Reconstruction with Irradiated Homograft Costal Cartilage

Berish Strauch, M.D., and Steven G. Wallach, M.D.

Bronx, N.Y.

The authors present their experience with 51 patients who underwent 55 reconstructive and cosmetic operative procedures with irradiated homograft costal cartilage, who were studied between August of 1988 and June of 2001. The procedures included 52 rhinoplasties and three penile implantations among a total of 130 grafts. Follow-up ranged from 7 months to 12 years. There were two immediate graft exposure complications. Late complications included displacement of the graft in two patients, fracture of the graft in one patient, and partial resorption in one patient at 6 months postoperatively. The experience is described and the literature is reviewed. (Plast. Reconstr. Surg. 111: 2405, 2003.)

In the search for an ideal medium with which to recontour bony and soft-tissue defects, many surgeons have used autograft material such as cartilage from the nasal septum, ears, and ribs. Bone grafts from a variety of sources have also been used. Among the advantages of autograft material are perfect biocompatibility, ease of contouring, and low risk of infection. However, some of the disadvantages include limitation in the tissue supply, various degrees of resorption, difficulty in harvesting, the possibility of significant donor-site morbidity, and prolongation of operating time. In contrast, alloplastic materials have the appeal of no resorption and relative ease of use, but they may lead to significant complications, such as lack of mobility, extrusion, infection, and foreign-body reaction. For these reasons, there has been some frustration with alloplastic implants.

An ideal graft would incorporate many of the advantages described above and eliminate many of the disadvantages. Irradiated homograft costal cartilage satisfies most of the characteristics of the ideal graft. It is readily available, can be very easily contoured, significantly shortens operating time by eliminating graft harvest, avoids donor-site morbidity, and has excellent tissue tolerance.

**Patients and Methods**

Our review represents a retrospective analysis of 51 patients (16 male patients and 35 female patients) who were treated between August of 1988 and June of 2001. A total of 55 operative procedures with 130 irradiated homograft costal cartilage grafts were performed. The ages of patients ranged from 12 to 65 years, and they were followed postoperatively from 7 months to 12 years. Irradiated cartilage was obtained from government-authorized tissue banks. The cartilage blocks were procured from donors, stored in jars with normal saline solution, and then exposed to 3 to 4 million rads of gamma irradiation using a cobalt-60 source for 12 to 14 hours.

Among the 55 procedures performed, there were 52 rhinoplasties and three penile implantations. Reasons for rhinoplasty included cosmetic deformity, airway obstruction, traumatic deformity, congenital deformity, and nasal reconstruction following tumor ablation. Most of the rhinoplasties were carried out through an open approach and the cartilage was secured with permanent sutures. In the first six rhinoplasties and in the penile implantations, the cartilage was placed in a preformed pocket. The reason for penile implantation was to provide a stiffener, after free-flap reconstruction of the penis.
RESULTS

A total of 130 grafts were performed (Table I). Fifty-four percent of the grafts were placed on the dorsum and columella of the nose, and 22 percent were placed as spreader grafts to correct airway obstruction. The immediate complication rate of this series, defined as occurring within 1 month of the operation, was 1.5 percent (two of 130) and consisted of two exposed grafts (Table II). In one case, the spreader graft was not secured in place and the intercartilaginous incision was not closed, resulting in graft exposure that required removal. The other case was a columella graft exposed after deliberate removal of sutures in a free flap that appeared congested; this went on to heal secondarily, without requiring removal of the graft. The total late complication rate in this series, defined as occurring more than 1 month after the operation, was 3.1 percent (four of 130). There was one fractured penile graft, and in two rhinoplasty patients, grafts that were not secured by sutures became displaced. Early in the series, some grafts were not routinely secured by sutures. As a result of these displaced grafts, all subsequent grafts were secured with sutures. In addition, there was partial resorption of one graft demonstrated at 6 months postoperatively.

The irradiated homograft costal cartilage was removed and examined in two cases. In one patient, a displaced cartilage was removed after 7 months; it showed no signs of resorption clinically and had normal architecture histologically. In the other case, the cartilage was removed 7 years after placement in a 12-year-old patient with Binder syndrome whose maturation by age 18 years demonstrated that she had “outgrown” the graft. The original cartilage was removed and replaced with a larger graft (Fig. 1). Clinically, the cartilage appeared exactly the same as when it was placed 7 years previously; however, the specimen could not be properly evaluated using histologic techniques, because it was decalcified in the pathology laboratory, and the cellular details of the graft were washed out. Aside from these two cases, the balance of patients achieved stable and satisfactory correction of their defects.

DISCUSSION

In 1961, Dingman and Grabb1 presented the first clinical experience with irradiated homograft costal cartilage. Seventy patients were treated for facial contour deformities and underwent reconstruction using irradiated homograft costal cartilage over a 4.5-year period; 30 patients returned for follow-up ranging from 7 months to 3.5 years. A total of 30 grafts were used, and graft resorption occurred in only two cases [6.7 percent (two of 30)]. There was no detectable curling or bending of the graft, although graft mobility was demonstrated in two cases [6.7 percent (two of 30)]. Infection did not occur in any of the grafts examined at follow-up, although the authors stated that one patient who was unable to return for follow-up developed a later infection in a mandibular graft. Emphasis on proper contouring of the graft to match the defect exactly was essential for successful aesthetic improvement. A later follow-up by Dingman and Grabb2 of 600 patients over a 15-year period suggests that these grafts were “extremely successful,” although exact documentation of their 15-year follow-up was not quantified.

