

Chimeric Autologous Costal Cartilage Graft to Prevent Warping

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Background: Carved autologous costal cartilage is widely used in different rhinoplasty procedures because of its availability and proven advantages. However, the usefulness of rib grafts is limited by warping postoperatively. The chimeric autologous costal cartilage graft is proposed. “Chimeric” means the combining of two different tissues (bone and cartilage in this case) to make a single dorsal onlay graft.

Methods: From October of 2010 to August of 2013, 31 patients underwent rhinoplasty or nasal reconstruction with costal cartilage graft using the chimeric autologous costal graft method. There were 14 men and 17 women, with ages ranging from 20 to 66 years (average, 33 years). Of the 31 patients, there were 12 with congenital nasal deformities, six with previous nasal trauma, eight with aesthetic rhinoplasty (four with primary rhinoplasty and four with secondary rhinoplasty), and five with nasal deformities after tumor extirpation. Patients’ profiles were documented and photographed. The outcomes were assessed by three plastic surgeons.

Results: Follow-up for all patients was 4 to 30 months (average, 14 months). No cartilage warping was noted during the follow-up period. Two patients suffered from minor infection 2 weeks postoperatively. The average operative time for carving cartilage was 10 minutes. The overall average time of making a chimeric autologous costal onlay graft added approximately 20 minutes to the original method.

Conclusion: From the clinical observation of all patients during the follow-up period, the chimeric autologous costal cartilage graft was shown to be effective for preventing cartilage warping. (*Plast. Reconstr. Surg.* 133: 768e, 2014.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, IV.

The carved autologous costal cartilage graft is becoming one of the most widely used techniques for primary and secondary rhinoplasty procedures. Autologous grafts offer advantages over alloplasts in that they cause lower rates of infection, tissue reaction, and extrusion of the implant; in addition to other considerable advantages over other types of grafts, the tissue feels more natural, it is easy to mold, and it has a low index of resorption. Even for severe reconstructive cases where we need a large quantity of costal cartilage, we have been pleased with the sufficient quantities, ease of carving, and low rate of postoperative resorption.¹⁻³

The usefulness of the costal cartilage is limited by some obstacles, such as donor-site morbidity and warping; where the latter always occurs to some degree. Tissue warping is related directly to the inherent stresses of costal cartilage and may lead to dorsal deviation when used for augmentation purpose.⁴⁻⁶ However, many techniques have

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been proposed to prevent cartilage warping, such as internal stabilization, rasping nasal bone, use of diced cartilage, the “edge-on” technique, dissection of cartilage, and others.⁵⁻⁹

The method proposed here to prevent warping is a chimeric autologous costal cartilage graft, which is based on strengthening the core of the cartilage with a piece of rib bone that is designed and carved to fit in the cartilaginous graft and to give internal stabilization to the whole framework, and according to our experience, it prevents warping significantly. “Chimeric” means the combining of two different tissues (bone and cartilage) to make a single dorsal onlay graft.

PATIENTS AND METHODS

From October of 2010 to August of 2013, 31 patients underwent rhinoplasty or nasal reconstruction with costal cartilage graft using the chimeric autologous costal graft method (Table 1). There were 14 men and 17 women, with ages ranging from 20 to 66 years (average, 33 years). Of the 31 patients, 12 had congenital nasal deformities (10 with cleft lips, one with Crouzon disease, and one with Romberg disease); there were six patient with previous nasal trauma, eight patients with aesthetic rhinoplasty (four with primary rhinoplasty and four with secondary rhinoplasty), and five patients with nasal deformities after tumor extirpation. These patients needed cartilage blocks to rebuild the nasal framework. Only patients who needed dorsal onlay grafts were included in this series. The average length of harvested seventh costal cartilage ranged from 4 to 7 cm. The average length of harvested seventh costal bone ranged from 3.5 to 4.5 cm. In the beginning, in five patients, en bloc costal bone was harvested. After modification, only the anterior surface of costal bone was harvested in the other patients. The average size of the dorsal grafts was 42 × 9 × 4 mm. The average size of the bony internal stabilization was 37 × 5 × 1 mm.

