

## Irradiated Homologous Costal Cartilage: Versatile Grafting Material for Rhinoplasty

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**Abstract.** For most surgeons, nasal septal cartilage is the first choice in septoplasty. However, when this source is depleted, an alloplastic implant material might be preferable over other autogenous donor sites in order to avoid additional scars, morbidity, and lengthened operating time. In the alloplastic spectrum, irradiated costal cartilage (ICC) has certain advantages. Herein, we present our results with ICC in a wide range of septorhinoplasties to show its versatility and reliability. Sixty-five patients were included in the study. There were 42 male and 23 female patients. According to the indications, there were four groups of patients: (I) secondary septorhinoplasty ( $n = 24$ ), (II) traumatic deformity ( $n = 21$ ), (III) primary septorhinoplasty ( $n = 13$ ), (IV) deformity due to previous septal surgery ( $n = 7$ ). The mean follow-up period was 33 months. No significant resorption was detected in any of the patients. Minor complications developed in four cases (6%), including deformity in the dorsal graft, excessive graft length, and erythematous nasal tips. Aesthetic and functional results were satisfactory in the remaining cases. The low incidence of major complications and the versatility of ICC make it a safe and reliable source of cartilage graft for both primary and secondary septorhinoplasties when autogenous septal cartilage is either insufficient or unsuitable.

**Key words:** Costal cartilage—Septorhinoplasty—Graft

Cartilage grafts are increasingly required in both aesthetic and reconstructive rhinoplasty [1,4,7,9,22, 24–26]. As grafting material, autogenous sources are preferred over allografts [33] and nasal septal carti-

lage is widely accepted as the ideal grafting material [7,9,32]. However, in many of the traumatic deformities and in patients who have already undergone a septoplasty procedure, this source may be unavailable. Furthermore, in certain septoplasty cases the septal cartilage may be unreliable due to severe deformation. In these graft-depleted patients, the surgeon faces a choice between moving to a new donor site or using an alloplastic material. Choosing a new donor site, such as the conchal or costal cartilage, lengthens the operation time, invites a series of potential complications, and creates additional scars. On the other hand, there is a plethora of alloplastic materials that have been used in rhinoplasty, including silicone, porous alumina (Proplast II<sup>®</sup>), high density porous polyethylene (Medpor<sup>®</sup>), polytetrafluoroethylene (Goretex<sup>®</sup>), allograft dermis (Allo-derm<sup>®</sup>) and allograft costal cartilage (Tutoplast<sup>®</sup>) [10,12,17,19,27,36]. Of these, nonbiologic implant materials have been reported to have a significant risk of extrusion and infection, with the exception of polytetrafluoroethylene [18,29]. However, the latter is not recommended in locations with limited soft tissue cover, such as the nasal tip and columella, or where the graft is required for its strength [10]. Allogeneic dermis is, again, only for contour deformities as it does not provide structural support.

Irradiated costal cartilage (ICC) grafts were first used by Dingman and Grabb in 1961 [37]. Later they published successful long-term results in more than 600 patients [36]. Similar results with minimal absorption (0–1.4%) have been published over the years by Schuller et al. [28], Chaffoo and Goode [8], Lefkovits [21], Murakami et al. [23], and Kridel and Konior [20]. However, several animal studies and some long-term follow-up studies that extend up to 15 years did not confirm the low resorption rates [5,31,35]. Furthermore, in contrary to initial reports, several authors, including Lefkovitz, mentioned a

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high warping potential, even when the carving was performed according to Gibson's principle of balanced cross-sections [9,16,21]. This resulted in confusion about, and possibly underutilization of, this graft source. In this article we present our experience with ICC in both primary and secondary rhinoplasty, and in nasal reconstruction due to various deformities.

