Dorsal Augmentation with Autogenous Rib Cartilage

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ABSTRACT

Reconstruction of the nasal osseocartilaginous framework is the foundation of successful primary and secondary rhinoplasty. When adequate septal cartilage is unavailable, the rib provides the most abundant source of cartilage for graft fabrication and is the most reliable when structural support is needed. We present the senior author's (J.P.G.) experience and evolution of techniques of dorsal augmentation with autogenous rib cartilage grafts with internal K-wire stabilization in rhinoplasty.

KEYWORDS: Rhinoplasty, secondary rhinoplasty, augmentation, graft, rib cartilage

Reconstruction of the nasal osseocartilaginous framework is the foundation of successful primary and secondary rhinoplasty. Although septal cartilage is the preferred grafting material in rhinoplasty, severe deformities or a paucity of available septal cartilage requires alternative sources of grafting material. This is particularly true in secondary rhinoplasty when structural deformities of the nasal dorsum result from previous procedures.^{1,2} These structural deformities often necessitate dorsal augmentation, which can require large quantities of grafting material.^{3,4}

Satisfactory and consistent long-term results rely on using grafts with low resorption rates and sufficient strength to offer adequate support.⁴⁻⁷ There are five potential donor sites for autogenous dorsal onlay grafts in rhinoplasty: septal cartilage, auricular cartilage, rib cartilage, iliac bone, and calvarial bone. Although initial results of dorsal augmentation with auricular cartilage are often satisfactory, surface irregularities can become apparent with the passage of time. Furthermore, the irregular contour and limited supply of auricular cartilage often preclude its use. Bone onlay grafts are difficult to shape and often undergo an unpredictable degree of absorption

by the surrounding tissues^{8,9} and are, therefore, reserved for more severe nasal deformities when other graft materials are deemed unsatisfactory.

Autogenous rib cartilage has been our graft material of choice for dorsal augmentation when sufficient septal cartilage is not available. The rib provides the most abundant source of cartilage for graft fabrication and is the most reliable when structural support is needed.^{10,11} We present the senior author's (J.P.G.) experience and evolution of techniques of dorsal augmentation with autogenous rib cartilage grafting with internal K-wire stabilization in rhinoplasty.

METHODS

Rib Harvest Technique

Rib cartilage harvesting is preferentially performed on the patient's left side to facilitate a two-team approach. Marking is initiated by palpating the sternomanubrial joint, which indicates the position of the second rib. The ribs are then palpated and numbered according to their position.

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The choice of rib to harvest depends on the planned use because the amount of cartilage required dictates whether the cartilaginous segment from one rib, one rib and a portion of another, or the entire cartilage segments of two ribs need to be harvested. In general, the surgeon should choose the cartilaginous portion of a rib that provides a straight segment as it is often possible to construct all required grafts from a single rib. For augmentation with dorsal onlay grafts, we harvest the cartilage from the fifth, sixth, or, on occasion, the seventh rib, depending on which rib feels the longest and straightest. If additional grafts are needed, a part or the entire cartilaginous portion of an adjacent rib may be harvested.

In female patients, the incision is marked ~5 mm above the inframammary fold and measures 5 cm in length. The incision should not extend beyond the medial extent of the inframammary fold. This avoids postoperative visibility of the incision if the patient wears low-cut clothing. In males, placement of the incision is not as important unless there is a hair-bearing area in which the incision can be camouflaged. If not, the incision is usually placed directly over the chosen rib to facilitate the dissection.

The skin is incised with a scalpel, and the subcutaneous tissue is divided with electrocautery. Once the muscle fascia has been reached, the surgeon palpates the underlying ribs and divides the muscle and fascia with electrocautery directly over the chosen rib. The dissection should be carried medially until the junction of the rib cartilage and sternum can be palpated. The most lateral extent of the dissection is demarcated by the costochondral junction. Identification of the junction is facilitated by the subtle change in color at the interface; the cartilaginous portion is generally off-white in color, whereas the bone demonstrates a distinct reddish-gray hue. In older patients, the cartilage tends to be more yellow and friable often with focal calcifications. To ensure the position of the lateral bony-cartilaginous junction, the sharp point of the Bovie needle is pressed against the anterior surface of the rib. It will easily penetrate into cartilage but not bone.

