


Original Investigation

Comparison of Microtia Reconstruction Outcomes Using Rib Cartilage vs Porous Polyethylene Implant

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IMPORTANCE Auricular reconstruction is a unique blend of cosmesis and functionality. The choice of the optimal framework material to use is an important decision for the patient with microtia.

OBJECTIVE To evaluate and compare the outcomes of reconstruction of microtia using porous polyethylene implants and rib cartilage grafts.

DESIGN, SETTING, AND PARTICIPANTS Retrospective medical record review from January 1, 2001, through December 31, 2012, at a tertiary academic institution. Thirty-five patients (36 ears) undergoing microtia repair were divided into groups using high-density porous polyethylene (17 ears), rib cartilage (17 ears), and both materials (2 ears). Only patients with completed repair were included in the analysis.

EXPOSURES Reconstructive surgery for microtia.

MAIN OUTCOME AND MEASURES We compared groups in terms of mean number of operations, age at treatment initiation, and complications (infection, extrusion, cartilage exposure, and pneumothorax). Photographs were graded by blinded observers to give each patient a score on protrusion, definition, shape, size, location, and color match.

RESULTS The cartilage group was older than the polyethylene group (mean age, 8.0 vs 6.9 years; $P = .23$). The mean number of operations was 4.88 for the cartilage group vs 3.35 for the polyethylene group ($P = .004$). Two patients in the polyethylene group had postoperative infections and implant extrusion and underwent subsequent reconstruction with cartilage grafts. Patients in the cartilage group had no infection or extrusion; 1 had a minor cartilage exposure. No patient had pneumothorax. Patients in the polyethylene group had significantly better grades for ear definition and size match, whereas those in the cartilage group had a significantly better color match. Patients in the cartilage group had better protrusion and location outcomes, although the difference was not significant.

CONCLUSIONS AND RELEVANCE Comparison of reconstruction with porous polyethylene implants and rib cartilage grafts showed neither material to be clearly superior. Polyethylene implants may achieve a better cosmetic outcome in the categories of ear definition, shape, and size with a higher risk for infection and extrusion. Patients in the cartilage group were older and underwent significantly more surgical procedures, which should factor into the decision on which technique to choose.

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Since the 1950s, the criterion standard for microtia repair has been a 4-stage technique using costal rib cartilage grafts developed by Tanzer¹ and Rueckert et al² and popularized by Brent.^{3,4} Costal cartilage has the benefits of durability, a low infection rate, and good cosmetic outcomes in experienced hands.

The classic technique involves 4 different operations timed 6 months apart. The first stage occurs at 5 or 6 years of age, when the cartilage of the chest wall is large enough to allow carving a framework to match the size of the normal ear. This stage is associated with scarring, pain in the chest wall, possible pneumothorax, and possible residual chest wall deformity. The second, third, and fourth stages are less complicated but do involve local flaps and at least 2 skin grafts. This technique is plagued by rather poor projection of the ear. Partial resorption of cartilage and lack of definition are common. During the last 2 decades, 2-stage procedures described by Nagata^{5,6} and Firmin⁷ have become popular. These techniques allow early positioning of the lobular segment and complete reconstruction of the framework and tragus in the first stage.

A high-density porous polyethylene (Medpor; Stryker) has a durable shape that integrates well with soft tissues, making it less apt to become exposed than materials previously used for implants. Since 2006, Romo et al,⁸⁻¹⁰ Reinisch and Lewin,¹¹ Berghaus et al,¹² and Yang et al¹³ have reported successful ear reconstruction using porous polyethylene as a substitute for rib cartilage. The polyethylene implant technique typically requires 2 or 3 stages spaced 4 months apart. The implant is covered with a temporoparietal flap, which is then covered by a skin graft. Because rib cartilage is not used, no chest morbidity results, and reconstruction can begin earlier, at 3 or 4 compared with 5 or 6 years of age. Reconstruction may be completed within 4 compared with 18 months. Because a temporoparietal flap is raised, however, the potential for temporary or permanent hair loss exists. In addition, polyethylene is an alloplastic material that has a higher rate of extrusion and infection.

Limited information exists comparing outcomes of standard rib cartilage reconstruction with those of polyethylene implantation, particularly from the same surgeon and institution. We believed that the polyethylene implant resulted in better projection and definition of the auricle but had a greater possibility of extrusion and infection. The objective of this study was to evaluate various outcomes of each method of reconstruction to help the physician and the patient decide which option is best for them.