Kriel and Konior3 reported their results in 122 patients (306 grafts). They categorized the complications as immediate or late, consider-
ing immediate ones to have occurred up to 1 month after operation and late ones to have occurred thereafter. All early complications were caused by infection and were treated with drainage and intravenous antibiotics, which successfully preserved all the grafts. The study by Schuller et al. included a similar definition of early and late complications, with the majority of early complications resulting from infection. These were also treated with systemic antibiotics and antibacterial irrigation, requiring that two of six grafts be removed. Our clinical experience was similar: an immediate complication rate of 1.5 percent and a later complication rate of 3.1 percent (Table III). However, we did not have any infections in our series.

The results of our clinical experience and those previously described\(^1\)\(^{-4}\) differ from those found in animal studies. In experimental animal studies, resorption of the irradiated cartilage is progressive.\(^5\)\(^,\)\(^6\) Several investigators\(^5\)\(^,\)\(^7\) have suggested that the discrepancies between clinical and animal studies may result from the way in which resorption is measured; that is, in animal studies, the exact quantification of remaining cartilage can be determined, whereas in humans, evaluation is limited because direct measurement is difficult without removing the graft surgically.

Donald\(^8\) pointed out that grafts placed over the dorsum of the nose and malar eminence show little resorption, whereas those placed under mimetic muscles may undergo significantly more resorption. This may partially explain why our clinical impression of resorption

<table>
<thead>
<tr>
<th>Study</th>
<th>Immediate (%)</th>
<th>Late (%)</th>
<th>Resorption (%)</th>
<th>Infection (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strauch and Wallach, this study</td>
<td>1.5</td>
<td>3.1</td>
<td>0.7</td>
<td>0.0</td>
</tr>
<tr>
<td>Krodol and Konior, 1993(^5)</td>
<td>1.0</td>
<td>3.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Schuller et al., 1977(^7)</td>
<td>5.5</td>
<td>2.1</td>
<td>1.4</td>
<td>4.8</td>
</tr>
<tr>
<td>Dingman and Grabb, 1961(^1)</td>
<td>-</td>
<td>-</td>
<td>6.7</td>
<td>0.0</td>
</tr>
</tbody>
</table>

\(^8\) Comparison of reported series of irradiated homograft costal cartilage with respect to complications. The results of our series are similar to those previously reported.
is so low because, in our series, the majority of grafts were placed in the nose. Furthermore, Welling et al.\textsuperscript{8} noted that complete resorption of irradiated homograft costal cartilage increased to 75 percent in patients 11 to 16 years after placement of grafts, but they claimed that this did not necessarily correlate with a poor clinical result. Our follow-up may not be long enough to allow for significant resorption to occur, because our longest follow-up period is approximately 12 years. In the one specimen removed 7 years after implantation, no resorption or alteration was noted.

The subject of resorption of the irradiated homograft costal cartilage is controversial; however, successful use of irradiated homograft costal cartilage has been demonstrated in our patient population, with retention of relatively normal cartilage architecture and minimal to no resorption demonstrated. If irradiated cartilage is resorbed over a very long period of time, as reported in one clinical study,\textsuperscript{8} it would appear as if enough significant architecture is retained to maintain cosmetic and functional improvement. In any case, if any cartilage is resorbed, it is believed that the volume deficit is replaced by fibrous tissue; therefore, the functional or cosmetic improvement originally obtained may not be lost.\textsuperscript{3,6,8}

Recently, Adams et al.\textsuperscript{9} analyzed the warping of irradiated and nonirradiated homograft costal cartilage specimens in vitro. They demonstrated warping in all specimens and did not find a significant difference in the warping between irradiated and nonirradiated grafts. We encountered no warping in our series, a finding similar to those of other clinical series.\textsuperscript{1,4,10} The difference may lie in the degree to which the cartilage is irradiated. Our specimens all received a dose of 3 to 4 million rads, whereas the specimens in Adams and colleagues' in vitro study received

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{image2}
\caption{Drawing of placement of columella strut. This is secured between the medial crura with nonabsorbable sutures. It rests on the maxilla and extends past the genu to obtain the desired tip projection.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{image3}
\caption{Drawing of three treatments of the projecting tip of the columella strut.}
\end{figure}
Fig. 4. (Left) Photograph of a patient before rhinoplasty. (Right) Same patient 2 years after rhinoplasty with use of spreader graft and columella post.

Fig. 5. (Left) Photograph of a patient before rhinoplasty. (Right) Same patient 8 years after rhinoplasty, with dorsal onlay and columella post.

A lower dose of 1.5 to 2.5 million rads. This was confirmed by Goode in his clinical series, in which warping was encountered when the irradiation dose was lowered to 2 million rads. No further warping was seen when the higher dose was reinstated.

In our last 21 consecutive cases, a columellar strut was used, which served to provide medial crural stability and tip projection (Fig. 2). The projecting portion of the graft can be carved to provide the required light reflection highlights (Fig. 3). This graft rests
on the maxilla and is secured in two places between the medial crura with nonabsorbable sutures. We have not seen the necessity for using Kirschner wire fixation in addition to the sutures.

**CONCLUSIONS**

Use of irradiated homograft costal cartilage for functional, traumatic, and aesthetic recon-
struction of the nose is recommended. It is specifically recommended for correction of contour defects and structural support (Figs. 4 through 7). The early and late complication rates are low, and the correction is stable over a prolonged postoperative period. We believe irradiated homograft costal cartilage has most of the characteristics of an ideal graft for nasal surgery in that it is readily available, is easily contoured for a variety of defects, and has yielded a low rate of complications in our study. The absence of donor-site morbidity and the shorter surgical time required in the absence of surgical harvesting are added significant advantages.

Barish Strauch, M.D.
Montefiore Medical Center
111 East 210th Street
Bronx, N.Y. 10467-2490
bstrauch351@pol.net

REFERENCES