Eight forehead flaps and one free flap were used as skin envelopes after building the cartilage framework because of nasal soft-tissue insufficiency. Patients’ nasal profiles were documented and photographed preoperatively and postoperatively. The rating of warping was classified into three categories, including obvious warping (easily identified by direct inspection), mild warping (identified by measure), and no warping. The first author (Y.-C.H.) and two independent senior plastic surgeons at Chang Gung Memorial Hospital assessed outcomes from photographs at follow-up.

Surgical Technique

Harvest of Costal Cartilage and Bone

The position and shape of the right seventh costal cartilage was confirmed by palpation and was marked. (See Video, Supplemental Digital Content 1, which demonstrates the surgical technique of chimeric autologous costal cartilage grafting, available in the “Related Videos” section of the full-text article on PRSJJournal.com or, for Ovid users, available at <http://links.lww.com/PRS/A1000>.) A 25-gauge needle was used to percutaneously puncture and to identify the osteochondral junction. A 1-cm incision mark was then located at the bony part and a 2-cm incision mark was located at the cartilaginous part, making a 3-cm incision length in total. After skin incision, the underlying fascia and muscle were dissected. Then, care was taken to keep the dissection plane just below the perichondrium and periosteum. After separation of the osteochondral junction, harvesting of needed cartilage was performed. The anterior surface of the costal bone was isolated by osteotomes and followed by middle, upper, and lower osteotomies. Finally, a distal osteotomy was performed. After retrieval of the cartilage and bone, bleeding was checked and signs of pneumothorax were evaluated by pouring normal saline solution into the wound and observing whether there was any air leakage.

Table 1. Patient Demographics

Cause	Case No.	Sex		Average Age (yr)	Average Follow-Up (mo)	Bone Donor Site		Skin Envelope			Fixation		
		M	F			R	I	Original Nasal Skin	Paramedian Forehead Flap	Free Flap	Suture	Lag Screw	Infection
Congenital	12	5	7	28	15	11	1	12	—	—	12	—	1
Traumatic	6	4	2	37	16	6		1	4	1	5	1	—
Following tumor extirpation	5	3	2	54	20	5		1	4	—	3	2	1
Aesthetic rhinoplasty	8	2	6	24	7	6	2	8	—	—	8	—	—

M, male; F, female; R, rib; I, iliac bone.



Video. Supplemental Digital Content 1 demonstrates the surgical technique of chimeric autologous costal cartilage grafting, available in the “Related Videos” section of the full-text article on PRSJournals.com or, for Ovid users, available at <http://links.lww.com/PRS/A1000>.

The wound was closed layer by layer without drain insertion. A catheter was inserted into the subperiosteal and subperichondrial space for postoperative pain control.

Carving the Dorsal Onlay Graft

The desired dorsal augmentation was estimated by the silicone dorsal sizer. The dorsal onlay graft was carved with a no. 11 blade. The graft was carved to the same shape as the silicone sizer. For total nasal reconstruction, the dimensions were 5×10 mm for the Asian male patient

and 4.5×8 mm for the Asian female patient. The edge of the graft was beveled carved (Fig. 1).

Carving the Base of the Dorsal Graft with the Large U-Shape Graver

After carving the estimated dorsal onlay graft, the graft was carved with the large U-shape graver (5 mm). A depth of 1 to 2 mm was carved, depending on the height of the graft (height, $2 - 0.5$ mm; if the desired height of the graft is 5 mm, then $5/2 - 0.5 = 2$ mm). The whole graft's base was carved except for the caudal part (approximately 5 mm) for fixation to the columella strut (Fig. 2).

Carving to the Center of the Dorsal Graft with the Small U-Shape Graver

When the estimated depth was achieved, a 0.5-mm-deep graft carving (the center of the graft) was performed continuously with the small U-shape graver (3 mm) to decrease the amount of cartilage removed and achieve sufficient support bilaterally.

Carving Bilateral Horizontal Grooves with the I-Shape Graver

When the center of the graft was achieved, 1-mm-high bilateral horizontal grooves were carved with the I-shape graver. The depth of the grooves depended on the bilateral cartilage column. At least a 2-mm cartilage column bilaterally should be preserved.

