Comparison of the Surgical Outcomes of Dorsal Augmentation Using Expanded Polytetrafluoroethylene or Autologous Costal Cartilage

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IMPORTANCE Dorsal augmentation material includes alloplastic implants and autologous tissues. However, there has been no comparison to date of dorsal augmentation using different materials performed by the same surgeon.

OBJECTIVE To compare the aesthetic outcomes and complications of dorsal augmentation using expanded polytetrafluoroethylene (ePTFE) and autologous costal cartilage (ACC) in rhinoplasty.

DESIGN, SETTING, AND PARTICIPANTS A retrospective review of the medical records of 244 patients who underwent dorsal augmentation performed by the same surgeon at the Asan Medical Center using ePTFE or ACC from March 1, 2003, through September 31, 2015.

MAIN OUTCOMES AND MEASURES Patient demographics and surgical procedures were analyzed. The aesthetic outcomes were scored from 1 (worst) to 4 (best) by 3 otolaryngologists. Changes in dorsal height and radix height were measured by comparing preoperative and postoperative profile views. Postoperative complications were also evaluated.

RESULTS A total of 244 patients who underwent augmentation rhinoplasty were reviewed in this study, including 141 men (57.8%) and 103 women (42.2%). The ePTFE group included 176 patients, and the ACC group comprised 68 patients. In the ePTFE and ACC groups, 96 patients (54.5%) and 45 patients (66.2%) were male, respectively. The patient ages ranged from 11 to 69 years, with a mean (SD) age of 30.3 (11.49) years in the ePTFE group and 36.04 (12.65) years in the ACC group. The mean (SD) aesthetic outcome scores were comparable between the 2 groups: 2.99 (0.05) in the ePTFE group and 2.99 (0.06) in the ACC group (P = .93). The change of dorsal (2.64% in ePTFE group and 5.82% in ACC group) and radix (3.62% in ePTFE group and 3.77% in ACC group) heights were significantly increased after augmentation in both groups (P < .001) even though the dorsal height of the ACC group after augmentation showed a significantly greater increase compared to the ePTFE group (P < .001). However, the complication rate was significantly higher in the ACC group: 4.0% in ePTFE group and 11.8% in ACC group (P = .02).

CONCLUSIONS AND RELEVANCE Dorsal augmentation with ACC produces similar aesthetic outcomes but a higher complication rate than dorsal augmentation with ePTFE. This higher complication rate may justify the use of ePTFE implants for dorsal augmentation in Asian patients undergoing rhinoplasty.

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For rhinoplasty in Asian patients, dorsal augmentation is one of the most important procedures because Asians usually have a lower dorsal height than whites. Dorsal augmentation for Asians typically creates a better augmented nasal bridge, forming a more balanced dorsal aesthetic line. Several options are available for the material to be used for dorsal augmentation rhinoplasty. Graffing with autologous material is considered ideal by many surgeons because this material has high biocompatibility and is presumed to carry lower risks of infection and extrusion. Among the various autologous tissue options, costal cartilage can be harvested in great quantities, can be carved into a variety of shapes, and has therefore been strongly advocated as the most useful graft material for Asian dorsal augmentation by many surgeons. However, harvesting costal cartilage is associated with donor site complications, and this material is difficult to handle and carve. Therefore, despite the wide acceptance that dorsal augmentation is best performed with autologous material, costal cartilage is not commonly the primary choice for this procedure by most rhinoplasty surgeons in Asia.

