraoperative View of a Patient With Type 2 Saddle Nose Deformity



Photograph of a patient with a type 2 saddle nose deformity having an L-strut costal cartilage septal replacement graft placed by holding the septal cartilage remnant. Inset shows L-strut costal cartilage septal replacement graft.

there is a warping at the area of the junction between the upper lateral cartilages and the lower lateral cartilages. Characteristic intraoperative findings in this group include the evidence of a septal remnant attached to the nasal bone with compromise of the remaining nasal septum. A septal replacement graft is required for this group. Auricular cartilage is not appropriate due to its limited rigidity and quantity for this type of deformity. Autogenous costal cartilage is ideal for septal replacement and provides a strong rigid support to the dorsal septum. Our approach differs from patients with type 1 saddle nose deformity in this instance. We prefer to use costal cartilage to form an L strut, which has a wide dorsal part, a notch to hold the remnant of the septal cartilage, and gives a spreader graft effect. The septal remnant is affixed to the dorsal part of the costal cartilage L strut during reconstruction. The dorsal part of the L strut is prepared wide enough to produce a strong and stable midline structure, act as a spreader graft to the middle nasal vault, and improve the airway. The dorsal part of the L-strut graft is shaped to have a vertical slit at its cranial tip to interdigitate the septal remnant and is affixed with nonabsorbable sutures. The caudal part of the L-strut graft is then affixed to the ANS with nonabsorbable sutures (Figure 3). To allow easier placement, we often prepare L-shaped septal replacement grafts as 2 separate pieces, and the tips of the struts are fashioned to allow strong attachment to each other by forming a slit on the caudal end of the dorsal strut and placing the cephalic portion of the caudal strut into this slot. While connecting the 2 struts at the anterior septal angle with sutures, the amount of tip rotation and middle vault projection is adjusted by changing the size and points of fixture of the struts. Collapsed upper lateral cartilages are freed and fixated onto the reestablished dorsal septum.

Type 3

This type of saddle nose often displays similar clinical findings as type 2. The characteristic difference that appears intraoperatively is that these patients do not have enough remnant septal cartilage in the key area to be used as a point of

Figure 4. Intraoperative View of a Patient With Type 3 Saddle Nose Deformity



Photograph of a patient with a type 3 saddle nose deformity having an L-strut costal cartilage septal replacement graft placed into a notch created between nasal bones. Inset shows L-strut costal cartilage septal replacement graft prepared as 2 separate pieces.