## Materials and Methods

From October 1998 till June 2002, 65 patients underwent a rhinoplasty procedure in which ICC (Tutoplast, Tutogen Medical, GmbH, Neunkirchen, Germany) was used. There were 42 male and 23 female patients, with a mean age of 28 years. According to the indications, ICC was used in four groups of patients in which septal cartilage could not be used because it was unsuitable for shaping or the amount was insufficient.

### *Group I: Secondary Septoplasty*

These 24 patients had undergone a prior septoplasty procedure that was unsuccessful either cosmetically or both cosmetically and functionally. Grafts were required either to correct the deformities related to the first operation or to support a weakened septum.

### *Group II: Traumatic Deformity*

These 21 patients had previously sustained major nasal trauma with nasal/septal fractures. They were either left untreated or were inadequately treated, leading to nasal obstruction and deformity. Grafts were mainly used for reconstructive purposes.

### *Group III: Primary Septoplasty*

These 13 patients were cases in which grafts were required either to support a crooked septum or for nasal augmentation.

### *Group IV: Deformity due to Previous Septal Surgery*

Saddle deformity had been caused in these seven patients by extensive resection of septal cartilage during a previous septoplasty procedure.

## Operative Technique

Open approach was used in 39 patients (60%). Homologous costal cartilage allografts were procured from prescreened donors, dehydrated, sterilized by gamma irradiation, and rehydrated in 0.9% NaCl and

packed in vacuum-sealed bags. Grafts of either 5 cm or 7 cm were preferred, and only the core parts of the rib were used to prevent warping. All the perichondrium was removed and the graft was soaked in sterile saline for 30 min before shaping. Shaping was done by scalpel carving. Following the final shaping, the graft was left in saline for another 10 min in order to check for any acute warping. Any acutely warped cartilage then either reshaped or discarded, as necessary.

Grafts were used in several shapes: elliptical dorsal grafts, hearth-shaped tip grafts, spreader grafts, segments for septum reconstruction, L-shaped profile grafts, leaf-shaped lower lateral cartilage grafts, chopped-diced grafts for Turkish delight [15], batten grafts for the columella and septum, butterfly grafts to support upper lateral cartilages, and smaller leaflets for nasolabial angle augmentation. Spreader, batten, and tip grafts were fixed by 5/0 prolene sutures. Dorsal grafts were immobilized by only a snugly fitting pouch and plaster cast.

## Results

The mean follow-up period was 33 months (range, 6–49 months) in the 59 patients that could be followed. Serial photographs were taken at one month, three months, and six months and then every six months to assess the amount of any possible resorption and warping. No resorption that affected the success or outcome of the operation was detected in any of the patients. The aesthetic and functional results were satisfactory, and no further surgical procedure was required in any of the patients, except one. This was a Group II patient who received a large elliptical dorsal graft to correct of a saddle deformity—the graft was exposed from under the membranous part of the columella at the end of the first postoperative month. It was thought to be related to the excess length and sharp tip of the graft, which was shortened and re-applied with success. Minor complications occurred in three other patients (4.6%). In two Group I patients, skin rashes developed over the tip graft and were successfully treated by topical steroid ointments. The cause of this reaction remains unknown but is thought to be allergic in nature. In one Group I patient, slight warping of a dorsally placed strut was observed four weeks after surgery. However, the patient did not want to have a revision. No infections were noted.

## Case Reports

### *Case 1: Secondary Septorhinoplasty*

A 24-year-old woman presented with the complaints of nasal deformity and obstruction of the left airway.