Despite concerns about complications after the use of an alloplastic implant for dorsal augmentation, alloplastic implants, such as silicone and expanded polytetrafluoroethylene (ePTFE), are viable and widely used primary options for dorsal augmentation, especially for the Asian nose. The merits of alloplastic implants include the lack of any harvesting morbidity, no requirement for additional harvesting time, and the ease with which this material can be carved to create a better refined dorsal line. Hence, there is a discrepancy between the ideal and real-world practice in Asian dorsal augmentation, and the selection of the ideal dorsal implant material is still a matter of debate that needs to be clarified by scientific evidence. The surgical outcomes of rhinoplasty using a single material, such as autologous costal cartilage (ACC) or ePTFE, have been analyzed. Contrary to the popular notion that ACC carries a lower risk of complications compared with alloplastic implant materials, the reported complication rate of ACC varies from 0 to 39.57%, whereas that of ePTFE, one of the most commonly used alloplastic implants for dorsal augmentation, varies from 1.9% to 10%. To provide better insights into the appropriate selection of a dorsal augmentation material, we present comparative data on a single surgeon's experience with dorsal augmentation using ACC vs alloplastic implants, particularly ePTFE, which is our preferred material for these procedures.

Methods

Study Design and Patients
A retrospective review of the medical records of patients who underwent dorsal augmentation from March 1, 2003, to September 30, 2015, at the Asan Medical Center was conducted. We selected patients who had received augmentation using ePTFE or ACC for analysis. Patients who had undergone dorsal augmentation using crushed or diced types of ACC were not included. Patient demographics, surgical procedures, and complications were analyzed. This study was approved by the Asan Medical Center Institutional Review Board. Written informed consent was obtained from all patients preoperatively, and all data were deidentified.

Surgical Techniques
All the procedures were performed by the same surgeon (Y.J.J.), and most operations were conducted via an external approach. After the skin incision, a subperichondrial approach was used. Septal framework reconstruction, osteotomies, and nasal tip work were performed as needed before the placement of the dorsal augmentation material. The ACC procedure was used for primary rhinoplasty candidates with thick skin, an underprojected tip, and a very low dorsal height. In addition, ACC was used for patients undergoing revision rhinoplasty with a weak septal cartilage framework that manifested as a saddle nose, deviated nose, or short nose. For patients who refused the use of alloplastic materials for the dorsal augmentation, ACC was also used. Except in cases in which the patients had a severe deformity that required the use of ACC for major reconstruction, ePTFE was chosen for dorsal augmentation. In particular, ePTFE was used in patients who wished to use alloplastic materials because of fears regarding donor site morbidity.

After identifying a rib through palpation, an approximately 3-cm incision was made above the sixth or seventh costal cartilage on the right side. The subcutaneous tissue was then dissected by electrocautery, and the fascia of the external oblique muscle was identified. After the fascial incision, the muscle was divided bilaterally, and the perichondrium over the costal cartilage was identified. The ACC was harvested as one 4- to 5-cm block, with or without the perichondrium. The peripheral part of the harvested ACC was cut into several laminated pieces using a dermatome blade. These laminated grafts were used for septal reconstruction and tip surgery. The core portion of the remnant ACC was saved for dorsal augmentation. The priority for ACC augmentation was to first use a well-designed monoblock type. The approximate 4-cm longitudinal central core of the ACC was carved using a No. 10 blade and then soaked in normal saline for 30 minutes to 1 hour to let the

Key Points

Question When a patient wants dorsal augmentation, is autologous costal cartilage (ACC) or expanded polytetrafluoroethylene (ePTFE) the better choice?

Findings In this medical record review of 244 patients who underwent dorsal augmentation, the mean aesthetic outcome and increase of the dorsal heights were not significantly different between the ACC and ePTFE groups. However, the complication rate of 11.8% in ACC group was significantly higher than the 4.0% complication rate in the ePTFE group.

Meaning Dorsal augmentation with ACC produces similar aesthetic outcomes but a higher complication rate than dorsal augmentation with ePTFE.
initial warping take place. The core was carved again immediately before insertion onto the dorsum. When the remaining ACC was not sufficient in size or shape for a 1-piece dorsal augmentation, the cartilage was further sliced and used in the form of a multilayered laminated graft. Then 2 or 3 laminated grafts were sutured with 5-0 polydioxanone sutures, and the margin was carved using a No. 10 blade.