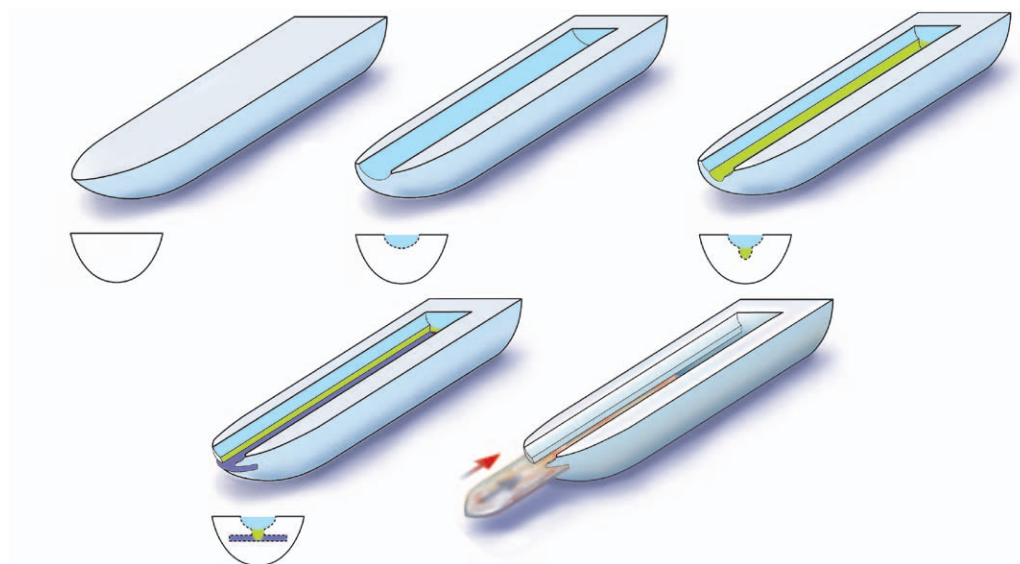


Fig. 1. The surgical technique of chimeric autologous costal cartilage grafting. (Above, left) Carving the dorsal onlay graft. (Above, center) Carving the base of the dorsal graft with the large U-shape graver. (Above, right) Carving to the center of the dorsal graft with the small U-shape graver. (Below, left) Carving bilateral horizontal grooves with the I-shape graver. (Below, right) Insertion of the internal bony stabilization into the cartilaginous dorsal graft.

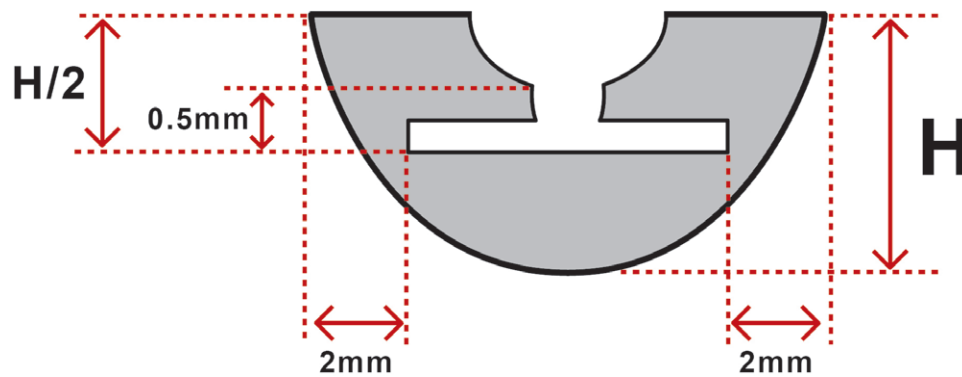


Fig. 2. The design of chimeric autologous costal cartilage graft (cross-section view). The dorsal onlay graft is carved with the large U-shape graver. The depth depends on the height of the graft (height/2 – 0.5 mm). A 0.5-mm-deep graft carving, to the center of the graft, is performed continuously with the small U-shape graver; 1-mm-high bilateral horizontal grooves are carved with the I-shape graver, and at least a 2-mm column bilaterally should be preserved.