She had received a septoplasty procedure three years before that was unsuccessful and repeated six months later by the same surgeon. However, her breathing problems did not resolve and she was dissatisfied with the aesthetic appearance. On examination, she had a wide, irregular nasal dorsum with a bump on the right side, a persisting cartilaginous hump, diminished tip support with blunted tip projection, and domal asymmetry (Fig. 1, left). The nasal septum was deviated to the left, posteriorly. The operative plan was as follows:

- 1 Open approach
- 2 Bony cartilaginous dorsum reduction of 3 mm
- 3 Resection of the obstructing segment in nasal septum
- 4 Cephalic trim (more from right)
- 5 Medial and lateral osteotomies
- 6 Batten graft to caudal septum (ICC) (5/0 polypropylene sutures)
- 7 Columellar strut (ICC) (5/0 polypropylene sutures)
- 8 Connection of batten graft to columellar strut for nasal elongation via two cartilage graft bridges (ICC) (5/0 polypropylene sutures)
- 9 Tip graft for tip definition (ICC) (5/0 polyglactone)
- 10 Placement of a thin, narrow layer of cartilage graft to dorsum to obtain a smooth contour

Figure 1 shows the frontal, three-quarter, and lateral views of the patient at one year (center) and three years (right) after the procedure. The dorsum was smooth with balanced, aesthetic lines. In profile views, the dorsum was straight with a slight supratip break. She had good symmetry at the nasal tip. Minimal nasal elongation was achieved in addition to improved tip projection, and both were maintained over the years. The nasal airway obstruction was corrected. In this case, ICC served as a tool for establishing a stable skeletal framework.

### Case 2: Traumatic Deformity

A 27-year-old male presented with severe nasal deformity and bilateral nasal airway obstruction. He had a history of a frontal impact in the nose during a traffic accident. Due to other intercurrent emergencies, the nasal trauma was left untreated. On examination, the nasal bones were separated in the midline with lateral displacement of the left nasal bone and posteromedial displacement of the right nasal bone (Fig. 2, upper left). The overall effect was a curvilinear external deviation to the left. The dorsum was broadened due to bony displacement and the complete absence of the cartilaginous septum. The tip support was negligible with a significant drop of the nasal tip that narrowed the nasolabial angle. A saddle

deformity was evident at the inferior border of the nasal bones (Fig. 2, lower left). The nasal septum was fractured, and segments were piled on top of each on a coronal plane, obstructing both the left and right nasal passages. The operative plan was as follows:

- 1 Intracartilaginous approach
- 2 Resection of the obstructing segments in nasal septum
- 3 Rasping of the anterior edge of left nasal bone
- 4 Medial and lateral osteotomies
- 5 Thick, elliptic cartilage graft (ICC) to the dorsum
- 6 A batten graft to columella (ICC) (5/0 polypropylene fixation to the anterior nasal spine)
- 7 5/0 polypropylene suture fixation of the columellar strut to the dorsal graft

Figure 2 (upper and lower right) shows the patient one year after the reconstruction. The separated nasal bones were set back together, significantly narrowing the dorsum. The thickness of the cartilage strut contributed to this narrowing, while also increasing the height. The lateral view reveals a straight dorsum with increased tip projection and a more obtuse nasolabial angle. Use of ICC obviated the need for costal cartilage harvesting in this patient.

### Case 3: Primary Septoplasty

A 34-year-old man presented with complaints of a beak nose deformity and difficulty in breathing on both sides. There was no history of nasal trauma or surgery. On examination there was a supratip deformity related to a short nasal septum that left the nasal tip unsupported and sagging (Fig. 3, lower left). The dorsal hump was minimal. The lower lateral cartilages curved upwards posteriorly, toward the dorsum, giving the tip a boxy appearance. The nasolabial angle was 75 degrees. The skin was thick and sebaceous. The septum was deviated to the right in the anterior part and to the left posteriorly. The operative plan was as follows:

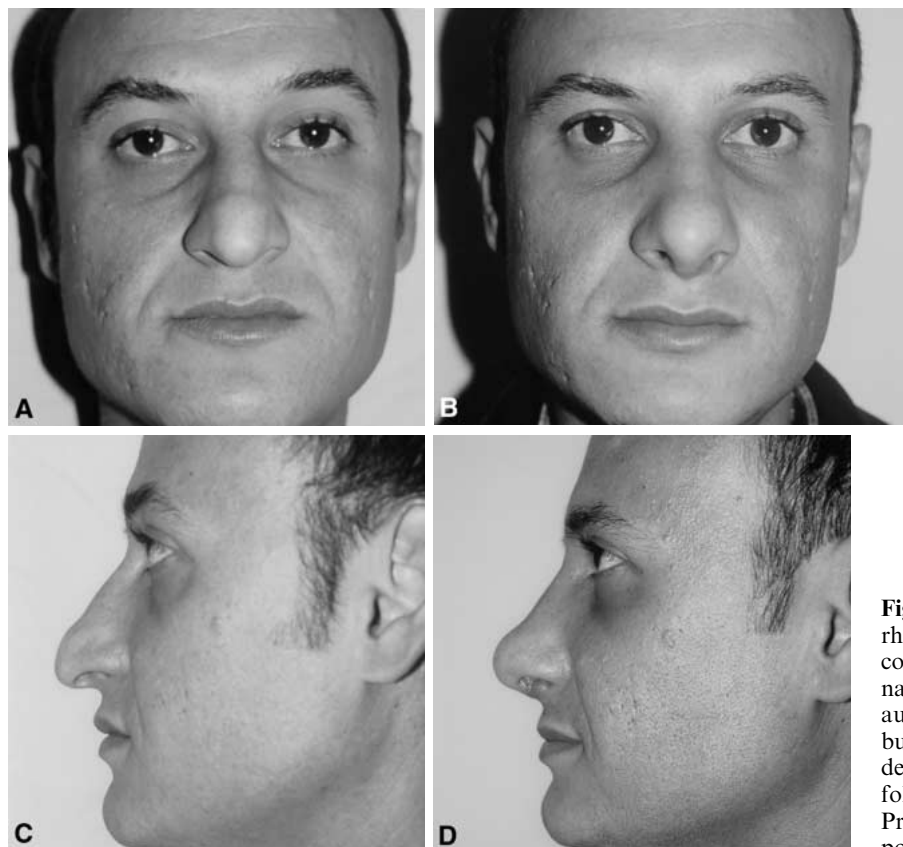
- 1 Open approach
- 2 Bony cartilaginous dorsum reduction of 2 mm
- 3 Submucous septal resection leaving 6 mm of cartilage caudally dorsally
- 4 Dissection and rotation of posterior part of lower lateral cartilages inferiorly (5/0 polypropylene suture fixation)
- 5 Cephalic trim
- 6 Medial and lateral osteotomies
- 7 Columellar strut (ICC) for tip support and projection (5/0 polypropylene sutures)
- 8 Tip graft for tip definition
- 9 Thin dorsal elliptic graft (ICC) for profile augmentation and smoothing