The ePTFE used in this study was a Gore-Tex Soft Tissue Patch (W.L. Gore & Associates Inc) with a 2-mm thickness. This patch was cut into 0.8 × 4-cm pieces and designed in a boat shape. When minimal augmentation was required, 1 layer was used, but 2 to 3 layers of Gore-Tex sutured with 5-0 polydioxanone sutures were used if a greater degree of augmentation was required.

Assessment of Outcomes
Photographs were taken preoperatively and postoperatively. Three otolaryngologists who were not involved in any of the operations analyzed the aesthetic outcomes by comparing preoperative and postoperative photographs taken at the last follow-up. On the basis of their consensus decision, postoperative aesthetic outcomes were classified as excellent, good, fair, or poor, scored from 4 to 1, respectively. The mean of the 3 scores was used. For anthropometric measurements, preoperative and postoperative profile views were analyzed by one of us (Y.H.J.). First, the vertical line joining the medial canthus and the alar crease was measured. Second, the dorsal and radix heights were measured as a distance from the rhinion and radix to the vertical line. The ratio of the dorsal and radix height was calculated as a percentage of the vertical line (Figure 1). We did not use a specific scale for measurement of dorsal and radix height because the photograph is different from the actual size. Therefore, the photograph showed the proportion of dorsal height to dorsal length. The ratios of the dorsal and radix heights were compared preoperatively and postoperatively. Complications were investigated by a review of the medical records and postoperative photographs.

Statistical Analysis
An independent t test was used to estimate differences in aesthetic outcomes, and a paired t test was used for anthropometric measurements. A Pearson χ² test and Fisher exact test were performed to compare the complication incidence between ePTFE and ACC for dorsal augmentation. All analyses were conducted using SPSS statistical software, version 21.0 for Windows (SPSS Inc). Graphs were generated using Prism software, version 5.0 (GraphPad Software Inc). P < .05 was considered statistically significant.

Results
A total of 244 patients who underwent augmentation rhinoplasty were reviewed in this study (eTable 1 in the Supplement), including 141 men (57.8%) and 103 women (42.2%). The ePTFE group included 176 patients, and the ACC group comprised 68 patients. Monoblock and laminated types of ACC were used in 57 patients (83.8%) and 11 patients (16.2%), respectively. In the ePTFE and ACC groups, 96 patients (54.5%) and 45 patients (66.2%) were male, respectively. The patient ages ranged from 11 to 69 years, with a mean (SD) age of 30.3 (11.5) years in the ePTFE group and 36.0 (12.6) years in the ACC group. The follow-up period ranged from 4 to 115 months (mean, 12 months). Primary rhinoplasties were conducted in 186 patients (76.2%) and revision rhinoplasties in 58 patients (23.8%). Of the patients undergoing revision rhinoplasties, 41 (23.3%) and 17 (25.0%) were included in the ePTFE and ACC groups, respectively.

In the ePTFE group, there were 59 excellent outcomes (33.4%), 65 good outcomes (36.9%), 45 fair outcomes (25.5%), and 7 poor outcomes (4.1%). In the ACC group, there were 19 excellent outcomes (27.4%), 29 good outcomes (44.5%), 19 fair outcomes (27.4%), and 1 poor outcome (0.7%) (Figure 2A, Figure 3, and Figure 4). The rates of unsuccessful outcomes (ie, fair or poor) were 29.6% in the ePTFE group and 46.1% in the ACC group, respectively (Figure 5). The mean (SD) aesthetic outcome scores were 2.99 (0.05) in the ePTFE group and 2.99 (0.06) in the ACC group, respectively. No statistical differences in the surgical outcomes of using different dorsal augmentation materials were evident (P = .93) (Figure 2B).