Methods

Institutional review board approval for the study was obtained from The University of Texas Southwestern Medical Center. A total of 35 patients (36 ears) who underwent microtia repair by a single surgeon (J.L.) from January 1, 2001, through December 31, 2011, were divided into groups receiving polyethylene implants (17 ears), rib cartilage grafts (17 ears), and both materials (2 ears). We included only those patients who underwent complete microtia repair. After 2006, the advantages and disadvantages of each technique were discussed at

length with each patient and family. Photographs and drawings were used to help with the decision process. The family decided in each case which technique was used.

Both techniques started from a radiograph template made from the normal ear or, in the case of bilateral microtia, a family member's ear. With the polyethylene implant technique, the ipsilateral side of the head was shaved and the course of the superficial temporal artery was marked. A 12 × 12-cm flap of temporoparietal fascia was harvested through a transverse incision near the superior temporal line. A skin pocket was raised via a curvilinear incision at the hairline past the remnant lobule. The fascia flap was then passed through the hairline incision. Using the template as a guide, the auricular framework was trimmed into the appropriate shape and assembled with 4-0 clear nylon sutures. The implant was placed in the skin pocket and covered with the temporoparietal flap. A full-thickness skin graft taken from the abdomen then covered the flap. Drains were placed under the implant and scalp and left in for 3 days. Patients wore a semirigid ear protector for 1 month. Four months later, a Z-plasty was performed to place the lobule in its correct position.

For the cartilage graft technique, cartilage from the contralateral sixth, seventh, and eighth ribs were harvested. Using the template as a guide, the conjoined sixth and seventh ribs were carved to form the antihelix, scapha, and fossa triangularis. The largest "extra" piece was conserved to form a wedge at a later date. The eighth rib was thinned and curved to form the helix. The framework was assembled with 4-0 nylon sutures. Next, a vertical incision was made anterior to the microtic ear. Most remnant cartilage was excised and discarded. Dissection was performed peripherally in the subcutaneous plane. The wedge cartilage was inserted posteriorly, behind the framework. The skin was closed over 2 drains, which were removed after 3 days. Six months later, a Z-plasty moved the lobule to its appropriate position. The third stage occurred 6 months later. The ear was elevated from the side of the head. The wedge cartilage was left pedicled on a strip of temporoparietal fascia and rolled anteriorly. The postauricular gap was covered by a full-thickness skin graft taken from the abdomen. Several months later, a stage 4 procedure might be performed in which the concha was excavated, hair-bearing skin was removed, or a tragus was developed.

We compared the groups in terms of the mean number of operations, age at start, and various complications, including infection, extrusion, cartilage exposure, and pneumothorax. Anterior and lateral preoperative and postoperative photographs of each patient were analyzed and graded on a 5-point scale by 2 blinded observers (J.G. and K.L.). These grades were then used to calculate a mean score on protrusion, definition, shape, size, location, and color match for each patient. $P < .05$ was used to determine significance in the statistical analysis.

Results

All patients undergoing reconstructive surgery had grade 2 or grade 3 microtia. Six patients in the polyethylene group had grade 2 microtia compared with 5 in the cartilage group. Three

patients in each of these groups had undergone atresia repair (canal reconstruction) by the time their photographs were evaluated. Age at the start of surgery is shown in Table 1. A Wilcoxon signed rank, 2-sample analysis of age at the start of reconstruction in the polyethylene and cartilage groups showed the cartilage group to be slightly older, but the difference was not significant ($P = .23$). The total number of reconstructive procedures performed in each group is shown in Table 1. The patients undergoing cartilage reconstruction had significantly more operations ($P = .004$).

We compared the frequency of complications, including infection, extrusion of the implant, cartilage exposure, and pneumothorax in each group, as shown in Table 2. These results reveal a trend of higher rates of infection and extrusion in patients undergoing reconstruction with a polyethylene implant. One minor cartilage exposure occurred in the cartilage group; the complication was treated in a clinical setting without anesthesia by superficial debridement and subsequent healing by secondary intent. Pneumothorax was not present in any of the patients in the study.