Tailoring Internal Bony Stabilization and Removal of Cancellous Bone

Anterior surface costal bone was prepared by removing cancellous bone to obtain pure cortical bone. Then, the bone was tailored to meet the dimensions of the space that was created at the center of the costal cartilage. The thickness was 1 mm to fix the bilateral horizontal grooves.

Insertion of the Internal Bony Stabilization into the Cartilaginous Dorsal Graft

After tailoring the internal bony stabilization, it was inserted precisely to create bilateral grooves. The chimeric autologous costal graft was achieved.

In patients in whom the open rhinoplasty approach was used, the graft was placed in the nasal pocket. The graft's upper pole was placed within the subperiosteal plane, and the lower pole was between the medial crura of the lower lateral cartilage. The nasal bone was rasped to achieve a smooth dorsum. The chimeric dorsal graft was sutured to the septal angle and fixed to the columellar strut. The nasal skin was redraped and the nasal profile was assessed. In nasal reconstruction patients with insufficient soft tissue, the grafts were placed and fixed overlying the reconstructive nasal lining, including the local flap, free flap, or original scar tissue. Then, varied skin cover was placed on the cartilage framework, including free and forehead flaps. In three patients, the dorsal onlay grafts were fixed by means of cantilever lag screws because of unstable nasal lining foundation.

RESULTS

Follow-up for all patients was 4 to 30 months (average, 14 months). The donor site at the right

chest wall was 3 cm in length. Three patients had no scars on the chest wall because cartilage was harvested from the umbilical; thus, an average 3-cm linear scar at the right iliac crest was created. The average operative time of carving cartilage ranged from 10 to 30 minutes (at the very beginning). The average operative time of bony rib harvesting was approximately 10 minutes. There were no associated intraoperative complications, such as uncontrolled bleeding or penetration into the chest cavity. No signs of pneumothorax were detected postoperatively in any of the cases. The investigators judged that all patients belonged to the no-warping category. Two patients suffered from minor infection 2 weeks postoperatively. One was a cleft lip/nose patient and the other had a nasal deformity after tumor extirpation with forehead flap reconstruction. None of them had lag screw fixation for the chimeric autologous costal cartilage. The infections were controlled by débridement and removal of partial infective cartilages.

CASE REPORTS

Case 1

A 25-year-old female patient had a left unilateral cleft lip. She sustained secondary nasal deformity. Preoperative views showed a deviated nose, low tip projection, and flared left ala. The deviated septum was examined intranasally. Cartilage grafts and bone grafts were harvested from the right seventh rib. An open rhinoplasty was performed. Medial and lateral osteotomies were carried out to correct deviated nasal bone. The deviated septum and septal bone were removed. The left lateral crus of the lower lateral cartilage was released completely. Then, cartilage framework including the lateral crural graft, the columella strut, the shield graft, the cap graft, and the 40 × 8 × 4-mm chimeric autologous dorsal onlay graft were placed. In addition, diced cartilage grafts were used to