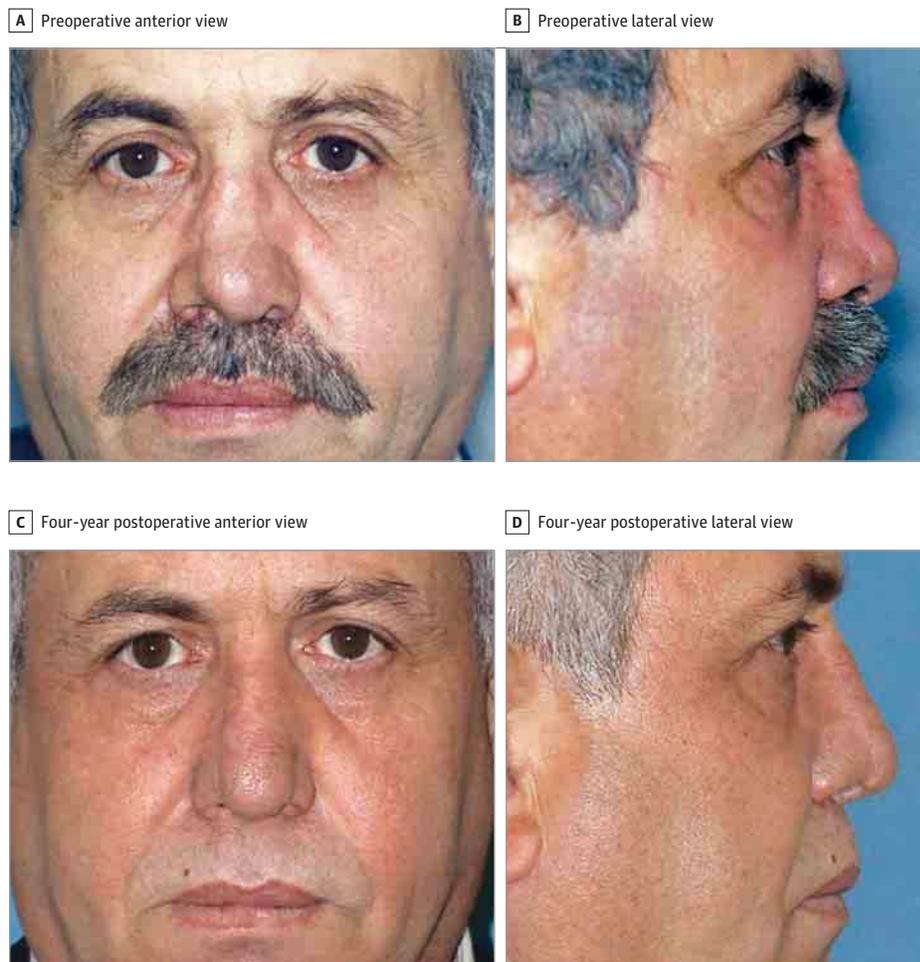
fixture for the L-shaped costal cartilage septal replacement graft. In these cases, nasal bones are used as an anchor for fixture. A notch is created between the nasal bones and the dorsal part of the costal cartilage septal replacement L-strut graft is shaped to fit inside of this notch for midline fixation (Figure 4). The shape of this strut is similar to the one mentioned in type 2 in that it is carved with a wider dorsal part to act as a spreader graft, but its dorsal part is typically prepared longer to reach and slide below the nasal bones. According to the determination of anchor points for midline fixture to the nasal bones, 2 different approaches can be used.

Type 3a is identified if the nasal bones are at midline, or there is mild to moderate deviation. A notch is created between nasal bones at the midline and 2 holes on each nasal bone are drilled where the L strut is fixed with nonabsorbable sutures. If required, the lateral osteotomies are performed as incomplete to keep the anchor points strong and stable. Type 3b is identified if nasal bones are severely deviated, and lateral osteotomies are needed to obtain a straight bony dorsum. In this case, an osteotomy is performed only on the deviated side, and the opposite side of the nasal bone is kept intact to produce a strong and stable anchor point for midline fixation. A notch is created on the nondeviated nasal bone, 2 holes are drilled, and the tip of the dorsal part of the strut is shaped to fit that notch and affixed with nonabsorbable sutures. After affixing the caudal part of the strut to the ANS, the rest of the middle vault closure, including preparation of the 2 arms of the L strut as 2 separate struts for easier placement, is performed similarly to patients with type 2 saddle nose deformity (Figure 5).

Type 4

The major difference in this group is the considerable loss of nasal bone projection besides the absence of the septal support. The absence of enough of a projected midline anchor

Figure 5. Preoperative and 4-Year Postoperative Photographs of a Patient With Type 3 Saddle Nose Deformity



structure makes it functionally unnecessary to restore a septal replacement L-strut graft. In such cases, a cantilevered costal cartilage graft is prepared that can sit on the radix. A wide columellar strut is used and is initially attached to the ANS through holes with nonabsorbable sutures. The wide columellar strut is then affixed to the caudal end of the cantilever graft supporting it both medially and anteriorly.

For each type of saddle nose reconstruction, after reconstructing the septal support various additional structural and nonstructural cartilage grafts and further rhinoplasty maneuvers are used depending on the deformity in each case. We prefer to use a columellar strut in most cases, but the tongue-in-groove technique can also be used to re-create adequate tip position and shape in selected cases. After reconstructing the septal and middle vault, the dorsum is made as flat and smooth as possible before dorsal onlay grafts are placed. The final dorsal irregularities are camouflaged with placement of slightly or moderately crushed cartilage onlay grafts as presented by the senior authors' previous articles.^{13,14} Occasionally, if a solid onlay cartilaginous graft is used for deeper defects, its contours are softened by placing small pieces of moderately crushed grafts on or around the solid graft.

