

Use of Costal Cartilage Allografts in Cartilaginous Tissue Reconstruction

Costal Cartilage Clinical Review

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Abstract

Allograft costal cartilage may be used for the surgical reconstruction of damaged cartilaginous tissue. Its use has been proven to be effective for a variety of reconstructive procedures including microtia, orbital floor defects, and primary and revision rhinoplasty. In order to lower the risk of disease transmission, allogenic cartilage may be treated with gamma irradiation. The articles reviewed below support the clinical use of irradiated allogeneic costal cartilage in reconstructive procedures.

Background

Traumatic, genetic, and iatrogenic deformities of nasal or auricular cartilaginous tissue are some of the primary reasons for reconstructive surgery. Because cartilage is inherently flexible and malleable, it is difficult to create a natural substitute for its repair and replacement. Cartilage substitutes may originate from autograft, allograft, or synthetic sources, each with inherent advantages and limitations. Synthetic cartilage products, for example, purport to be non-toxic and non-immunogenic while maintaining proper support and aesthetic qualities. However, synthetic materials are subject to complications due to lack of biocompatibility and infections [1]. Autologous costal cartilage grafts are often considered the “gold standard” because they eliminate concerns regarding biocompatibility and immunogenic response [2]. However, they risk greater rate of complications due to donor site morbidity which may lengthen rehabilitation time and decrease quality of life [3]. An additional issue with autologous cartilage is limited availability due to patient-dependent health or preference. These challenges have increased the use of costal cartilage from allograft sources. Please note that in costal cartilage literature, allograft tissue is frequently referred to as “homograft” and those terms will be considered interchangeable here. Allografts are natural human matrices, available in a variety of configurations, and are readily shaped for custom fit on a patient-to-patient basis for a particular clinical procedure. Sterility is also of utmost importance when utilizing allograft transplants, due to the potential of disease transmission and infection. Thus, allografts may be disinfected or sterilized through the use of various processes, with gamma irradiation being a common method used to sterilize human tissues. In this review, the use of irradiated costal cartilage allografts/homografts in a variety of clinical applications is detailed.

Literature Review Data of Irradiated Homograft Costal Cartilage (IHCC) in Reconstructive Surgery

Allograft costal cartilage is a relatively new surgical option but has risen in demand over the past decade as the medical field discovers new ways to utilize its advantageous properties: biocompatibility, structural support, and malleability. The following studies provide solid evidence for the use of allograft costal cartilage as a viable alternative to both autograft and synthetic materials in cartilaginous tissue repairs.

- ❖ **Kridel RW, Sturm AK. Dorsal augmentation with homologous rib. *Facial Plast Surg.* 2017;33(2):195-201.**

Kridel and Sturm [4] examined different grafting options for dorsal augmentation used to reconstruct and raise the nasal dorsum in patients with dorsal saddling due to trauma, infection, or previous nasal surgery, as well as in patients with a narrow, congenitally low, and/or wide dorsum. The article specifies that IHCC grafts for rhinoplasty are durable and provide enough cartilage for the surgeon to mold and contour the graft to meet the patient's specific needs. The authors state that "IHCC is readily available, conveniently stored, easy to carve, and relatively inexpensive" and it can also "provide adequate volume as well as support." In a previous study, Kridel et al showed that the rate of complications associated with cartilage grafting was 3.25% in a study with over 941 IHCC grafts. The complications included infection, warping, infective and noninfective resorption, mobility, and extrusion. In a long-term follow-up, Kridel and Sturm concluded that the use of IHCC grafts proved to be a successful alternative to using patient-derived rib cartilage for dorsal augmentation. The authors concluded that the irradiation processing of the grafts and lack of immunogenic effects makes IHCC grafts "a reliable, safe, and readily available grafting material" that has been "proven to be associated with low rates of warping, infection, resorption, and extrusion."

- ❖ **Kridel RW, Konior RJ. Irradiated cartilage grafts in the nose a preliminary report. *Arch Otolaryngol Head Neck Surg.* 1993;119(1):24-30.**

