Reconstructive Rhinoplasty Using Multiplanar Carved Costal Cartilage

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IMPORTANCE Reconstructive rhinoplasty often requires the use of cartilage grafts. Full-thickness autologous costal cartilage grafts provide a large amount of cartilage in a single uncarved block and are often used for major reconstructions. Warping is frequently described as a complication of rib cartilage use in rhinoplasty.

OBJECTIVE To describe an approach to cartilage carving whereby a single block of cartilage is carved in a multiplanar manner to mimic or redefine the anatomic relationships and resist warping.

DESIGN, SETTING, AND PARTICIPANTS A retrospective review of reconstructive rhinoplasty cases using multiplanar costal cartilage grafting technique was performed. A consecutive sample of 11 patients with complex nasal deformity underwent reconstruction with an autologous costal cartilage block carved in 3 dimensions to address complex deformities at the University of New Mexico Hospital between January 2010 and December 2014. The follow-up period ranged from 3 to 36 months.

INTERVENTIONS Autologous rib cartilage harvest was performed to obtain a full-thickness segment of rib cartilage. The deficient or malformed nasal cartilage is defined and soft tissue prepared using an open rhinoplasty approach. Rib cartilage graft curvature is removed to create a uniform, symmetric, solid block of cartilage. A cartilage graft is carved in a multiplanar fashion to simulate normal nasal anatomy.

MAIN OUTCOMES AND MEASURES Postoperative evaluation of nasal airway function, cartilage graft warping, and aesthetic outcomes were reported in the follow-up period. Nasal Obstructive Symptom Evaluation (NOSE) scores are documented in the majority of cases and were obtained at least 3 months postoperatively.

RESULTS Overall, 11 patients with complex nasal deformity underwent reconstruction with an autologous costal cartilage block carved in 3 dimensions. The most common use was for reconstruction of the septum with the upper lateral cartilage. There were no major complications. No patients experienced graft warping in the follow-up period. Several patients required minor revision procedures. All patients reported improved nasal airway and improved aesthetic appearance of the nose.

CONCLUSIONS AND RELEVANCE Multiplanar costal cartilage grafting is a useful surgical technique for complex reconstructive rhinoplasty that yields optimal and predictable results.

LEVEL OF EVIDENCE 4.
Reconstructive rhinoplasty after traumatic, congenital, or postsurgical deformity often requires the use of cartilage grafts. Full-thickness autologous costal cartilage grafts provide a large amount of cartilage in a single uncarved block. We describe an approach to cartilage carving whereby a single block of cartilage is carved in a multiplanar manner to mimic or redefine the anatomical relationships. This technique is particularly useful when anatomical junction zones, such as the septum and upper lateral cartilage, are notably deformed, absent, or structurally deficient. The use of a single cartilage block carved in multiple planes allows for a 3-dimensional reconstruction with decreased reliance on suture fixation to maintain the required angular relationships and resist warping.

Methods
Institutional review board approval was obtained prior to initiating this study. A retrospective review of a consecutive sample of reconstructive rhinoplasty cases using multiplanar costal cartilage grafting technique was performed at the University of New Mexico Hospital. Nasal Obstructive Symptom Evaluation (NOSE) scores are documented in the majority of cases. Postoperative NOSE scores are obtained at least 3 months postoperatively.

Technique
A 3 to 5 cm incision is made on the right chest overlying rib level 8 or 9 in men to place the incision low and more lateral along the rib margin, or level 5 or 6 in women to place the incision in the inframammary crease. A full-thickness segment of rib cartilage is harvested sharply as shown (Figure 1) and submerged in a saline bath. The chest incision is then filled with saline during ventilation and a Valsalva maneuver is performed to confirm that no pleural leak is present. The rib cartilage donor site is then closed in multiple layers. In most cases requiring significant reconstruction, an open rhinoplasty approach is used to access the middle vault and remaining septum. The deficient or malformed anatomy is defined, and the dimensions are transferred to the cartilage block. How the cartilage is carved depends largely on what nasal anatomy is being replaced. For an internal nasal valve reconstruction with septum and upper lateral cartilage components, the superior or inferior edge of the costal graft will become the dorsal aspect, taking advantage of the height of the rib for the septal replacement segment of the graft. If there is significant warping or natural bend to the rib in the axial plane, this is removed prior to anatomical carving. The rib graft curvature is removed by direct excision to create a uniform, symmetrical, solid block of cartilage. Once the most uniform surface is chosen for the best dorsal component, the septum component is made by successively removing cartilage from either side, working from inferior to dorsal and medial to lateral making sure to preserve the connection between the neoseptum and neodorsum/

Figure 1. Creating the Multiplanar Costal Cartilage Graft

A, A full-thickness segment of rib cartilage is harvested, and (B) the autologous costal cartilage block carved in 3 dimensions. C, After completed, the construct will be submerged in a saline bath.