Grading of the preoperative and postoperative photographs by the 2 blinded observers was analyzed with a Wilcoxon signed rank test for protrusion, ear definition, shape, size, location, and color match. The mean score of each variable on a scale of 1 to 5 (5 being best result) is shown in Table 3. Ear protrusion and location achieved slightly better grades in the cartilage group, but the difference between groups was not significant ($P = .31$ and $P = .75$, respectively). Definition and shape of the reconstructed ear achieved better grades in the polyethylene group ($P = .05$ and $P = .08$, respectively). Size of the reconstructed ear achieved a better grade in the polyeth-

ylene group ($P = .05$), and color match was better in the cartilage group ($P = .05$).

Discussion

Tanzer¹ described his experience with 44 patients undergoing microtia reconstruction with costal cartilage reconstruction; he reported no incidence of cartilage extrusion and no long-term complications aside from chest wall deformity, suture extrusion, and loss of auricular definition. In a review of that patient population since the author's retirement in 1970,² lasting results were found with autogenous cartilage auricular reconstructions. No cartilage distortion was found in his patients, and most patients were satisfied with their cosmetic outcome. Brent³ also reported his experience using costal cartilage for microtia reconstruction with 1200 cases and similar success with minimal complications and no failures, even for ears involved in trauma. In another study, Brent⁴ reported that after postoperative day 10, no loss of autogenous ear framework was observed in more than 70 reconstructed ears surviving major trauma.

The study by Williams et al¹⁴ of the soft-tissue response after exposure to porous polyethylene in rabbits showed fibrous ingrowth by day 24 with only 1 extrusion. Subsequent split-thickness skin grafts applied to the exposed implants showed a high rate of graft survival. The authors concluded that polyethylene implants are a good option for replacement of cartilage in auricular reconstruction. The most likely reason for this finding is the ability of the implant to act like native tissue with limited foreign-body reaction.

Table 1. Patient Characteristics

Study Group	Age at Start of Reconstructive Surgery, y		Total No. of Procedures per Patient	
	Mean (SD)	Median	Mean (SD)	Median
Porous polyethylene implant	6.9 (3.0)	6.1	3.35 (1.27)	3.00
Rib cartilage graft	8.0 (3.8)	8.0	4.88 (1.54)	5.00
Both techniques	6.1 (1.5)	6.1	7.50 (3.54)	7.50

Table 2. Complications of Microtia Reconstruction

Study Group	Complication, No. of Ears			
	Infection	Extrusion	Cartilage Exposure	Pneumothorax
Porous polyethylene implant	1	1	0	0
Rib cartilage graft	0	0	1	0
Both techniques	2	2	0	0
All	3	3	1	0

Table 3. Mean Grade Based on Preoperative and Postoperative Photographs^a

Study Group	Characteristic, Grade					
	Protrusion	Definition	Shape	Size	Location	Color
Porous polyethylene implant	3.62	3.53	3.71	4.32	4.24	3.88
Rib cartilage graft	3.88	3.06	3.21	3.94	4.26	4.18
Both techniques	3.75	3.00	3.50	4.00	4.00	3.75

^a Grades were obtained by 2 blinded observers (J.G. and K.L.) who rated anterior and lateral views of the reconstructed ears on a scale of 1 to 5 (5 being best result).

Romo et al⁸ described outcomes with an approach that combined porous polyethylene and a bone-anchored hearing aid. In that study, 25 patients (28 ears) underwent evaluation for cosmetic results and complications after a 2-staged reconstruction. During the first stage, a polyethylene framework was placed under a temporoparietal fascia flap, followed by a second stage for lobule transposition and placement of the hearing aid. All patients were satisfied with the cosmetic appearance, and no major complication such as infection, extrusion, loss of implant, or flap necrosis was seen. Romo et al^{9,10} continued to demonstrate good aesthetic results and reduced morbidity with polyethylene implants compared with cartilage grafts. Reinisch and Lewin¹¹ showed that ear reconstruction with porous polyethylene implants on 786 ears during an 18-year span had a rate of exposure of 7% and an implant fracture rate of 3% using a temporoparietal flap with underlying subgaleal fascia. This method allowed for earlier implants and a good aesthetic outcome. Berghaus et al¹² also described using porous polyethylene implants for improved tissue projection and better matching to the opposite ear. In a similar method, Yang et al¹³ reported using a 2-flap method, using a temporoparietal flap and a skin flap for coverage of the polyethylene implant. Tissue expanders were used in the mastoid region for creation of an adequate skin flap. No framework extrusions were reported with this method.

