A Novel Ear Cartilage Caudal Septal Extension Graft

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Abstract

In cases of weak or deficient caudal septum, the caudal septum extension graft (CSEG) is the most commonly used reconstructive method. In the current study we introduce a newly-designed conchal cartilage CSEG and evaluate its cosmetic and functional outcomes. The graft has an average length of 3 ± 0.3 cm and composed of a distal double-layered part, which is 3 to 4 mm wide and a proximal single-layered part, which is 1.2 to 1.7 cm wide. The graft design allows the proximal single-layered part to be fixed on either sides of the caudal septum while keeping the distal double-layered segment in the midline. The study included 230 patients, of which 83% were revisions, all patients completed a validated patient-reported outcome measure (PROM) questionnaire pre- and postoperatively. The PROMs used were either the Nasal Obstruction Symptom Evaluation (NOSE) survey or the Standardized Cosmesis and Health Nasal Outcomes Survey (SCHNOS). During the mean follow-up period of 18.2 months (range: 9–192 months) no serious complications were encountered and only six cases (2.3%) required minor revisions of the CSEG.

Using the proposed conchal cartilage, CSEG resulted in an improved cosmetic and functional outcome as evidenced by the significant postoperative improvement in the NOSE, SCHNOS-O, and SCHNOS-C scores with a p-value <0.001, <0.05, and <0.0001, respectively. The graft provided adequate tensile strength and support to the nasal tip, which resulted in improved tip projection, rotation, definition, and symmetry, while maintaining a degree of flexibility and elasticity which is much more than that of the rib or even the septum thus resulting in the most natural feel of the nasal tip lobule.

Keywords
- ear cartilage
- nose
- septum extension graft
- rhinoplasty

The caudal segment of septal cartilage plays a pivotal role in the architectural support of the nasal tip.[1,2] Many aesthetic as well as functional problems can occur if the caudal septal cartilage was weak, receding, or missing. Caudal septum deficiencies may be congenital, as in Binder syndrome, or acquired following trauma, infection, or previous nasal surgeries.[3] Such caudal septum deficiencies weaken the support of the tip cartilages which will fail to resist the constant pull of gravity thus leading to a depressed droopy nasal tip especially in cases of thick heavy nasal skin. In other cases, excessive caudal septum resections or caudal septum destruction secondary to major trauma or severe infection can lead to a short nose with over-rotated tip as a result of fibrous tissue contracture.

Many grafting techniques were described to replace, extend, or augment the deficient caudal septum. Of these techniques, the caudal septum extension graft is one of the commonest and most widely used. That extension graft was described by Byrd et al[4] to control the tip position and shape, and by Toriumi[5] to correct the retracted columella and the alar-columellar relationship. Autogenous septal cartilage is universally accepted as the graft material of choice in rhinoplasty as no other biological or alloplastic material can match the quality of fresh autogenous cartilage in terms of safety, biocompatibility, durability, and versatility.

However, in most cases where a CSEG is needed, the septal cartilage is usually found depleted or insufficient as in

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revision cases or weak and flimsy as in non-Caucasian noses with thick skin and weak cartilages.

When septal cartilage is depleted, insufficient, or too weak to be used for grafting, the ear and rib are the alternative sources available for autogenous cartilage. The costal cartilage is similar to the nasal cartilages in being hyaline in nature, however, it is more stiff and rigid than septal and alar cartilages, this is due to the significant ultrastructure differences between these cartilages.[6,7] This difference in mechanical properties, beside making the tip stiff and rigid, may also limit the ability of the harvested cartilage to be shaped and to bear a load.

On the other hand, the ear cartilage, which provides an alternative source of autogenous cartilage for nasal grafting, contains elastic fibers which make the cartilage less rigid and more flexible, than the hyaline cartilage of the rib and the septum, so it can be easily shaped and contoured to fit in any region of the nose.[8–15]

In the current study, we present a new CSE graft made of ear cartilage and evaluate its aesthetic and functional outcome.

Methods

Between January 2005 and December 2021, the senior author (H.M.T.F) used ear cartilage in 1,430 cases of rhinoplasty. Out of these, 338 patients had an ear cartilage CSEG. Only (230) patients, who completed a validated patient-reported outcome measure (PROM) questionnaire pre- and postoperatively were included in the current study. The PROMs used were either the Nasal Obstruction Symptom Evaluation (NOSE)[16] survey or the Standardized Cosmesis and Health Nasal Outcomes Survey (SCHNOS).[17] Higher scores on the NOSE and SCHNOS imply lower satisfaction with nasal breathing or aesthetics.

Data recorded included (demographics) age, gender, and stage of rhinoplasty; primary or revision and number of previous rhinoplasties. Postoperative complications, including hematoma, infection, gross absorption, graft exposure or migration, as well as any conchal cartilage donor site morbidity were evaluated and recorded.