The change of dorsal (2.64% in ePTFE group and 5.82% in ACC group) and radix (3.62% in ePTFE group and 3.77% in ACC group) heights were significantly increased after augmentation in both the ePTFE and ACC groups (P < .001 for all; eTable 2 in the Supplement). However, the increase in dorsal height of the ACC group cases after dorsal augmentation was significantly greater than that of the ePTFE group (P < .001).
Complications from the use of ePTFE and ACC were detected in 7 of 176 and 8 of 68 patients, respectively (eTable 3 in the Supplement). In the ePTFE group, 1 infection (0.6%) and 1 irregularity (0.6%) were observed. Two patients (1.1%) in this group presented with a displacement of the implant, and another 2 patients (1.1%) presented with an obvious implant contour. A short nose deformity was detected in 1 patient. In the ACC group, resorptions were observed in 4 patients (5.9%), and warping was also observed in 4 patients (5.9%). There were no infections, short noses, or obvious implant contour complications in the ACC group. However, the total frequency of complications was significantly higher in the patients in the ACC group compared with those in the ePTFE group (P = .02). Unlike revision rhinoplasty, the complication rate in the ACC group for primary rhinoplasty was higher than that of the ePTFE group (P = .02). No significant differences were observed in the complication rate between primary and revision cases in the ePTFE group (13.73% in primary cases and 5.88% in revision cases, P = .66) and ACC group (3.7% in primary cases and 4.88% in revision cases, P = .67).

**Discussion**

The present study analyzed the aesthetic outcomes and complications of dorsal augmentation using ePTFE and ACC performed by the same surgeon. We found that dorsal augmentation using ACC resulted in similar aesthetic outcomes but a higher complication rate compared with ePTFE. This finding suggests that ACC, which has been considered the optimal choice for nasal implant materials, may not be the best dorsal augmentation material for Asian rhinoplasty. The proportion of men was higher in the ACC group, likely because men are typically less concerned about chest scars than female patients. In addition, male patients tend to have thicker nasal skin, which is more suited to the use of ACC.

Regarding the nasal shape after dorsal augmentation using ACC, 76% of patients were reported previously as having excellent or good results. Similarly, in the present study, 49 patients (71.9%) in the ACC group achieved an excellent or good result. Although, to our knowledge, the aesthetic outcomes of rhinoplasty using ePTFE have not been evaluated in previous reports, ePTFE and ACC produced similar aesthetic out-

![Figure 2. Aesthetic Outcomes According to the Augmentation Material Used](https://archfaci.jamanetwork.com/fullarticle/1234567890)

A, Excellent and poor outcomes were observed more often in the expanded polytetrafluoroethylene (ePTFE) group compared with the autologous costal cartilage (ACC) group. B, There was no statistically significant difference between the aesthetic outcomes in the ePTFE and ACC groups.

![Figure 3. Patients With Good Aesthetic Outcomes After Dorsal Augmentation Using Expanded Polytetrafluoroethylene](https://archfaci.jamanetwork.com/fullarticle/1234567890)

Preoperative (A, C, E, and G) and postoperative (B, D, F, and H) photographs are shown.
comes and significantly increased the nasal dorsum and radix height in profile photographs of the current study population. Therefore, the results indicate that these 2 augmentation materials have similar effects in terms of postoperative aesthetic outcomes. Notably, the increase in dorsal height was significantly greater in the ACC group, which was likely attributable to more patients with a very low dorsum or destroyed nose requiring major framework reconstruction being treated with this material and thus having a more notable change compared with the ePTFE group.

No patient in the ACC group developed an infection, the rate of which was lower in the present study series than reported previously.10 We speculate that the low infection rate may be attributable to the use of ACC for the nasal dorsum only. In our experience, infection is more prone to occur when ACC is used at the nasal tip area.11 In the present analysis, we found that warping and resorption were the most common complications in the ACC group. Miranda et al12 also reported previously that warping is the most common complication after dorsal augmentation in patients with ACC implants. In the present patient group, warping occurred in 3 patients who underwent dorsal augmentation using a monoblock ACC implant and in 1 patient who received a laminated ACC implant. In the ACC group, resorption was the second most common complication. Four patients had resorption in this study, and all of them received monoblock augmentation. We think that any type of costal cartilage dorsal implant can result in resorption, and surgeons have to keep in mind this problem when using costal cartilage. In contrast to the current findings, Yilmaz et al10 reported previously that the resorption rate was not high after using ACC for dorsal augmentation, and the shape of the nose had satisfactory long-term results. This discrepancy needs further clarification in future studies.