The hypothesis for this study was that porous polyethylene offers superior cosmetic results to rib cartilage, despite its risks. At our institution, patients and their families are counseled extensively in this regard and given the option of one method or the other. Many choose the polyethylene implant technique, understanding that when successful, a realistic-looking ear is achieved and remains so for a long period. Others, wary of the risks for infection and extrusion, choose the rib cartilage graft technique.

The data from our analysis show that porous polyethylene ears have significantly better definition and size match than a classic rib cartilage reconstruction; why remains unclear. With both techniques, a template is made from a normal ear and used to model the reconstructed ear. The temporoparietal fascia/skin graft may provide a thinner cover for the framework, allowing better visualization of the underlying structural framework. Over time, some subtle softening or resorption of the cartilage edges may occur in the cartilage group. Contracture of overlying tissue occurs after auricular reconstruction and has been a factor limiting the use of resorbable implants seeded with autologous chondrocytes. Porous polyethylene may be slightly more rigid than rib cartilage and thus better able to withstand the significant amount of scar contracture caused by the surrounding skin/soft-tissue envelope.

Two blinded observers graded the postoperative photographs in terms of symmetric ear projection on anterior view. We expected the porous polyethylene framework would be better able to prevent loss of projection. Surprisingly, we found that ears reconstructed from cartilage had better projection than those using polyethylene implants, although not significantly so. This difference may be due to 2 factors. In the cartilage group, a vascularized cartilage wedge is used at stage 3

to maintain projection, and at stage 4 an otoplasty is often performed on the normal ear to bring it closer to the head.

Children in this study who had auricular reconstruction with rib cartilage were older. This finding is not surprising. Because enough cartilage must be available at the donor site, patients undergoing cartilage reconstruction typically started the process when older (typically 6 years) than those undergoing polyethylene reconstruction. We believe that this difference is an important advantage to the polyethylene implant, because younger patients are not as self-conscious about their deformity. Children often start school at a younger age, and having their reconstruction finished before their peers begin asking questions is helpful.

In our study, the cartilage material provided a significantly better color match than the polyethylene implant, probably because abdominal skin was used to surface the polyethylene ears. Reinisch and Lewin¹¹ performed reconstruction using a polyethylene implant and a full-thickness skin graft from the contralateral postauricular sulcus to cover exposed temporoparietal fascia. The postauricular donor site is then covered with a skin graft from the groin. For most patients in our polyethylene group, however, a full-thickness skin graft was taken from the abdomen to cover the upper and outer portion of the ear. Our early impression was that this provided excellent color and texture match without the need for the morbidity of an additional donor site and additional operative time. These data, however, will probably cause us to reevaluate our technique.

Follow-up in the cartilage group ranged from 2 to 11 years, whereas follow-up in the polyethylene group ranged from 2 to 6 years. Although we observed no long-term problem with fracture, exposure, or infection in each group, whether polyethylene-reconstructed ears retain their good characteristics 30 and 40 years after implantation remains to be seen. Other issues not addressed in this study were the incidence of chest wall deformity using the cartilage graft technique and the incidence of alopecia with the polyethylene implant technique.

Patients undergoing a cartilage graft reconstruction underwent more surgical procedures. The classic cartilage graft technique involves 4 steps compared with 2 for the polyethylene implant technique. In our experience with both techniques, performing more operations than these was the rule rather than the exception. Often, some type of “fine-tuning” was required, such as bringing the normal ear closer to the head or moving a lobule to its normal location in 2 stages rather than 1.

Although complications with either technique are uncommon, infection and extrusion only occurred with polyethylene implants. This risk should be weighed carefully with the possible benefit of a better cosmetic result should the surgeon and family of the patient decide to proceed with the polyethylene implant technique.

Conclusions

To our knowledge, our center is one of the few in which both types of reconstruction of microtia are offered and per-

formed routinely. Based on our analysis, neither the polyethylene implant technique nor the cartilage graft technique was clearly superior to the other. Polyethylene implants may have a better cosmetic outcome at the small risk for infection and extrusion of the implant. Both of our patients with extruded polyethylene implants underwent

successful revision reconstruction with rib cartilage grafts. The decision regarding which technique to pursue is a personal one for the patient and the surgeon performing the procedure. The information from this research will help microtia surgeons counsel their patients more effectively and accurately.

ARTICLE INFORMATION

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Study concept and design: Constantine, Leach.
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Drafting of the manuscript: Constantine, Leach.
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