Preoperative and postoperative digital photographs were recorded in the standard rhinoplasty views and were used for aesthetic evaluation of nasal tip. For aesthetic evaluation, the senior author (H.F.) and two other independent reviewers (Youssef Ghanem and Carine Hamdy), with more than 10 years' experience in rhinoplasty, were presented a slide with the paired frontal and lateral preoperative and postoperative views of each patient. The reviewers were asked to rate four aesthetic features of the nasal tip: the projection, rotation, definition, and symmetry to subjectively assess if each feature got (1) improved, (2) unchanged, or (3) worse.

Surgical Technique

Harvest of Conchal Cartilage

The ear is disinfected with alcohol 70% then infiltrated using a solution of 1% lidocaine with 1:100,000 units of epinephrine. Infiltration of the concha is performed using a #27-gauge needle aiming at hydrodissection in the subperichondrial plane anteriorly and the subcutaneous plane posteriorly. This is followed by prepping the ear thoroughly with Q-tips soaked in Betadine solution.

Posterior Approach

With the ear retracted forward, a #15-gauge blade is used to perform a longitudinal incision, on the back of conchal cartilage, through the skin and subcutaneous tissue but stopping short of the perichondrium. A fine tenotomy scissors is used to expose the conchal cartilage with its overlying perichondrium intact, the dissection is continued anteriorly, till reaching the antihelix and its inferior crus, and posteriorly till reaching the mastoid periosteum. With the surgeon's middle finger pressing in the conchal bowl, a curvilinear cartilaginous incision is made, with a # 15-gauge blade, 2 mm behind and parallel to the antihelical fold and its inferior crus, the incision goes through the full-thickness of the conchal cartilage without injuring the anterior skin then a Cottle elevator is used to expose the anterior surface of conchal cartilage in the subperichondrial plane stopping 5 mm short of the posterior wall of the external auditory canal to avoid skin sagging into the posterior canal wall. After full anterior and posterior undermining of the conchal cartilage, the cartilage is excised using sharp dissection with a Joseph type scissors (►**Fig. 1**).

Anterior Approach

Cartilage is harvested through an anterior approach using a curved incision parallel to the antihelix but 2 mm below it to allow the scar to be hidden by the curve of the antihelix and its inferior crus. The skin and the anterior perichondrium are raised, by a combination of sharp and blunt dissection, till exposing the entire conchal bowel then a # 15-gauge blade is used to make a full-transfixion incision through the cartilage a few millimeters below and parallel to the antihelical fold and its inferior crus. The conchal cartilage, with its posterior perichondrium attached, is dissected from the postauricular

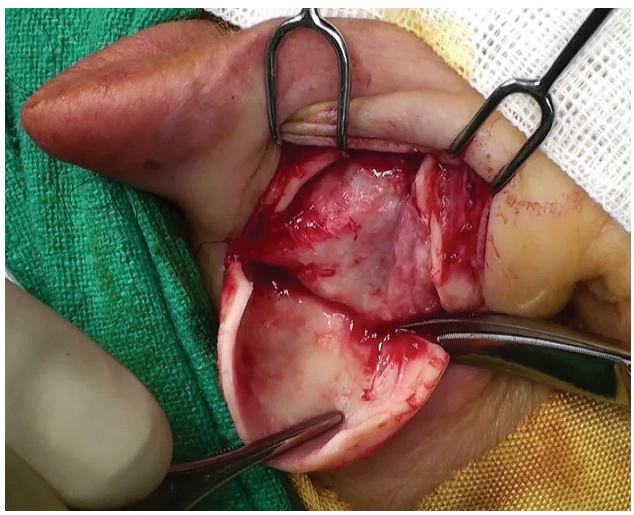

Fig. 1 Conchal cartilage harvest through the posterior approach.

Fig. 2 Conchal cartilage harvest through the anterior approach.

skin till reaching the external auditory canal where it is vertically separated half a centimeter behind the posterior canal wall (►**Fig. 2**).

At completion of cartilage harvest through the anterior or posterior approach, meticulous hemostasis is performed, and the skin incision is closed using 5/0 Vicryl Rapid in a continuous running fashion making sure to leave the lower 3 to 4 mm open to act as a drain.

A compression Mastoid-type dressing is applied to the ear and kept for 48 hours to prevent any hematoma formation. The patients were instructed to use a soft pillow and to avoid sleeping on the operated side for 1 month.