After exposing the selected rib, a longitudinal incision is made through the perichondrium along the length of the central axis of the rib. Perpendicular cuts are also made at the most medial and lateral aspects of the cartilaginous rib to facilitate reflection of the perichondrium.

A Dingman elevator is then used to elevate the perichondrium superiorly and inferiorly from the cartilaginous rib. The subperichondrial dissection is then continued circumferentially along the length of the cartilaginous portion of the rib until the posterior aspect of the rib is exposed. During elevation, the perichondrium may become tight and limit further dissection. If this occurs, it is useful to perform additional perpendic-

ular "back-cuts" on the anterior surface of the perichondrial flap to release tension. Perichondrial elevators are then employed to release the posterior adherence between the cartilage and perichondrium as far as possible. A curved rib stripper completes the posterior dissection. We have found it useful to pass the tip of the rib stripper with gentle upward force to stay within the subperichondrial space. However, care must be taken to not enter the body of the cartilaginous rib or cause a fracture, which may limit graft fabrication.

The remainder of the subperichondrial dissection is generally straightforward and bloodless as long as the perichondrium is not violated and the correct plane is maintained. The curved rib stripper is slid back and forth along the rib taking care to stay between the cartilage and perichondrium until the undermining is complete. Perichondrial tears should be avoided so that a tight postoperative closure can later be accomplished to help "splint" the wound, which aids in relieving postoperative pain.

The final step involves separating the cartilaginous rib from its medial attachment near the sternum and laterally at the bony rib. This is performed by making a partial-thickness incision perpendicular to the long axis of the rib using a no. 15 blade at the aforementioned junctions. The cartilaginous incision can then be completed with the sharp end of a Freer elevator using gentle side-to-side movement. Once the cartilage segment is released both medially and laterally, the graft is easily removed from the wound and placed in sterile saline with gentamicin (50 mg/500 mL) until the surgeon is ready for fabrication. If more grafting material is required, a portion of cartilage or the entire cartilaginous part of another rib should then be harvested. After choosing an adjacent donor rib, access to the perichondrium is obtained by undermining deep to the existing muscle to avoid an additional incision through the fascia and muscle. This prevents the creation of a "bridge" of denervated and devascularized muscle between adjacent ribs, which may result in delayed healing at the donor site. The adjacent rib is then harvested in a similar fashion.

After hemostasis is achieved, the donor site is checked to ensure that no pneumothorax has occurred. The wound is filled with saline solution and the anesthesiologist applies positive pressure into the lungs. If no air leak is detected, a pneumothorax can be excluded. A 16-gauge Angiocath (Becton, Dickinson and Company, Franklin Lakes, NJ) catheter is inserted through the skin and placed in the subperichondrial space to allow instillation of a long-acting local anesthetic at the conclusion of the procedure. The wound may then be closed in layers using 2-0 Vicryl (Ethicon, Somerville, NJ) sutures. Particular attention should be directed at reapproximating the perichondrium. It is important to close the perichondrium, muscle, and muscle fascia layers

tightly to prevent a palpable or visible chest wall deformity. A tight closure also helps “splint” the wound and reduce postoperative pain. Skin closure is performed using deep dermal and subcuticular 4-0 Monocryl (Ethicon, Somerville, NJ) sutures.