Kridel and Konior [5] reported on the use of 306 IHCC grafts in the reconstruction of 122 nasal augmentation procedures between January 1, 1984 and December 31, 1990. IHCC was used in all patients over autogenous cartilage, either due to limited donor tissue availability or patient's objections to donor site morbidity surgery. High-quality photographs were taken of the patient's profile view to provide comparison from preoperative to postoperative stages. Palpitation was also performed pre- and postoperatively to assess for graft integrity and degree of graft resorption. Resorption was classified as a percentage and also as short term (less than three months) or long term (more than three months). Reasons for surgery ranged from correction of deficiencies during primary rhinoplasties to reconstruction of severe posttraumatic deformities. The follow-up period averaged 15 months, with the latest follow-up at 84 months, and a total of 13 complications were

observed in 122 operations. There were four cases of infection, including one that resulted in short term resorption, all observed early in the postoperative period. Different suture material was used for the remaining 62 patients in the series and no infection occurred during the follow-up period. Non-infectious, long-term graft resorption was observed in two patients, both with dorsal onlay grafts, with minimal resorption (0% to 25%). The “low complication rates and negligible resorption rates” observed in this study supported the use of IHCC grafts in nasal surgery and the authors supported the need to extend the follow-up period to further “define the role of resorption and fibrous replacement on the overall success of IHCC in augmentation nasal surgery.”

❖ **Go JY, Kang BY, Hwang JH, Oh KS. Management of chest deformity caused by microtia reconstruction: Comparison of autogenous diced cartilage versus cadaver cartilage graft partial filling techniques. *J Plast Reconstr Aesthet Surg.* 2017;70(1):104-109.**

Go, Kang, et al. [6] investigated the effects of two methods, using either irradiated cadaveric (homograft) cartilage (ICC) or autogenous diced cartilage (ADC), in the prevention of donor site deformity within the chest wall after costal cartilage grafting for microtia reconstruction. The groups were comprised of 24 patients with ADC and 18 patients in the ICC group. After costal cartilage grafting from either the sixth or seventh rib for microtia reconstruction, the empty perichondrial space was then filled with either autogenous diced cartilage or irradiated cadaver cartilage. Post-operative data from digital photographs and rib cartilage three-dimensional computed tomography (3D-CT) were analyzed after 20 months for the ADC group and 24 months for the ICC group to compare the preventive effect of donor site deformity. No complications were observed during surgery. The results were analyzed using a graded scale (grade I: 0-25%, grade II: 25-50%, grade III: 50-75%, grade IV: 75-100%) with 0% denoting the postoperative absence of costal cartilage and 100% denoting a postoperative costal cartilage volume equivalent to the preoperative volume. There were no signs of wound dehiscence or infection for either group. The ADC group had numerous incidences of noticeable chest wall deformation, covering all grades of severity. Ten patients showed postoperative costal cartilage volume of less than 50% from preoperative volume, and 12 patients had over 50% of postoperative costal cartilage volume as denoted above. Alternatively, the homograft ICC group grafts rated exclusively higher grades (III and IV), and showed no external evidence of chest wall deformity. The authors concluded that using the ICC technique over ADC leads to “less intercostal space narrowing and chest wall depression” and is “effective in preventing chest wall deformity after costal cartilage grafting.”

❖ **Kridel RW, Ashoori F, Liu ES, Hart CG. Long-term use and follow-up of irradiated homologous costal cartilage grafts in the nose. *Arch Facial Plast Surg.* 2009;11(6)378-94.**

In this retrospective review by Kridel, Ashoori, Liu, and Hart [7], post-operative data was gathered from 357 patients who underwent primary or revision rhinoplasty using IHCC

grafts. Grafts were evaluated for post-operative complications and patient-satisfaction rates were available from 42 patient files. The authors concluded that IHCC is a well-tolerated grafting material in rhinoplasty and yielded optimal functional, structural, and cosmetic results in complex and challenging operative cases. Kridel et al stated that “not only did very few complications occur following the use of 1025 IHCC grafts in 357 patients after 386 rhinoplasties over 24 years (rate, 3.25%), but the rate of complications was no greater than rhinoplasty complication rates when AC grafts are used”. Results from this follow-up study indicate “safety and reliability and justify the convenient use of IHCC grafts for primary and revision rhinoplasty without creating donor site morbidity often seen in autologous cartilage grafting procedures.”

❖ **Bevivino JR, Nguyen PN, Yen LJ. Reconstruction of traumatic orbital floor defects using irradiated cartilage homografts. *Ann Plast Surg.* 1994;33(1):32-37.**

The authors conducted a review of 31 patients who underwent reconstructive surgery with IHCC to address orbital floor defects due to blunt trauma to the craniofacial region [8]. The authors examined 21 patients, recorded photographic documentation, during long-term follow-up from 18 to 48 months. There were no cases of graft infection and only one patient experienced any complications within the follow-up period. The patient developed maxillary sinusitis that did not lead to graft removal. Even though a number of the grafts were implanted through severe lacerations on the patient, the IHCC grafts were still well tolerated within the periorbital tissues. The authors stated that “the use of irradiated cartilage in selected sites combines off-the-shelf availability with avoidance of a second surgical site and the superiority of biological materials for optimal reconstruction.”