Figure 2. Clinical Images and Placement of Multiplanar Costal Cartilage Graft

A, Lateral view of cartilage graft
B, Anterior view of cartilage graft
C, Intraoperative placement of the graft

A and B, Photographs of the lateral view and anterior view of the constructed cartilage graft. C, Photograph of the intraoperative placement of the cartilage graft.
upper lateral cartilage. Carving of the cartilage block is performed using a series of standard surgical blades and gouges. A punch biopsy can be used as a gauge. Any remaining perichondrium is removed. Care is taken to simulate normal nasal anatomy by carving the single solid cartilage graft in multiple planes (Figure 1, B and C). Cartilage fragments removed from the graft should be preserved in saline until completion of the case, as additional cartilage grafts are necessary in some cases. Photographs of a carved multiplanar cartilage graft is shown in Figure 2A. Intraoperative placement of the graft is shown in Figures 2C and 3B, and preoperative and postoperative photographs are shown in Figures 3 and 4.

Results

Eleven patients with complex nasal deformities underwent reconstruction with an autologous costal cartilage block carved in 3 dimensions to address complex deformities by the senior author (MJN) between January 2010 and December 2014. The most common use was for reconstruction of the septum with upper lateral cartilage. There were no major complications. The follow-up period ranged from 3 to 36 months. One patient experienced a mild contour deformity at the junction of the graft with the nasal bone that required a
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Table. Multiplanar Costal Cartilage Graft for Nasal Reconstruction

<table>
<thead>
<tr>
<th>Patient No./Sex</th>
<th>Etiology</th>
<th>Anatomic Defect</th>
<th>NOSE Score</th>
<th>Postoperative</th>
<th>Detail</th>
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</thead>
<tbody>
<tr>
<td>1/M</td>
<td>Trauma</td>
<td>Tip, caudal septum, LLC</td>
<td>80</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2/M</td>
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<td>ULC, septum, dorsum</td>
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<td>NA</td>
</tr>
<tr>
<td>3/F</td>
<td>Cleft nasal Deformity</td>
<td>Tip, caudal septum, septal Perforation</td>
<td>100</td>
<td>55</td>
<td>Postoperative Injury</td>
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<td>4/M</td>
<td>Trauma, iatrogenic</td>
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<td>10</td>
<td>Perforation remaining</td>
</tr>
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<td>9/M</td>
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<tr>
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<tr>
<td>11/M</td>
<td>Trauma</td>
<td>Tip, caudal septum, septal perforation</td>
<td>100</td>
<td>20</td>
<td>NA</td>
</tr>
</tbody>
</table>

Abbreviation: LLC, lower lateral cartilage. NOSE, Nasal Obstructive Symptom Evaluation Instrument scores; ULC, upper lateral cartilage.

Discussion

Complex nasal reconstruction can be challenging. It is widely reported that rib grafts provide necessary autologous cartilage.²⁻⁹ Use of costal cartilage includes carving traditional rhinoplasty grafts, such as dorsal onlay, spreader, or septal extension grafts.³⁻⁶,⁸⁻⁹ The possibility of warping is the major deterrent to the use of costal cartilage despite low rates of infection or extrusion. Warping is often considered the most common complication of rib cartilage use in rhinoplasty.¹¹ Use of a chimeric autologous costal cartilage graft is reported by Hsiao et al¹² and describes a combination of bone and cartilage to construct a single dorsal onlay graft to prevent cartilage warping. Billent and Kilinc⁷ report 9 patients using a 3-dimensional dorsal graft that allows a groove for the septum and bony vault, yet the septum is still reconstructed with a separate graft. We report using a similar concept to replace as much anatomical defect as can be accomplished with a single graft. In the report by Billent and Kilinc, they postulate the 3-dimensional shapes allow the graft to have a larger interface with surrounding and underlying tissue, helping to resist displacement and warping.⁷ We postulate that the act of carving in multiple planes creates counter forces of torsion to resist warping, leaving a greater amount of the original supportive structure of the rib intact. Gibson and Davis¹⁰ described this concept in 1958, showing the tensional forces in costal cartilage reaching equilibrium across a fulcrum. The multiple planes needed in nasal reconstruction when the septum is included generally allow for carving planes to meet at right angles. It is our theory and experience that warping is most likely to occur perpendicular to the flat plane of a traditional graft. Therefore, if a strut of cartilage is maintained in the perpendicular plane it sustains an intrinsic resistant force to prevent the warping. The resistance is provided by the intrinsic tensile strength of the cartilage itself. This leaves a perpendicular force to prevent warping in any given plane. Farkas et al² show that costal cartilage will warp regardless of the plane in which it is harvested, yet they did not evaluate warping when multiple planes remain intact. Further biomechanical studies are needed to confirm this concept.

Conclusions

Multiplanar costal cartilage grafting is a useful surgical technique for complex reconstructive rhinoplasty that yields functional and predictable results.
Acquisition, analysis, or interpretation of data: Nuara, Loch.

Drafting of the manuscript: Nuara, Loch, Saxon.

Critical revision of the manuscript for important intellectual content: Nuara, Loch.

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Additional Information: Drs Saxon and Nuara designed the images in Figure 1 and were previously affiliated with the Division of Otolaryngology–Head and Neck Surgery, University of New Mexico, Albuquerque, New Mexico.

REFERENCES