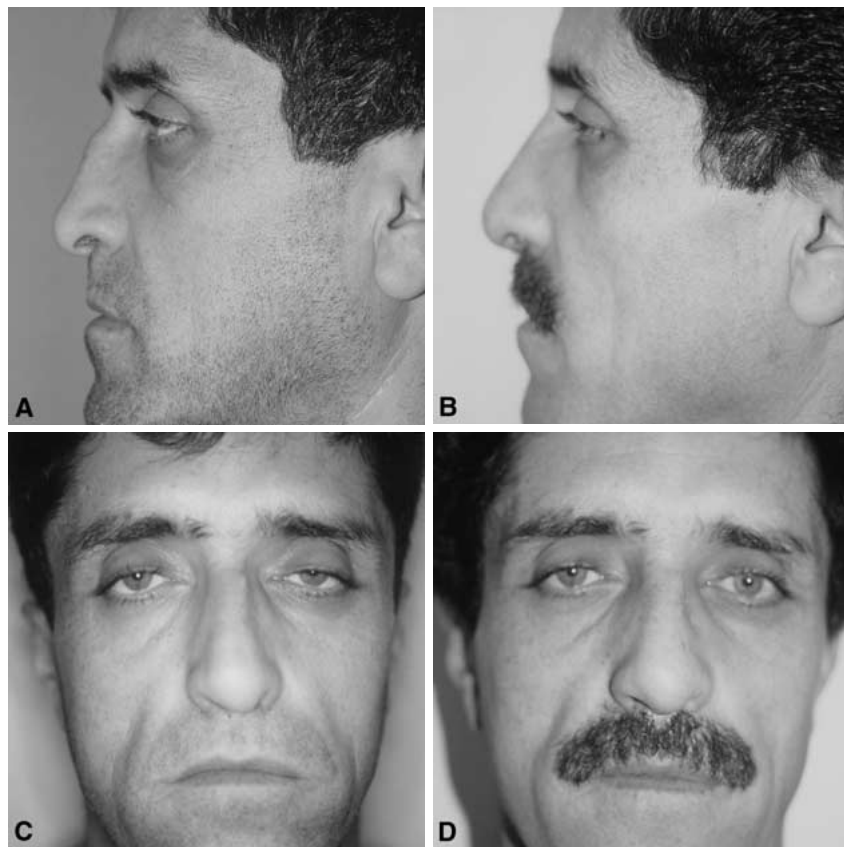
**Fig. 1.** *Case 1:* Secondary septoplasty due to inadequate aesthetic result and nasal obstruction. The allograft costal cartilage was used to support septum, to increase columellar projection for tip augmentation, and as a thin dorsal layer. Preoperative (left), one year postoperative (center), and three years postoperative (right) appearance.



**Fig. 2.** *Case 2:* Severe traumatic deformity that was left untreated. The allograft costal cartilage was shaped into a thick dorsal strut to augment the nasal profile and into a columellar batten graft for tip support. Preoperative (left) and one year postoperative (right) appearance.



**Fig. 3.** *Case 3:* Primary augmentation rhinoplasty with septoplasty. Allograft costal cartilage was used to support the nasal tip, to increase tip projection, to augment nasolabial angle, and as a butterfly graft to prevent secondary depression in the supratip region following the increase in tip projection. Preoperative (left) and one-year postoperative (right) appearance.



**Fig. 4.** Case 4: Nasal deformity due to extensive submucosal resection of the nasal septum. The allograft costal cartilage was used as inter (medial) crural batten graft and a dorsal elliptical strut. Preoperative (left) and 18 months postoperative (right) appearance.

10 Butterfly graft to fill the secondary depression that occurred in the supratip region following significant increase in tip projection

11 Chunk grafts (ICC) for augmentation of the nasolabial angle

Figure 3 (upper and lower right) shows postoperative appearance one year after the surgery. The boxy appearance at the tip was corrected. The nasal tip support was shifted from the supratip region to the tip itself while increasing the anteroposterior projection. The sagging appearance was changed into a slight supratip break. The nasolabial angle was increased to 95 degrees. The tip definition was more round than usual and this was in balance with the curved contour of the forehead and chin. The airway obstruction was corrected. As the resected septal cartilage was in small fragments and deformed, it could only be used as an adjunct to ICC in nasolabial angle augmentation. This case represents an augmentation rhinoplasty, which requires significant amount of cartilage grafting.

#### *Case 4: Deformity due to Previous Septal Surgery*

A 43-year-old man reported dissatisfaction with the appearance of his nose. He had a septoplasty operation to correct nasal obstruction three years before his admission. The operation was successful in re-

leasing the airways, however the results were complicated by a drooping of the lower part of the nose in the following years. On examination, the patient had minimal nasal tip support, and on palpation, the cartilaginous septum was absent. The lower two-thirds of the nose was posteroinferiorly displaced, creating a pseudohump at the junction of the nasal bone and the absent cartilaginous septum (Fig. 4, upper left). The nasolabial angle was decreased. The operative plan was as follows:

- 1 Open approach
- 2 Bony dorsum reduction of 3 mm
- 3 Cephalic trim
- 4 Medial and lateral osteotomies
- 5 Columellar strut (ICC) (5/0 polypropylene sutures)
- 6 Dorsal elliptic graft (ICC) for profile augmentation

Figure 4 (upper and lower right) shows a straight nasal profile 18 months after the surgical procedure. The ICC served as an excellent source of cartilage graft, again obviating the need for a cumbersome costal cartilage harvesting.