Figure 4. Patients With Good Aesthetic Outcomes After Dorsal Augmentation Using Autologous Costal Cartilage

Preoperative (A, C, E, and G) and postoperative (B, D, F, and H) photographs are shown.

Figure 5. Patients With Poor Aesthetic Outcomes

Preoperative (A) and postoperative (B) photographs of a patient after dorsal augmentation using expanded polytetrafluoroethylene and preoperative (C) and postoperative (D) photographs of a patient after dorsal augmentation using autologous costal cartilage are shown. Although the postoperative dorsal and radix height was considerably elevated compared with preoperative photographs, both patients had too high radix and an unnatural-looking nasal dorsum.
Ham and Miller\textsuperscript{13} reported an overall complication rate of 3.0\% for rhinoplasty using ePTFE, and Conrad et al\textsuperscript{14} reported a rate of 4.8\%. Similarly, the overall complication rate of dorsal augmentation using ePTFE was 4.0\% in the present study. In previous studies,\textsuperscript{8,15} infection was the most common complication at 3.2\% or 3.5\%. However, the infection rate in our study was only 0.6\%, possibly because most of the rhinoplasties in our patient series were conducted using an open approach with copious irrigation before and after the insertion of the ePTFE material.

Yap et al\textsuperscript{16} analyzed undesirable outcomes in patients after the use of ePTFE for dorsal augmentation and reported that 0.85\% of these patients had a visible implant or an overly elevated bridge. In the present study, the most common complication in the ePTFE group was an obvious implant contour. This sequela might have resulted in particular from the use of a poorly carved implant in thinner-skinned patients. Two patients also experienced displacement, possibly attributable to the soft nature of ePTFE that caused a kinking deformity. In addition, the wide undermining of the skin soft-tissue envelope in our rhinoplasty method, instead of creating a tight skin pocket for the implant, might have predisposed these patients to this outcome. There was also 1 patient with a short nose deformity in our ePTFE group but none in the ACC group. A short nose deformity in an Asian nose is usually the result of capsular contraction of the skin soft-tissue envelope. Although ePTFE is considered to have a reduced tendency for capsular contracture compared with silicone, previous results indicate that one should also consider short nose deformity as a possible complication of dorsal augmentation using ePTFE.\textsuperscript{17}

Several studies\textsuperscript{13,18,19} to date have reported that the complication rate is lower in primary cases but increases significantly in revision cases when using ePTFE or ACC. However, in the present study, in contrast, the complication rates were no different between the primary and revision cases.

This study had some limitations of note. First, there was a selection bias because we did not conduct a randomized clinical trial and used ACC in patients with a weaker framework or very low dorsal height. Second, the patient numbers in the 2 groups are different; the patient number of the ACC group was less than half of the ePTFE group. This discrepancy could have affected the results. In addition, the mean follow-up period was only 12 months, which is insufficient to detect delayed complications. Despite these drawbacks, however, the study has important clinical implications because it is the first report, to our knowledge, to compare the outcomes of dorsal augmentation using ePTFE or ACC performed by the same surgeon. We found that ACC had a similar cosmetic effect but a higher complication rate than ePTFE for dorsal augmentation in rhinoplasty, although ePTFE also causes some complications, such as a short nose or an obvious implant contour. We therefore suggest that surgeons should not hesitate or be overly concerned about choosing ePTFE instead of ACC for dorsal augmentation in an Asian nose.

Conclusions

Autologous costal cartilage results in similar aesthetic outcomes but a higher complication rate than ePTFE when used for dorsal augmentation. This higher complication rate may justify the use of ePTFE implants for dorsal augmentation in Asian patients undergoing rhinoplasty.

ARTICLE INFORMATION

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