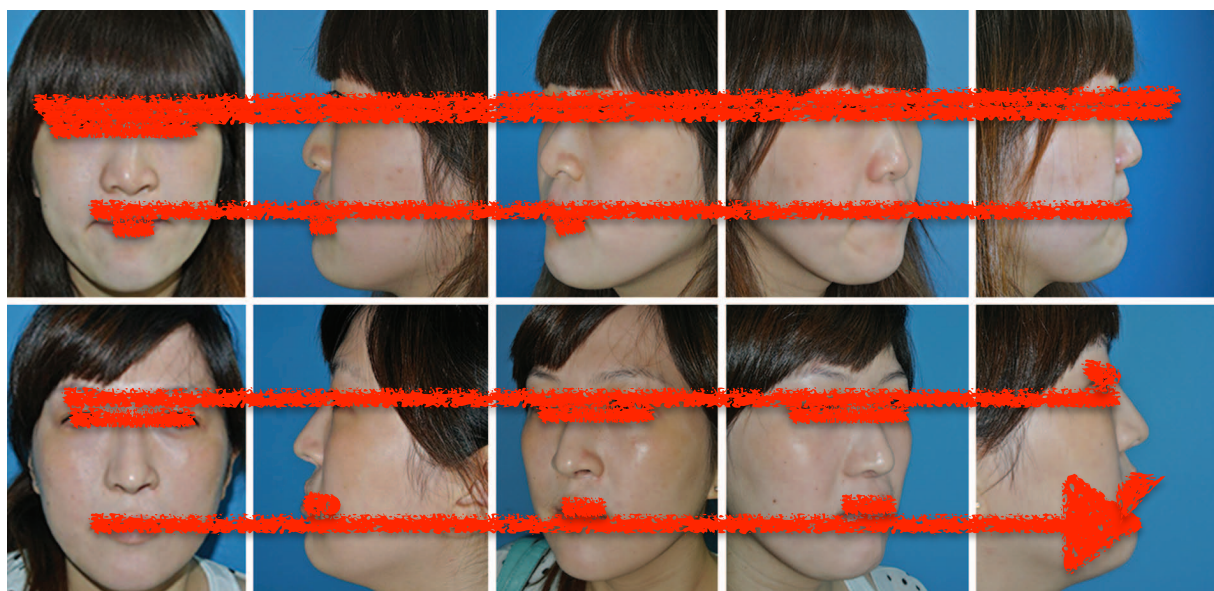


Fig. 3. (Above, left) Preoperative frontal view. (Below, left) Postoperative frontal view after 15 months. (Above, second from left) Preoperative left lateral view. (Below, second from left) Postoperative left lateral view after 15 months. (Above, center) Preoperative left 45-degree view. (Below, center) Postoperative left 45-degree view after 15 months. (Above, second from right) Preoperative right 45-degree view. (Below, second from right) Postoperative right 45-degree view after 15 months. (Above, right) Preoperative right lateral view. (Below, right) Postoperative right lateral view after 15 months.

camouflage the concave shape at the left sidewall. The postoperative photographs show the nasal profile 15 months after surgery (Figs. 3 and 4).

Case 2

A 38-year-old female patient had previously had intranasal hemangioma. After undergoing tumor extirpation 15 years

previously, she sustained saddle nose deformity. Preoperative views showed middle vault collapse and contracture of the skin envelope with the retruded nasal tip. Internal examination revealed bilateral internal valve collapse.

Cartilage grafts of 6.5 cm were harvested from the right seventh rib. A 4-cm rib bone was harvested. An open rhinoplasty was performed. Release of contracture scars was performed. Two cartilage framework systems were built.¹⁰ The first fundamental cartilage system included the bilateral spreader grafts to correct the middle vault collapse and the anterior septal graft to stabilize the retruded nasal tip. The second contouring system included the columellar strut, the shield graft, the cap graft, and the 42 × 8 × 4.5-mm chimeric autologous dorsal onlay graft to restore aesthetic nasal profile. The postoperative photographs show the nasal appearance 8 months after surgery (Figs. 5 and 6).

DISCUSSION

The autologous costal cartilage graft is becoming one of the most commonly used materials for primary and secondary rhinoplasties, as it covers a wide range of nasal reconstructive procedures, including congenital deformities, posttraumatic mutilations, repair following oncologic surgery, and aesthetic surgery.^{1-3,7,11} The costal cartilage shows superiority over both auricular and septal cartilages because of their limited supply and the fact that they might be absent because of previous operations and thus insufficient. Moreover, a large amount of cartilage or solid cartilage might be required for special types of procedures, such as effective tip modification or revision surgery, which is becoming more common because of