#### **Discussion**

In this series, ICC was found to be a very reliable and versatile grafting material for all forms of septorhin-

oplasty. It could be used for any type of cartilage defect in the nose, ranging from a lamellar dome augmentation graft to a thick dorsal graft for saddle deformity. It was easy to handle and shape and allowed suture placement for secure fixation. None of the feared complications occurred to any significant extent: there was no resorption and little warping (1.3%) or extrusion (1.3%). This was in concordance with some previously published data [8,20,21,23,28,36,37]. However, it should be noted that our results regarding the resorption potential are still preliminary as our mean follow-up period was 33 months.

Several variables have been postulated to affect the resorption rate of ICC. Observation of increased absorption rates in irradiated cartilage in comparison to thiomerosal-preserved cartilage led Donald to propose that the technique and duration of irradiation might influence graft resorption [14]. It appears that irradiation somehow prevents infiltration of the graft by viable host cells [11]. Resorption rates of ICC may also differ according to the recipient site [13]. Grafts placed in locations that exposed to regular muscle activity or constant pressure seem to be absorbed earlier. In this respect, the nasal dorsum is a good location and the columella is not [11,13]. A third factor is the presence of infection, which may cause total resorption if it is not treated promptly [20]. Welling et al. assumed that another variable that affects the amount of resorption was time [35]. In a reevaluation study performed by them, it was shown that ICC used in facial reconstruction was initially successful, but resorbed significantly when follow-up periods were extended from 5 to 16 years [35]. Fibrous tissue replacement of the resorbed cartilage does affect the final success of reconstruction as proportionate fibrosis may preserve the cosmetic and functional results, particularly in the nose [20]. This latter finding may explain the discrepancy between the long-term results of Dingman and Grabb and those of Welling et al. [35, 36]. In fact, the onset of resorption in cartilage after many years, as shown in Welling's study, is unexpected, and results of animal studies indicate that resorption already occurs within three to four weeks of implantation [3]. However, animal studies are complicated by cross-species barriers. It should be noted that resorption is not a specific problem related to ICC, as cartilage autografts and autogenous bone grafts used in nasal reconstruction do also have a variable resorption rate [6,30]. Similar long-term resorption of septal cartilage does occur following septoplasty [34], possibly related to trauma/ischemia-induced changes in the life cycle of chondrocytes. In our series, although the follow-up period is relatively short, no resorption was detected. In the serial photographs of our patients, if there had been some degree of cartilage resorption it would have been unrecognizable in the natural healing course of rhinoplasty, a dynamic process that lasts at least several months. Therefore, we did not attempt to overcorrect any deformity.

Warping is second major problem related to costal cartilage use in rhinoplasty. The incidence of warping differs within the literature, from 0 to 14.8% [8,20,21,23,28,37]. Clinically, it has been postulated that ICC warps less than autogenous costal cartilage [20] and warping occurs between 10 days and three weeks after implantation [21]. However, it was recently shown that radiation has no effect on the warping potential of costal cartilage [2]. Warping is probably more related to the cartilage carving technique. We believe that by adhering to the following guidelines, warping could be totally eliminated: (1) remove perichondrium, totally, (2) carve the grafts from the straightest segment of the rib, (3) use only the core part of the rib and discard the peripheral struts, (4) shave the segment in a balanced fashion while thinning, (5) soak the prepared segment in saline for 10 min to check for an acute warping before implantation, (6) prepare and place the graft in a way that ensures visual compensation should any warping take place. Fractures may occur in the allograft cartilage during surgical manipulation and at any time in the postoperative period. We noticed that fresh-looking grafts (whiter in shape and more elastic) are more resilient to fracture than others (yellowish in color and calcified). Apparently this difference is related to the age of the donor, grafts from older donors being less preferable.