Fabrication of the CSE Graft

The size of harvested conchal cartilage measured 2.8 to 3.4 cm in length and 1.9 to 2.5 cm in width (►**Fig. 3**). Using a #15 blade, a piece of cartilage is trimmed from the curved posterior border of the graft to change it into a straight border with an average length of 3 ± 0.3 cm long then another vertical cut is made 3 to 4 mm posterior and parallel to the created straight border. That new cut is made on the anterior concave surface of the cartilage and is only a partial-thickness cut (leaving the posterior perichondrium intact) that allows the 3 to 4 mm segment to be folded, on the rest of the conchal cartilage, in a back-to-back fashion and sutured into a double layer using 5/0 PDS mattress sutures. Accordingly, the finished graft (►**Fig. 4**) has a double-layered distal part, which is 3 to 4 mm wide and a single-layered proximal part, which is 1.2 to 1.7 cm wide and a mean length of 3 ± 0.3 cm.

Preparation of CSE Graft Pocket

An external open rhinoplasty approach[18] is used to access the nasal septum after evaluating the extent of missing caudal septum by instrument palpation. The medial crura are pulled apart and any scar tissue, between them, is excised using sharp dissection with #15 blade, then a fine tenotomy scissors is used to continue the dissection downward, between the footplates of the medial crura, till reaching the premaxilla and the anterior nasal spine. Dissection is then

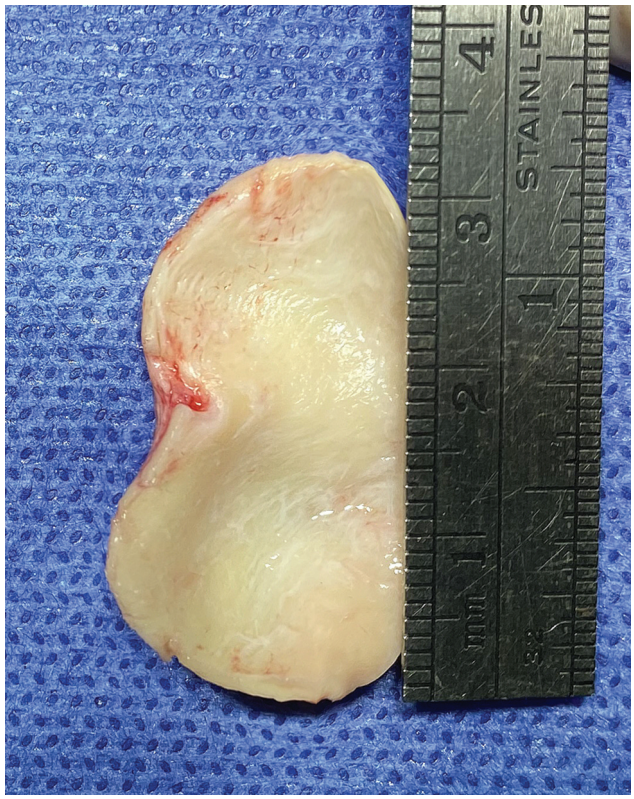

Fig. 3 The size of harvested conchal cartilage measured 2.8 to 3.4 cm in length and 1.9 to 2.5 in width.

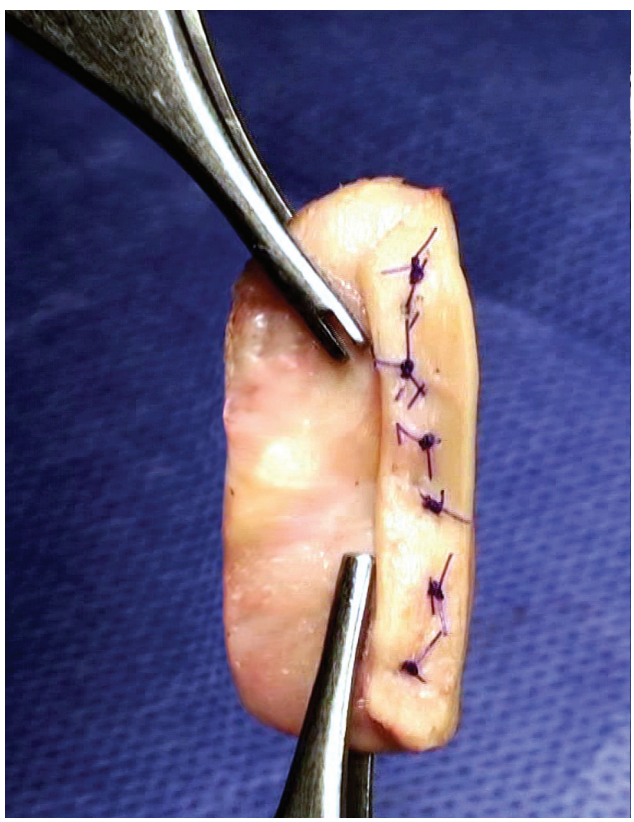

Fig. 4 The fabricated CSEG with a double-layered caudal segment and single-layered cephalic segment. CSEG, caudal septum extension graft.