Recipient Site Preparation

Prior to graft preparation, the dorsum of the nose must be prepared to receive the dorsal graft. The recipient bed on the dorsum must be made as flat and smooth as possible to give the greatest surface area for the dorsal onlay graft to contact. The dorsal septum and upper lateral cartilages are trimmed with a no. 15 blade or angled scissors, and any contour irregularities of the bony dorsum are removed with a rasp or a drill with a diamond burr. A uniform surface of the dorsal recipient bed aids in the graft adhering solidly to the osseocartilaginous framework. This prevents postoperative movement of the graft after healing is complete, as is often seen in grafts placed in soft tissue envelopes. Soft tissue irregularities and scar tissue also should be judiciously removed from the undersurface of the soft tissue envelope to prevent overlying irregularities.

Frequently in secondary rhinoplasty, the dorsum has been overresected and the septal “L-strut” weakened. In these circumstances, dorsal spreader grafts should be placed along either side of the septum to provide a stable platform for the dorsal onlay graft. The spreader grafts should be secured with horizontal mattress sutures at the same level as the septum and extend from the keystone area to the septal angle. Spreader grafts are also used to widen a narrow dorsum when necessary in preparation for receiving the dorsal onlay graft. If the nasal bones are too narrow, medial osteotomies are performed and the spreader grafts extended cephalad.

To prepare for placement of the columellar strut sizer, a pocket is dissected between the medial crura to expose the nasal spine, which is removed with a rongeur. A drill with a 1.0-mm wire passer bit is used to place a 1.0-mm drill hole just lateral to the maxillary midline. This avoids damage to the incisive foramen. The hole is drilled to a depth of 11 to 12 mm and lays parallel to and 2 to 3 mm inferior to the nasal floor. After drilling this hole, a smooth 0.028-inch K-wire is placed in the drill hole to make certain that it is contained in the bone of the palate and did not perforate intraorally or intranasally. If it did, a new drill hole is placed on the opposite side of the midline of the maxilla.

Graft Preparation

Before carving of the grafts is begun, silicone sizers are used to estimate the shape and size of the needed grafts (Fig. 1). The silicone sizers are prefabricated by the surgeon. Molds of anatomically shaped dorsal onlay

Figure 1 Prefabricated silicone dorsal sizers.

grafts and columellar struts are carved in a paraffin wax block in an assortment of shapes and sizes. RTV (room temperature vulcanizing) silicone is mixed and poured into the molds and left for 24 hours to polymerize before trimming to the final forms.

After preparation for placement of the columellar strut graft and the dorsal onlay graft, various columellar sizers are placed in the maxillary drill hole, and the appropriate length sizer is selected. With the columellar sizer in place, various dorsal sizers are then placed on the dorsum and the skin redraped until the desired combination is determined.

The major disadvantage in using rib cartilage is its tendency to warp. In response to this, the senior author (J.P.G.) devised a technique in which the larger grafts, the dorsal onlay graft and the columellar strut, are reinforced with a centrally placed K-wire to decrease warping and provide a more stable and predictable result.¹²

The harvested rib segment that is selected for the dorsal onlay graft is manually stabilized in a specifically designed K-wire guide jig, and a smooth 0.028-inch K-wire is drilled longitudinally through the center of the graft (Fig. 2). The 0.028-inch K-wire is removed and

Figure 2 Harvested rib segment is stabilized in jig while an 0.028-inch K-wire is drilled longitudinally through the center of the graft.

Figure 3 The cartilage grafts with the internal K-wires are then carved to the same dimensions as the selected silicone sizers.

replaced with a threaded 0.035-inch K-wire to better stabilize the graft and avoid migration of the K-wire. The same routine is used for placing the internal K-wire in the columellar strut.

The cartilage grafts with the internal K-wires are then carved into similar but slightly larger shapes of the selected sizes (Fig. 3). The K-wire in the dorsal onlay graft should be placed to within 2 to 3 mm of the cephalic end of the graft and cut flush with the caudal end. The K-wire in the columellar strut should extend three-quarters of the length of the graft with 8 to 10 mm of the K-wire left exposed at the graft base, which will be seated into the drill hole created in the maxilla.