Results

The range of follow-up for 206 patients (96 men and 110 women; age range, 15-68 years [mean age, 39.7 years]) was 6 to 148 months (mean, 32 months). Except for 9 patients with traumatic nasal deformity and 3 patients with unknown origin, all patients had a history of previous nasal surgeries (47 had septoplasty and 147 had septorhinoplasty). Costal cartilage was harvested in 84 patients and auricular cartilage in 113 patients. When 206 patients were categorized according to the Cakmak algorithm, 36 had type 0 saddle nose deformities; 79, type 1; 50, type 2; 20, type 3a; 7, type 3b; and 14, type 4. Evaluations of preoperative and postoperative photographs showed improvement of the patients' saddle nose deformities. The patient survey for the evaluation of aesthetic success revealed improvement in 201 patients and no improvement in 5 patients (1 patient in type 0; 2, type 1; 1, type 2; and 1, type 3). The anterior rhinoscopy showed enlarged nasal valve area due to correction of strength and height of the septal skeleton and restored connections between the upper lateral and dorsal septal cartilages. While the patient survey revealed improve-

ment in nasal breathing in 195 patients, 11 patients stated no improvement (1 patient in type 0; 2, type 1; 1, type 2; and 7, type 4).

Postoperative infection of the columellar skin developed in 3 patients, resolved by antibiotics in 2 patients. The third patient's infection prolonged and caused partial graft resorption of the caudal part of the septal replacement graft. Minimal warping was noticed in 4 patients with rib cartilage (3 in septal replacement graft and 1 in dorsal-onlay graft). Twenty-one of the 206 patients (10.2%) underwent revision surgery with 8 patients requiring revision septal surgery (10 for correction of minor dorsal contour irregularities, 2 for release of the mucosal synechia around the nasal valve area, and 1 with partial graft loss of septal replacement graft secondary to infection).

Discussion

The surgical correction of saddle nose deformity should be approached using an algorithm in accordance with the severity of the deformity. From a practical point of view, saddle nose deformities can be classified as minimal, moderate, and major. Minimal saddle nose deformities can be camouflaged using cartilage filler grafts. The majority of mild or moderate deformities with reasonable septal support can be successfully treated with dorsal onlay grafts in combination with columellar strut and tip grafts shaped from the remaining septal and/or conchal cartilage. Major saddle nose deformities, often devoid of septal cartilage, require significant structural restoration to resupport the lower two-thirds of the nose. These patients are often treated with cantilevered dorsal grafts of various materials.^{6,15-17} However, the main reason for the depression of nasal dorsum is weakening of the septal skeleton, which if not reestablished, cannot produce a functional improvement with a simple onlay graft or a cantilevered dorsal graft.

Until recently, reported classifications were based on cosmetic appearance, and the emphasis was put on the aesthetic aspect. Reestablishing a straight nasal dorsum was regarded as a successful procedure.^{3-6,15-17} Since the main feature of a saddle nose is loss of septal support with both functional and aesthetic implications, it could be argued that the surgeon should provide a more projected, strong, and stable septal support to improve the airway before augmentation of the saddle deformity. Besides reestablishing ideal strength and height of the septal skeleton, functional improvements are only possible after correcting nasal valve angles, decreasing mucosal tension, and reestablishing ideal connections between the upper lateral and dorsal septal cartilages. On the other hand, dorsal onlay or cantilever grafts, which are positioned on the depressed middle vault for cosmetic benefits, can possibly impair nasal breathing further by pushing on an already weak and collapsed middle vault.