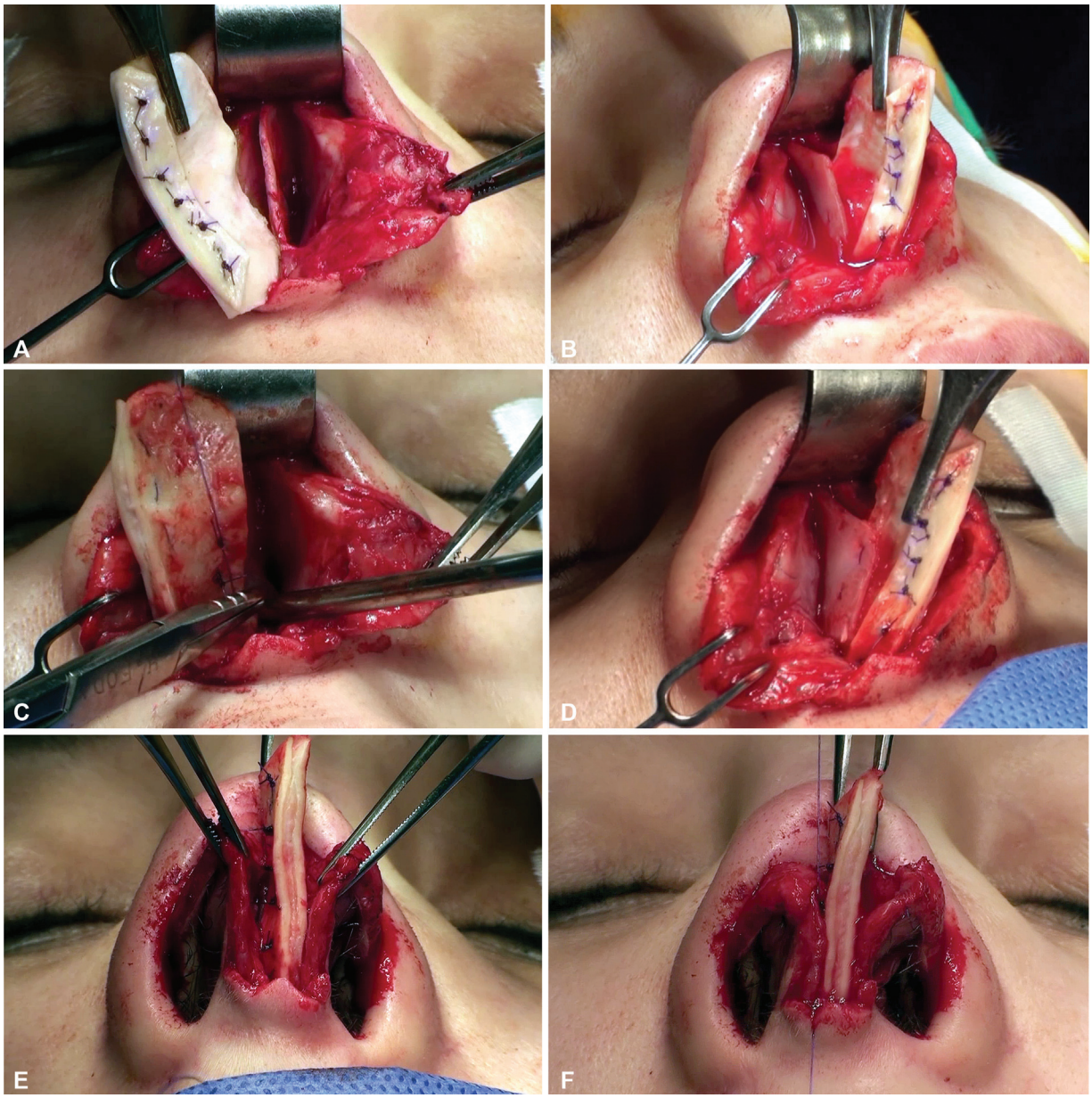

Fig. 5 Intraoperative photos. (**A**) Exposure of caudal septum. (**B**) Insertion of the CSE graft. (**C,D**) Fixation of the single-layered part of the graft to the caudal septum. (**E, F**) Fixation of the double-layered part of the graft to the medial crura.

continued cephalically, in the membranous septum, till reaching the caudal edge of the septal cartilage where the tip of the scissors is used to tease the perichondrium off the cartilage then a Cottle elevator is used to perform bilateral caudal septum flap elevation in the subperichondrial plane to expose 5 to 10 mm of caudal septal cartilage (►**Fig. 5A**).