❖ **Karimi-Yazdi A, Sadr-Hosseini M, Sadeghi M, Sazgar AA, Safikhani R. Comparison of microtia reconstructive surgery with autograft versus homograft. *Arch Iran Med.* 2007 Jan;10(1):43-47.**

The authors conducted a retrospective study to compare the results of microtia reconstruction with both autograft and homograft costal cartilage grafts. Data included medical records, follow-up notes, and satisfaction questionnaires from September 1992 to December 2002 for 23 patients, all diagnosed with the highest level of microtia [9]. Autograft cartilage was used in nine cases with a single-stage procedure, while homograft cartilage was used in fourteen cases in a two-stage procedure. During the follow-up period, averaging 4 years, postoperative cartilage graft resorption was seen in two (8.7%) cases (one patient in homograft and one patient in autograft group) and cartilage bending was seen in one case of homograft group. Two cases with homograft cartilage resorption and bending were reoperated using new homograft cartilage. No postoperative infections were observed in either group. The status of postauricular sulcus was deemed optimal in 85.5% of homograft and 77.8% of autograft groups. The follow-up questionnaire indicated patient and/or parent satisfaction in 66.7% of autograft cartilage procedures, and 92.9% of homograft cartilage procedures. Even though the homograft cartilage procedures occurred

in multiple stages, they still amounted to less surgical duration than the autograft cartilage procedures. Also, homograft cartilage for microtia reconstruction used in this study was associated with low incidence of early and delayed complications and had comparable surgical results as well as aesthetic appearance to autograft auriculoplasty. The authors stated “that improved clinical results and no need for thoracic surgery for cartilage graft harvest have led to better acceptance of homograft auriculoplasty and satisfaction of the patients and parents.”

❖ **Menger DJ, Nolst Trenite GJ. Irradiated homologous rib grafts in nasal reconstruction. *Arch Facial Plast Surg.* 2010;12(2):114-118.**

Menger and Nolst Trenite [10] conducted a study on the long-term resorption and complication rates for irradiated homologous rib grafts (IHRGs) in rhinoplasty, between November 1998 and August 2005. This study included 66 patients who underwent nasal surgery with a total of 177 IHRGs implanted. Follow-up period ranged from 18 to 96 months after surgery. A majority of the surgeries were revision procedures and the rest were primary rhinoplasties. There were differences between most cases including number of previous surgeries, surgical approach, and patient-dependent variations. Out of 177 nasal grafts, 121 grafts (68%) had no signs of graft resorption and 55 grafts (31%) had moderate resorption (25%-50%). There were 15 patients (23%) who experienced complications other than resorption. No recurrent or chronic infection was observed in any grafts. The study found that nasal IHRGs underwent no or only minimal reduction in volume. Resorption of the graft was characterized by a loss of support function, possibly due to replacement of the original grafts by fibrous scar tissue over time. Because of this, different types of nasal IHRGs had different clinical consequences for resorption. Complete resorption requiring revision surgery was only necessary for one case. The authors concluded from their study that “the use of IHRGs in rhinoplasty resulted in relatively low complication rates” and can be used as a natural alternative to autologous cartilage grafts.

❖ **Yazdi AK, Amali A, Firouzi F. Microtia reconstruction with irradiated homograft costal cartilage: A preliminary report. *Indian J Otol.* 2015;21(1):47-50.**

Yazdi, Amali, and Firouzi [11] conducted a study comprised of 13 patients, with a total of 19 ears, who underwent surgical treatment of type III microtia using IHCC. In the two staged procedure, with the second surgery occurring 3-6 months after the initial procedure, short-term complications (within the first 3 months) included erythema (38.8%), painful swelling (10.5%), and ulceration (5.3%) within the operated ears. Two patients experienced late complications, with one case of homograft cartilage extrusion and the other case was an infection, both treated accordingly without further complications. There were no cases that showed cartilage resorption during the 12-46 month follow-up period. The authors concluded from their study that the IHCC grafts “resulted in relatively high satisfaction and low complication rates for auricular reconstruction.”

Discussion

There are numerous reconstructive procedures where the use of cartilage would be an excellent option. While autogenous cartilage is an attractive option for these procedures, there are challenges including availability, quality, and donor site morbidity. Alternatively, allogeneic, or homograft, costal cartilage may be used in these procedures. These tissues are often sterilized or treated with gamma irradiation to negate the risk of disease transmission from another individual. As reviewed here, the successful use of irradiated allogeneic costal cartilage in a variety of clinical procedures is supported.

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