The costal cartilage allografts were very resistant to infection and extrusion, unlike all other nonbiologic alloplastic materials used in rhinoplasty. This is a clear advantage as such complications with high-density porous polyethylene or silicone implants are catastrophic and difficult to handle in the nose. The single exposure in this series was related to an overlong dorsal graft with a sharp end that perforated the mucosa at the membranous portion of the columella. Therefore, it seems that complications with ICC are less dramatic and easier to handle.

In conclusion, contemporary septoplasty frequently requires the use of a wide range of grafts, forcing us to find a generous source of cartilage. Irradiated costal cartilage allografts might be a non-invasive way of obtaining cartilage grafts when autogenous septal cartilage is either insufficient or unsuitable. It provides a grafting material that is safe and versatile.

## References

1. Adams WP, Rodrich RJ, Hollier LH, Minoli J, Thornton LK, Gyimesi I: Anatomic basis and clinical implications for nasal tip support in open versus closed rhinoplasty. *Plast Reconstr Surg* **103**:255–261, 1997
2. Adams WP, Rodrich RJ, Gunter JP, Clark CP, Robinson JB: The rate of warping in irradiated and non-irradiated homograft rib cartilage: A controlled comparison and clinical implications. *Plast Reconstr Surg* **103**:265–270, 1999