Insertion, Positioning, and Fixation of the CSE Graft

The graft is then introduced into the membranous septum pocket with the double-layered part placed between the medial crura and pushed downward till it is tightly pressed against the premaxilla and anterior nasal spine (►**Fig. 5B**), the graft can be moved forward and backward to change the tip projection or upward and downward to change the tip rotation. After reaching the desired degree of projection and rotation, the single-layered part of the graft is fixed, to the CS, in a side-to-side fashion using three horizontal mattress stitches of 5/0 PDS (►**Fig. 5C, D**). The graft design allows it to be fixed on either sides of the caudal septum by flipping it vertically in order to keep its double-layered segment aligned with the septum. It is important to shave any prominent ridge on the back of concha before fixing it to the septum to avoid causing a bulge intranasally that may obstruct the airway. Two methods of side-to-side fixation were used; the vertical fixation (►**Fig. 6A**) where the cephalic border of the graft is parallel to the caudal border of the septum and the oblique fixation (►**Fig. 6B**) where the graft is tilted downward and splinted by a splinter graft to achieve maximum inferior rotation of tip and lengthening of the nose. In rare situations where the graft shows a tendency to deflection, the base of the graft is fixed to the anterior nasal spine using 4-0 polydioxanone sutures.

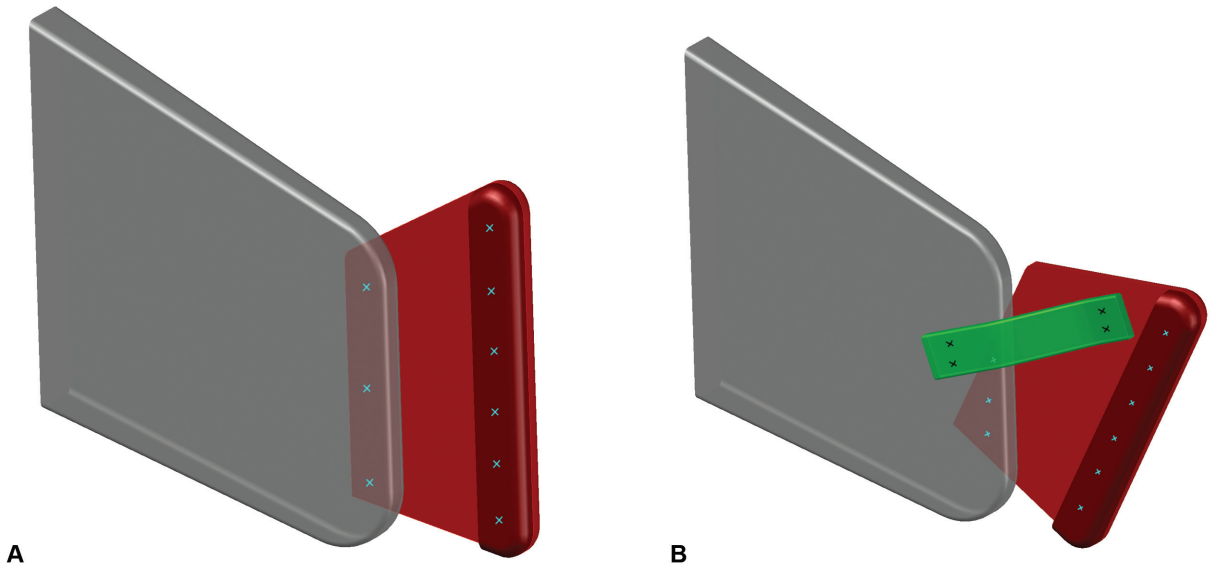

Fig. 6 Schematic illustration showing the difference between (**A**) the vertical fixation of CSEG and (**B**) the oblique fixation with a splinter graft. CSEG, caudal septum extension graft.

The double-layered part of the graft is fixed to the medial crura using 5/0 PDS sutures in a horizontal mattress fashion (►**Fig. 5E, F**). Three sutures are used, the first at the level of medial crural footplates, the second in the columellar segment of medial crura, and the third in the lobular segment of the medial crura.

After reaching the final degree of tip projection and rotation, shaving the part of graft, bridging between the anterior septal angle and domes, is incrementally done to avoid any supratip fullness.

Results

Of 336 patients who had an ear cartilage CSE graft, only 230 patients, who completed a validated PROM questionnaire pre- and postoperatively, were included in this study. Of these, 162 patients completed a pre- and postoperative NOSE survey,[16] whereas 68 completed the Standardized Cosmesis and Health Nasal Outcomes Survey (SCHNOS) survey.[17] The SCHNOS survey includes an obstructive (SCHNOS-O) and a cosmetic (SCHNOS-C) component. The age of patients ranged from 17 to 64 years, with an average of 28.4 years, 72% were females. The mean follow-up was 18.2 months, with a range from 9 to 192 months.