Recently, new classifications were reported addressing the reconstruction of septal support.⁷⁻⁹ In 2006, Daniel and Brenner⁸ classified saddle noses in 5 types and suggested a treatment algorithm according to the degree of septal sup-

port: type 1, minor deformity requiring cosmetic concealment only; type 2, loss of tip projection and septal support requiring cartilage vault grafts attached to a columellar strut; type 3, total loss of cartilaginous vault integrity requiring foundation layer of pistol spreader grafts extended below the nasal vault and a true septal strut to provide deep support; type 4, severe deformity with bony vault involvement requiring osseocartilaginous dorsal graft from rib; and type 5, catastrophic deformity requiring forehead flaps. Young and Rowe-Jones⁹ modified Daniel and Brenner's classification into 3 types: type 1, mild depression in the middle nasal third requiring columellar strut and diced camouflage grafts; type 2a, significant saddle in the middle third requiring a wide columellar strut; type 2b, significant saddle in the middle third requiring wide columellar strut and spreader grafts; and type 3, severe saddle deformity with loss of support, requiring spreader grafts and caudal septal strut.

Both of these excellent classifications put emphasis on restoring the supportive nasal framework to improve breathing, and they also offer solutions for aesthetic improvement. However, the reconstruction of patients devoid of enough septal cartilage remnant in the key area were not mentioned in either of these reports. With the Cakmak algorithm, we used nasal bones as the anchor point to affix the L-strut septal replacement and/or spreader graft complex for such cases (type 3). We believe that reconstruction of the weakened septal support and reestablishment of ideal connections between the upper lateral and dorsal septal cartilages with spreader grafts are the mainstay of functional improvement. In our algorithm, exclusive of type 4, all collapsed upper lateral cartilages are sutured onto a more projected, widened, and strengthened dorsal septum to improve the nasal valve area and breathing. For the exceptionally rare cases with significant loss of nasal bone projection, we used cantilever grafts to sit on the radix without expecting any functional improvement. Fortunately, these patients accounted for less than 10% of our major saddle nose deformities.

Autogenous cartilage is our graft of choice for the reestablishment of structural support. Initially, we search for any viable remnant septal cartilage we may use. If none is present, we prefer to use auricular cartilage as our second option. However, for the reconstruction of a major saddle nose deformity requiring a septal replacement graft or the formation of an L strut, we use costal cartilage. The main disadvantage of the autogenous costal cartilage graft is its tendency to warp. The key to minimizing warping is to be sure to carve the cartilage equally on each side. Most warping occurs within 15 to 60 minutes of harvesting. Waiting for early warping to occur and reshaping the graft before placement can largely diminish this problem.¹⁸

In our algorithm, the restoration of a strong, high middle dorsum improves major dorsal depression requiring significant augmentation, and only camouflaging of small depressions are then needed. Residual contour irregularities can be successfully concealed with slightly or moderately crushed autogenous cartilage grafts. The senior author's previous studies^{13,14} showed that slight or moderate crush-

ing of autogenous cartilage produces an outstanding graft material that is effective in concealing minor irregularities, filling defects, and creating a smoother surface with excellent long-term clinical outcomes and predictable aesthetic results.

We have presented an algorithm on saddle nose reconstruction based on the breadth of the senior author's 15-year experience. An algorithm is a self-contained set of operations performed with data processing and common sense. It is a descriptive study, and since the sole purpose of our study was to describe the views and procedures of the senior author, we do not consider its descriptive nature a limitation. Increasing the number of participants would strengthen the analytical process, but since this is a true algorithm described by a single surgeon, the treatment methods would not change except under unique circumstances.

Conclusions

The surgery of a saddle nose deformity is characteristically reconstructive and is not simply cosmetic camouflage. Previously, the emphasis had been put on the aesthetic aspect, and reestablishing a straight nasal dorsum with a simple overlay graft had been regarded as a successful procedure. The main feature of a saddle nose is loss of septal support with both functional and aesthetic implications, and the surgeon should provide more projected, strong, and stable septal support before augmentation. The Cakmak algorithm enables achieving functional improvement by restoring the ideal strength and height of the septal skeleton, reestablishing ideal connections between the upper lateral and dorsal septal cartilages, and correcting nasal valve angles alongside producing a positive aesthetic result.

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Study concept and design: Cakmak, Emre, Ozkurt.
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Drafting of the manuscript: Cakmak, Emre, Ozkurt.

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