The grafts are then placed in their anatomic position to see what further shaping is required. Carving proceeds carefully from this point usually by scraping the grafts with the sharp edge of a no. 10 blade perpendicular to the graft surface until the exact desired size, shape, and contour is obtained. After the carving is completed, the K-wire placement can be adjusted if indicated.

Placement of and Securing the Graft

Next, the dorsal onlay graft is placed and secured. Fixation of the cephalic end of the dorsal graft is achieved with a smooth 0.028-inch K-wire placed percutaneously through the graft into the nasal root (Fig. 4). This percutaneous K-wire is removed in the office with a wire twister 1 week postoperatively when the external splint is removed. Caudally, the graft is secured to the nasal dorsum by a suture that passes around or through the graft and through the upper lateral cartilages and nasal septum-spreader graft complex in the area of the septal angle. Any remaining tip work is then completed as well as indicated osteotomies, if not previously performed.

The dorsal onlay and columellar strut grafts are not connected. A distance of 3 to 4 mm is left between

Figure 4 Dorsal onlay graft with cephalic fixation with a percutaneous K-wire and caudal fixation with a suture placed through the septum-spreader graft complex near the septal angle. Columellar strut with internal K-wire is placed in maxillary drill hole.

the caudal end of the dorsal onlay graft and the columellar strut to allow a small amount of movement when upward or side-to-side pressure is placed on the tip. It should also be noted that internally stabilized dorsal onlay grafts and columellar struts are not always performed in combination if only one is needed.

CASE ANALYSES

Case 1: Nasal Reconstruction

A 30-year-old woman with a history of cocaine abuse complained of bilateral breathing problems and dissatisfaction with her nasal appearance.

Preoperative views (Figs. 5 and 6, left) demonstrate severe collapse of the cartilaginous portion of her nose. Her nasal tip is markedly deformed with an asymmetric configuration and increased rotation. Internal examination revealed a large nasal septal perforation and internal nasal valve collapse bilaterally.

Cartilage grafts were obtained from her left fifth and sixth ribs, and an open rhinoplasty was performed (Fig. 7). Silicone columellar and dorsal sizers were placed in their respective locations to determine the adequate dorsum-tip relationship. An anatomically contoured dorsal onlay rib graft was internally stabilized with an 0.035-inch threaded K-wire and used to augment the dorsum. The dorsal onlay graft was fixated superiorly with a smooth 0.028-inch K-wire percutaneously through the graft and into the nasal root. Inferiorly, the upper lateral cartilages were fixed to the sides of the graft with 5-0 Vicryl suture to open the nasal valves further. The patient's tip was reconstructed with a columellar strut with internal 0.035-inch threaded K-wire and lateral crural strut grafts of rib cartilage placed beneath the remaining lateral crura. Bilateral

Figure 5 Case 1. (Left) Preoperative views. (Right) Postoperative views.

Figure 6 Case 1. (Left) Preoperative views. (Right) Postoperative views.

alar contour grafts were placed in subcutaneous pockets above the alar rim.

The postoperative photographs (Figs. 5 and 6, right) show the appearance 18 months after surgery.

Case 2: Secondary Rhinoplasty

A 14-year-old girl with a history of one prior nasal surgery after nasal trauma as a young child desired surgical correction of her breathing problems and an improvement in the appearance of her nose.

Preoperative views (Figs. 8 and 9, left) demonstrate marked shortening of her nose with saddling of the dorsum. Her nasal tip has decreased projection and increased rotation, an excess of nostril show, and a retracted columellar-labial angle (Fig. 10). Intranasal exam revealed no significant septal deviation or valve collapse.