Out of the 230 patients, 39 (17%) were primaries and 191 (83%) were revisions. A breakdown of the patients' previous septorhinoplasties showed that 96 had one, 48 had two, 19 had three, 16 had five, eight had four, and four had seven previous septorhinoplasties.

The PROM (NOSE or SCHNOS) score follow-up dates ranged from 270 to 5,140 days with a mean of 495 days (16.5 months). The mean (SD) preoperative NOSE score was 48.8 (22.9) and mean (SD) postoperative score was 27.9 (14.1), which significantly improved from preoperative to postoperative ($p < 0.001$) result. A similar improvement was also observed on the SCHNOS-O which decreased from 31.6 (16.4) preoperatively to 24.5 (12.2) postoperatively ($p < 0.05$), although this difference was not significant. Highly significant improvements were observed between pre- and postoperative SCHNOS-C (75.9–16.7, $p < 0.0001$) scores.

Subjective evaluation of nasal tip aesthetics, done by three independent raters, by comparing per- and postoperative photos, reported an average of 98.3% improvement in projection, 96.7% improvement rotation, 75% improvement in definition, and 73% improvement in symmetry.

Nasal complications included three patients who had a postoperative infection that was managed conservatively and nine patients who required revision to correct cosmetic nasal deformities. The cosmetic deformities were unrelated to the CSEG in three cases (bony asymmetries and/or dorsal irregularities) and were directly related to the CSEG in six cases (2.3%) including tip deflection, columellar deviation, and nostril asymmetries.

Ear harvest site morbidity included 11 patients who had small seromas which was managed conservatively without needing any surgical intervention, eight patients had sensory impairment which improved with time. No cases of hypertrophic scars, infection, or auricular deformity were encountered.

Discussion

The caudal septum is considered the largest supporting force of the nasal tip projection as it provides the majority of the critical load-bearing tip support.[1,2,19,20]

In cases of weak or deficient CS, the CSE graft[4,5] is the most commonly used reconstructive method.

Autogenous septal cartilage is universally accepted as the graft material of choice in rhinoplasty but, unfortunately, in most of the revision cases, where a CSE graft is needed, the available amount of septal cartilage is insufficient. Even in 1ry, non-Caucasian noses with thick skin, it is common to find the septal cartilage small, thin, and weak. In such cases, the

alternative sources of cartilage include the ear and rib cartilage. Costal cartilage is the best option when large amounts of strong cartilage is needed. Some drawbacks include warping and calcification, which interferes with carving and suturing, prolonged operative time, and the high donor site morbidity which includes increased pain, hematoma, chest scar, damage of the intercostal nerves and vessels, a possibility of pneumothorax and transient atelectasis.[21–28]

In experienced hands, almost all these drawbacks can be easily avoided but the only thing that is impossible to overcome is the inherent strength and rigidity of rib cartilage which is a lot higher than that of nasal cartilages. This problem is more manifested when the rib cartilage is used in the soft parts of the nose like in the tip and alar lobules thus rendering them unnaturally stiff and rigid.

On the other hand, the ear, which is the second alternative source of cartilage available, has many advantages including its proximity to the nose so it can be included within the same operative field, ease of harvest, well-hidden scar, and very low donor site morbidity. Also, the elastic nature of ear cartilage gives it a degree of flexibility and elasticity similar to that of nasal cartilages. Despite this, using conchal cartilage in CSE grafts has been generally avoided due to multiple inherited beliefs. First of which, is that the conchal cartilage curvature and elastic nature makes it unsuitable to provide the tensile strength required for good long-term support of the nasal tip; second, its limited size which cannot be wide enough to lengthen the caudal septum in short noses with over rotated nasal tip; third, the risk of deforming the external ear; finally, that aging makes ear cartilage brittle and of poor quality.[22,23,27,29–32]

Many techniques have been proposed to make the curved weak ear cartilage straighter and stronger, in order to be used to support the tip, including doubling its thickness by folding it over[11]; adding a strip of perpendicular plate of ethmoid, making a composite bony-cartilaginous graft[30]; using contour-modifying sutures[33,34]; and assembling the ear cartilage in different shapes, to increase its strength, as pea-pod shaped,[35] seagull-shaped,[12] butterfly-shaped,[8] cylinder-shaped,[36] or *M*-shaped graft.[37]

In the current study, the caudal distal part of the extension graft was folded on itself and sutured in a back-to-back fashion to create a strong and straight double-layered graft which, when fixed to the medial crura, provided strong support to the nasal tip which maintained an adequate degree of projection throughout our long-term follow-up that extended to over 17 years (►**Fig. 7**). This is in accordance with many previous studies that found layering of ear cartilage to provide excellent tip support.[3,8,9,11,14,15,34,36–44]