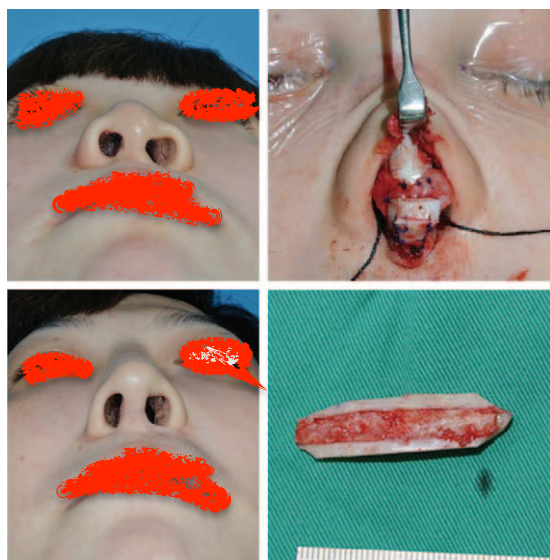


Fig. 4. (Above, left) Preoperative basal view. (Below, left) Postoperative basal view after 15 months. (Above, right) Intraoperative view. (Below, right) Chimeric autologous costal cartilage dorsal onlay graft.



Fig. 5. (Above, left) Preoperative frontal view. (Below, left) Postoperative frontal view after 8 months. (Above, second from left) Preoperative left lateral view. (Below, second from left) Postoperative left lateral view after 8 months. (Above, center) Preoperative left 45-degree view. (Below, center) Postoperative left 45-degree view after 8 months. (Above, second from right) Preoperative right lateral view. (Below, second from right) Postoperative right lateral view after 8 months. (Above, right) Preoperative right 45-degree view. (Below, right) Postoperative right 45-degree view after 8 months.

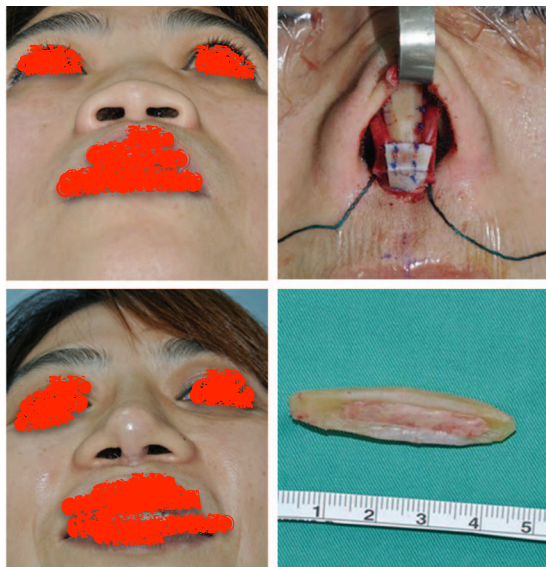


Fig. 6. (Above, left) Preoperative basal view. (Below, left) Postoperative basal view after 8 months. (Above, right) Intraoperative view. (Below, right) Chimeric autologous costal cartilage dorsal onlay graft.

heightened patient expectations and the increase in the number of rhinoplasties.¹² In addition, autologous cartilage is showing superiority over alloplast implants, which carry the well-known significant risks of infection and extrusion⁷; even patients who seek aesthetic rhinoplasty prefer cartilage as a good alternative.

In spite of the great advantages of the costal cartilage graft, it has its own inherent drawbacks, which are donor-site morbidity and warping. The warping characteristics of costal cartilage can complicate its use and must be accounted for during surgery.^{4,6,11}

Many methods have been proposed to prevent or delay costal cartilage warping, and some of the common techniques are discussed here. The first, which gives a clear understanding of cartilage warping, is Gibson's balanced cross-sectional carving, which significantly reduces cartilage warping.¹³ However, a curved rib cannot always be modified into a straight dorsal graft or columella without violating the cross-section concept. The second method is Gunter's internal stabilization technique, which is the insertion of a thin Kirschner wire inside the graft to strengthen its core.⁶ Although this technique is widely used and accepted, wire extrusion has been observed on follow-up of some of these patients.

The third method is the use of diced cartilage grafts, where the diced cartilage is either used as it is or wrapped in fascia.^{14,15} Despite its good results in preventing warping and flexibility given by easy molding, some problems have been associated with its use, such as extensive necrosis of the graft and replacement by fibrous tissue. In addition, the reduction in average volume retention of crushed cartilage limits its use, where it cannot be used to provide much structural support.¹⁶