Cartilage grafts were obtained from her left fifth rib, and an open rhinoplasty was performed in addition to suction-assisted lipectomy of the cheeks and neck and mentoplasty. Silastic columellar and dorsal sizers were placed in their respective locations to determine the adequate dorsal-tip relationship. An anatomically contoured dorsal onlay rib graft, measuring $6 \times 8 \times 40$ mm and internally stabilized with an 0.035-inch threaded K-wire, was used to augment the dorsum. The dorsal onlay graft was fixated superiorly with a smooth 0.028-inch K-wire placed percutaneously through the graft and into the nasal root. An 0.035-inch threaded K-wire was placed through the center of the carved columellar to stabilize the nasal tip. Bilateral alar contour grafts were placed in subcutaneous pockets above the alar rim and sutured to the columellar strut.

The postoperative photographs (Figs. 8 and 9, right) show the appearance 1 year after surgery.

Case 3: Posttraumatic Nasal Deformity

A 16-year-old girl with one prior nasal reconstruction 1 year previously, after facial trauma resulting in an open comminuted nasal septal and multiple maxillary fractures, complained of breathing difficulty through her nose and dissatisfaction with her nasal appearance.

Preoperative views (Figs. 11 and 12, left) demonstrate a dorsal saddle deformity with collapse of her upper lateral cartilages bilaterally. Her nasal tip has a boxy configuration with increased rotation, decreased columellar show, and retraction of the columellar-labial angle (Fig. 13). Internal examination showed septal deviation and internal nasal valve narrowing.

Cartilage grafts were obtained from her left sixth and seventh ribs, and an open rhinoplasty was performed. The bony dorsum was rasped, and the cartilaginous dorsum was trimmed to prepare for the dorsal onlay graft. Medial osteotomies were performed, and the nasal bones were outfractured to widen the bony base.

Bilateral spreader grafts of autogenous rib cartilage were sutured to either side of the dorsal septum to open the internal nasal valve and provide a stable platform for the dorsal onlay graft. A pocket was dissected between the medial crura extending to the nasal spine, which was removed with a rongeur. A drill hole ~ 12 mm deep and parallel to the nasal floor was placed just to the right of the nasal spine. Silastic columellar and dorsal sizers were placed in their respective locations to determine the adequate dorsal-tip relationship. An anatomically contoured dorsal onlay rib graft, measuring $6 \times 9 \times 40$ mm and internally stabilized with an 0.035-inch threaded K-wire, was used to augment the dorsum. The dorsal onlay graft was fixated superiorly with a smooth 0.028-inch K-wire placed percutaneously through the graft and into the nasal root. Inferiorly, the upper lateral cartilages were fixed to the sides of the graft with 5-0 Vicryl suture to open the nasal valves further. An 0.035-inch threaded K-wire was placed through the center of the carved columellar strut to within 5 to 6 mm of the tip leaving 10 mm exposed out of the base. The exposed end of the K-wire in the columellar strut was placed in the maxillary drill hole, and the medial crura were sutured into their desired position to the columellar strut. Lateral crural strut grafts of rib cartilage were placed beneath the remaining lateral crura and sutured to the columellar strut.

The postoperative photographs (Figs. 11 and 12, right) show the appearance 10 months after surgery.

DISCUSSION

The rib offers an abundant supply of cartilage for use in virtually every aspect of rhinoplasty and is the preferred donor site when rigid support is necessary. Dorsal augmentation with rib cartilage grafts has proved useful in the secondary rhinoplasty patient. It is also useful in patients with congenital deformities, posttraumatic deformities, or in primary rhinoplasty patients who require a significant amount of dorsal augmentation. The most significant advantage of rib cartilage is that grafts can be produced with considerable versatility with respect to shape, length, and width. This facilitates reconstruction of the nasal framework in patients with virtually all types of functional and aesthetic requirements.

Use of rib cartilage also has several disadvantages. First, an additional incision at a distant donor site is required to harvest the cartilage. Fortunately, the resulting scar is relatively short (~ 5 cm) and is generally inconspicuous in women due to its placement under the breast. Additional concerns include postoperative pain, the risk of pneumothorax, excessive calcification of rib cartilage, and the potential of rib cartilage to warp.