The second criticism about the size of ear cartilage being insufficient to lengthen short noses has been based on the fact that, in all previously described ear cartilage CSE grafts,[9,11,34,37–44] the whole conchal cartilage was folded on itself and fixed to the caudal septum making its width inadequate to lengthen short noses. Furthermore, folding the whole conchal cartilage on itself and fixing it to the caudal septum, may by itself, result in over rotation which made surgeons combine it with supratip suturing and grafting to

Fig. 7 Preoperative views (**A, C**) of a revision patient with a large pollybeak and a depressed underprojected nasal tip which is wide and ill-defined. Postoperative views (**B, D**) of the same patient 15 years after restructuring the nasal tip using an ear cartilage CSEG which improved tip the support, projection, and definition. (Courtesy of Hossam M.T. Foda, MD, Alexandria, Egypt).

decrease the risk of over rotation. This drawback was overcome in the design of our CSEG as the folding was limited to the distal (caudal) 3 to 4 mm only thus maximizing the width of the final graft, that measured 1.6 to 2.1 cm, which is wide enough to provide adequate lengthening of most short noses (►**Fig. 8**). Additional nasal lengthening can be achieved by using the oblique fixation technique and adding a splinting graft that inclines the CSEG downwards to derotate the tip and provide it with the strength needed to counteract cephalic rotation forces resulting from increasing the tip projection as well as from the wound healing process and skin flap contracture.

Regarding the risk of deforming the external ear, no ear deformations were encountered in any of our cases as utmost care was taken during cartilage excision to leave the anterior perichondrium adherent to the skin (to prevent scarring and contracture) and to preserve the antihelical fold and the root of the helix intact to avoid excessive medialization of auricle. No hematomas were encountered due to meticulous hemostasis, use of a compressive mastoid-type dressing for 48 hours, and leaving the lower 3 to 4 mm of the

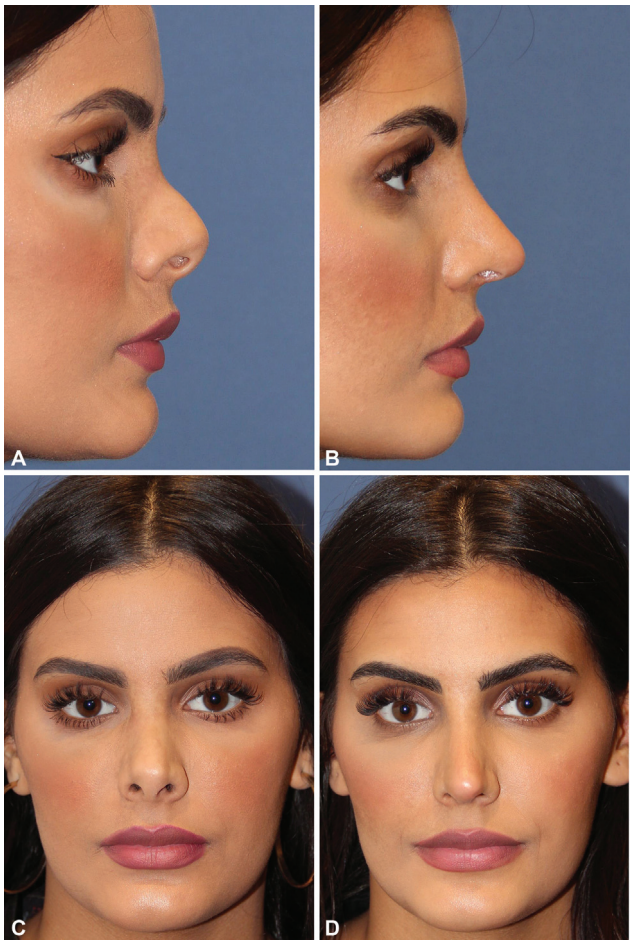

Fig. 8 Preoperative views (**A, C**) of a revision patient with a very short nose, over-rotated nasal tip, and excessive nostril show. Two-year postoperative views (**B, D**) of the same patient after using an ear cartilage CSEG which was obliquely fixed to the caudal septum to provide maximum inferior rotation and nasal lengthening. (Courtesy of Hossam M.T. Foda, MD, Alexandria, Egypt).

postauricular incision open to act as a drain. This rent in the postauricular incision helped to evacuate seromas, that developed in nine cases, without needing any aspiration or surgical intervention. No patient's complained about the conchal cartilage harvest scar as it was well-hidden on the back of the ear in the posterior approach and in the shadow of antihelix in the anterior approach.