3. Alechniewicz A: Research on grafted conserved homogenous cartilage. *Acta Chir Plast* **6**:229–233, 1964
4. Andrade M, Fernandes VS, Boleo-Tome JP: Saddle nose: Our approach to the problem. *Aesthetic Plast Surg* **23**:403–406, 1999
5. Babin RW, Ryu JH, Gantz BJ, Maynard JA: Survival of implanted irradiated cartilage. *Otolaryngol Head Neck Surg* **90**:75–80, 1982
6. Bateman N, Jones NS: Retrospective review of augmentation rhinoplasties using autologous cartilage grafts. *J Laryngol Otol* **114**:514–518, 2000
7. Cardenas-Camarena L, Guerrero MT: Use of cartilaginous autografts in nasal surgery: 8 years of experience. *Plast Reconstr Surg* **103**:1003–1014, 1999
8. Chaffoo RAK, Goode RL: Irradiated homologous cartilage in augmentation rhinoplasty. In: Stucker FJ Eds. Plastic and reconstructive surgery of the head and neck, proceedings of the Fifth International Symposium. BC Decker, Philadelphia, pp 297–305, 1989
9. Collawn SS, Fix J, Moore JR, Vasconez LO: Nasal cartilage grafts: More than a decade of experience. *Plast Reconstr Surg* **100**:1547–1552, 1997
10. Conrad K, Gillman G: A 6-year experience with the use of expanded polytetrafluoroethylene in rhinoplasty. *Plast Reconstr Surg* **101**:1675–1683, 1998
11. Crumley RL: Editorial footnote. *Arch Otolaryngol Head Neck Surg* **119**:30–31, 1993
12. Deva AK, Mertern S, Chang L: Silicone in nasal augmentation rhinoplasty: A decade of clinical experience. *Plast Reconstr Surg* **102**:1230–1237, 1998
13. Donald PJ, Col A: Cartilage implantation in head and neck surgery: Report of a national survey. *Otolaryngol Head Neck Surg* **90**:85–90, 1982
14. Donald PJ: Cartilage grafting in facial reconstruction with special consideration of irradiated grafts. *Laryngoscope* **96**:786–807, 1986
15. Erol OO: The Turkish delight: A pliable graft for rhinoplasty. *Plast Reconstr Surg* **105**:2229–2241, 2000
16. Gibson T: The distortion of autogenous cartilage grafts: Its causes and prevention. *Br J Plast Surg* **10**:257–262, 1957
17. Gryskiewicz JM, Rohrich RJ, Reagan BJ, Schwartz BM: The use of alloderm for the correction of nasal contour deformities. *Plast Reconstr Surg* **107**:571, 2001
18. Hiraga Y: Complications of augmentation rhinoplasty in the Japanese. *Ann Plast Surg* **24**:495–499, 1980
19. Juraha LZ: Experience with alternative material for nasal augmentation. *Aesthetic Plast Surg* **16**:113–140, 1992
20. Kridel RW, Konior RJ: Irradiated cartilage grafts in the nose. A preliminary report. *Arch Otolaryngol Head Neck Surg* **119**:24–30, 1993
21. Lefkovits G: Irradiated homologous costal cartilage for augmentation rhinoplasty. *Ann Plast Surg* **92**:317–327, 1990
22. McKinney P, Loomis MG, Wiedrich TA: Reconstruction of the nasal cap with a thin septal graft. *Plast Reconstr Surg* **92**:346–351, 1993
23. Murakami CS, Cook TA, Guida RA: Nasal reconstruction with articulated irradiated rib cartilage. *Arch Otolaryngol Head Neck Surg* **117**:327–330, 1991
24. Ortiz-Monasterio F, Olmedo A, Oscoy LO: The use of cartilage grafts in primary aesthetic rhinoplasty. *Plast Reconstr Surg* **67**:597–605, 1981
25. Ramirez OM, Pozner JN: The severely twisted nose. Treatment by separation of its components and internal splinting. *Clin Plast Surg* **23**:327–340, 1996
26. Rohrich RR, Hollier LH: Use of spreader grafts in the external approach to rhinoplasty. *Clin Plast Surg* **23**:255–262, 1996
27. Romo 3rd T, Sclafani AP, Sabini P: Use of porous high-density polyethylene in revision rhinoplasty and in the platyrrhine nose. *Aesthetic Plast Surg* **22**:211–221, 1998
28. Schuller DE, Bardach J, Krause CJ: Irradiated homologous costal cartilage for facial contour restoration. *Arch Otolaryngol* **103**:12–15, 1977
29. Sevin K, Askar I, Saray A, Yormuk E: Exposure of high-density porous polyethylene (Medpor) used for contour restoration and treatment. *Br J Oral Maxillofac Surg* **38**:44–49, 2000
30. Smith JW, Kawamoto HK: Saddle nose deformity. Symposium on aesthetic surgery of the nose, ears and chin. CV Mosby, Saint Louis, pp 91–95, 1973
31. Stoksted P, Ladefoged C: Crushed cartilage in nasal reconstruction. *J Laryngol Otol* **100**:897–906, 1986
32. Tardy ME, Denneny J, Fritsch MH: The versatile cartilage autograft in reconstruction of the nose and face. *Laryngoscope* **95**:523–533, 1985
33. Toriumi DM: Autogenous grafts are worth the extra time. *Arch Otolaryngol Head Neck Surg* **126**:562–564, 2000
34. Tzadik A, Gilbert SE, Sade J: Complications of submucous resections of the nasal septum. *Arch Otorhinolaryngol* **245**:74–76, 1988
35. Welling RO, Maves MD, Schuller DE, Bardach J: Irradiated homologous cartilage grafts, long-term results. *Arch Otolaryngol Head Neck Surg* **114**:291–295, 1988
36. Dingman DB, Grabb WC: Costal Cartilage homografts preserved by radiation. *Plast Reconstr Surg* **50**:516, 1972
37. Dingman DB, Grabb WC: Costal Cartilage homografts preserved by radiation. *Plast Reconstr Surg* **28**:562–570, 1961