If a pneumothorax has been diagnosed, this usually represents an injury only to the parietal pleura and not to the lung parenchyma itself. As such, this does not mandate chest tube placement. Rather, a red rubber

Figure 7 Graphic representation of intraoperative maneuvers performed in case 1 demonstrating dorsal onlay graft with internal K-wire.

Figure 8 Case 2. (Left) Preoperative views. (Right) Postoperative views.

Figure 9 Case 2. (Left) Preoperative views. (Right) Postoperative views.

Figure 10 Graphic representation of intraoperative maneuvers performed in case 2 demonstrating dorsal onlay graft with internal K-wire stabilization.

Figure 11 Case 3. (Left) Preoperative views. (Right) Postoperative views.

Figure 12 Case 3. (Left) Preoperative views. (Right) Postoperative views.

Figure 13 Graphic representation of intraoperative maneuvers performed in case 3 demonstrating dorsal onlay graft with internal K-wire stabilization.

catheter can be inserted through the parietal pleural tear into the thoracic cavity. The incision should then be closed, as previously described, in layers around the catheter. Positive pressure is then applied, and the catheter is clamped with a hemostat until the surgeon is prepared for removal. At the end of the operation, the anesthesiologist applies maximal positive pressure into the lungs and holds this as the catheter is placed on suction and removed. A postoperative chest x-ray should be taken if there is any concern about the effectiveness of reestablishing negative pressure within the pleural space.

In older patients, ossification of the cartilaginous rib is a significant concern, and a limited computed tomography scan of the sternum and ribs with coronal reconstructions is recommended in those patients where there is a high index of suspicion. Despite appropriate preoperative screening, occasionally patients will present with premature calcification of the cartilaginous rib. Frequently, this is limited and occurs commonly at the junction of the osseous and cartilaginous portions of the rib. Small foci of calcification may also be found within the body of the rib cartilage itself. This can impair the preparation of individual grafts as well as act as a site of weakness often having a tendency to fracture during graft harvest. We have found that the use of a smooth diamond burr can also prove useful in contouring areas of calcification to salvage these uncommon circumstances. If the cartilage is unexpectedly found to be so extensively calcified at the time of the operation that it is unusable, we would then consider the use of irradiated donor cartilage accepting the increased risks of progressive resorption over time. Irradiated homologous rib cartilage has been used successfully,¹³ but problems with infection, absorption, and warping limit its routine use in dorsal augmentation (R.O. Dingman, personal communication, 1980).

Graft warping can occur in autogenous rib cartilage and lead to long-term postoperative distortions of nasal shape. The use of stabilizing K-wires placed through the center of these grafts has been a successful technique to counterbalance the tendency of the grafts to warp. To avoid warping of smaller grafts, we follow the principle of carving balanced cross-sections originally described by Gibson and later substantiated by Kim et al.^{14,15}

Recently, there has been considerable interest in the role of diced cartilage grafts for dorsal augmentation, but controversy exists as to the long-term viability of the diced cartilage and the predictability of molding it into the desired shape.^{16,17} Although diced cartilage may represent a viable means of contour restoration, at present, structural grafting and moderate to large dorsal augmentations are better corrected with a more substantial grafting alternative.

Various types of alloplastic materials have been used for dorsal augmentation including Silastic, high-

density porous polyethylene (Medpor; Portex Surgical, Inc., College Park, GA), and expanded polytetrafluoroethylene (Gore-Tex; W.L. Gore Associates, Flagstaff, AZ). Alloplastic materials have the advantages of being easy to use, readily available, and an unlimited supply. Unfortunately, because of their permanent nature, many of these alloplastic materials are fraught with long-term complications such as infection, migration, extrusion, and palpability.¹⁸⁻²¹ Thus, autogenous tissue continues to be our preferred source of grafts.

CONCLUSION

Reliable, reproducible results of dorsal augmentation can be achieved with autogenous rib cartilage grafting. Our technique has proved useful not only in secondary rhinoplasty but also in primary rhinoplasty and in correcting posttraumatic deformities.

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