The last criticism is that ear cartilage gets brittle with aging thus limiting its use in older patients. Our experience in using ear cartilage, for over 30 years, is in total contrast with that common belief, this is supported by recent histologic studies which found that auricular cartilage, with aging, maintained a higher cell density and more stable glycosaminoglycans content than the septal cartilage which makes it less susceptible to age-related cartilage degradation.[45]

The use of CSEG, although not specifically aimed at airway improvement, was associated with an improvement in breathing evidenced by the significant reduction in both the NOSE and SCHNOS-O scores. This may be contributed to the increased midline structural support and stability and increased tension across the alar lobule. However, identifying the sole effect of CSEG on nasal airway would be difficult to perform in any clinical study because nasal airway obstruction is multifactorial and occurs at numerous levels, beside the fact that many other airway improvement maneuvers are usually performed simultaneously.

Aesthetically, using the CSEG was associated with an aesthetic improvement in all cases as evidenced by the significant postoperative improvement in the SCHNOS-C scores reported ($p < 0.0001$) and by the subjective improvement in nasal tip projection, rotation, definition, and symmetry which was reported by three independent reviewers on comparing the patients' pre- and postoperative photos (►**Figs. 7–9**).

The main drawback of any CSEG is nasal tip stiffness which is due to two main factors, the first is the physical characteristics of the graft material used and the second is the fixation of CSEG and columella to the CS. Regarding physical characteristics, the conchal cartilage possesses a degree of elasticity that makes it more soft and flexible than the rib or even the septum, this is in accordance with

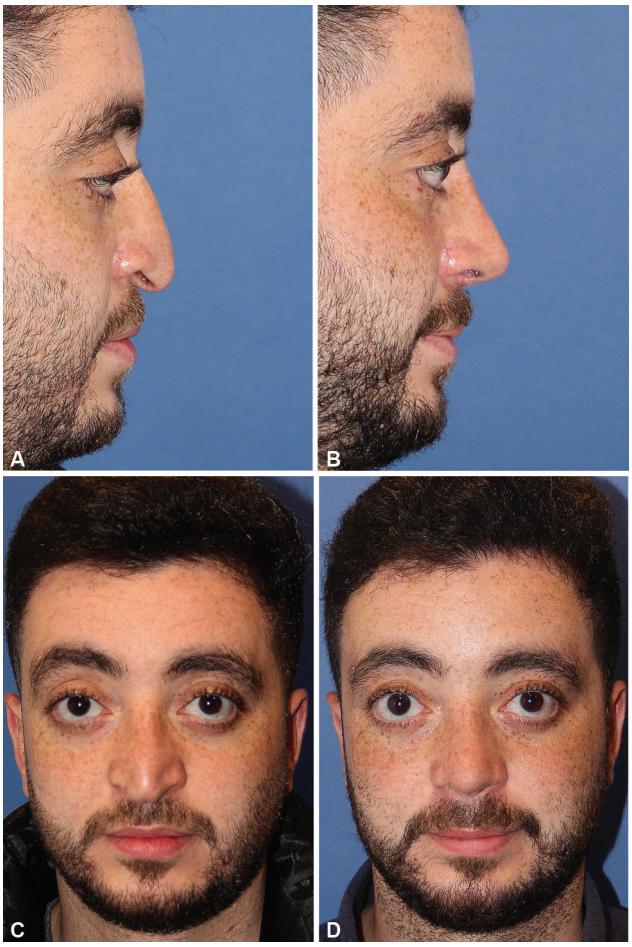

Fig. 9 Preoperative views (**A, C**) of a patient with caudal septum deficiency, following a septal abscess, which resulted in total loss of tip support, depressed droopy nasal tip, premaxillary deficiency, and a very acute nasolabial angle. Postoperative views (**B, D**) of the same patient after using an ear cartilage CSEG to support, project, and superiorly rotate the nasal tip. (Courtesy of Hossam M.T. Foda, MD, Alexandria, Egypt).

cartilage studies that showed ear cartilage to have similar degree of stiffness as that of tip cartilages.[7] Moreover, the design of our CSEG, allowed the fixation to be done between the caudal septum and the single-layered part of the CSEG which is less rigid than septal cartilage thus allowing for more tip mobility especially on the side-to-side movement.

Conclusion

The use of our proposed ear cartilage CSEG was associated with a significant aesthetic and functional improvement. There are several advantages to using this graft. First, the ear CSEG can provide adequate tensile strength while maintaining a degree of flexibility and elasticity which closely resembles that of the tip cartilages thus resulting in the most natural feel of the nasal tip lobule. Second, the side-to-side fixation is easier and more stable than the end-to-end fixation. Third, the graft design allows it to be fixed to either sides of the caudal septum while keeping the distal double-layered segment in the midline, thus eliminating the risk of columellar and/or tip deflection associated with the side-to-side fixation. Fourth, the unique graft design assures efficient utilization of ear cartilage as in all cases only one ear was enough to provide tip support, projection, and up to 2 cm of nasal lengthening. Fifth, the technique is easy to use, has a low complication risk, and results in predictable long-term improvement.

Conflict of Interest
None declared.

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