Original Article

Outcomes of perichondrium and composite cartilage-perichondrium island grafts in type 1 tympanoplasty: A Randomized Controlled Trial

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ABSTRACT

Objectives: In this study we compared patient outcomes after placement of perichondrium and cartilage-perichondrium grafts and explored the advantages and disadvantages of the two graft materials in terms of graft viability and hearing improvement.

Patients and Methods: Sixty patients with chronic otitis media undergoing type 1 tympanoplasty using the underlay technique were randomly divided into two groups, a perichondrium graft (PER) group (n=30) and a cartilage graft (CG) group (n=30). We obtained audiograms; measured pre- and postoperative airway thresholds, air-bone gap gains and anatomical graft success rates, and recorded Middle Ear Risk Index (MERI) scores.

Results: The success rates did not differ significantly between the two groups (PER group [90%, n=27]; CG group [96.7%, n=29]; p>0.05). We found no significant between-group differences in postoperative bone and airway changes, hearing gains, or mean MERI values (all p>0.05).

Conclusion: The success rates of tympanoplasty does not differ between grafts containing perichondrium or island cartilage. Thus, island cartilage grafts should be placed not only in cases at risk but also in those undergoing standard tympanoplasty.

Keywords: Cartilage; hearing; tympanoplasty.

The most common graft materials placed during tympanoplasty are temporal fascia, perichondrium and cartilage.[1] Cartilage metabolism is slow and nutrients are acquired via diffusion. Cartilage is thus stable, and tolerates poor conditions such as negative pressure and eustachian tube dysfunction.[2,3] Therefore, placement of cartilage grafts during tympanoplasty is common. However, perichondrium is strong, thin, and easier to manipulate than cartilage. Many studies have compared temporal muscle fascia and cartilage/perichondrium grafts and found cartilage grafts superior; the operations were successful and the functional hearing gains were good.[4-6]

The objective of this study was to evaluate the effects of cartilage use in tympanoplasty on functional and anatomical tympanoplasty outcomes. We compared patients who underwent type 1 tympanoplasty employing the underlay technique, who received perichondrium or cartilage-perichondrium-composite island grafts. We explored the advantages and disadvantages of the two grafts, and hearing improvements.

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PATIENTS AND METHODS

The study was performed between October 2013 and February 2015 in the Ear, Nose, and Throat Clinic of İzmir Bozyaka Training and Research Hospital. The study was approved by Izmir Bozyaka Hospital Ethics Committee (date of approval: March 24 2015, approval number 13 [N-13]) and adhered to all principles of the Declaration of Helsinki. All patients were told of the nature of the study and gave written informed consent.

Patients with dry perforations caused by chronic otitis media underwent tympanoplasty with placement of either perichondrium or cartilage-perichondrium grafts, and were prospectively evaluated. Patients with chronic suppurative otitis media with cholesteatomas, adhesive otitis media, or who had undergone prior mastoidectomy and/or ossiculoplasty were excluded. Patients who did not undergo type 1 tympanoplasty, who received other types of grafts, and/or for whom the underlay technique was not employed were also excluded.

By definition, tympanic membrane perforations are grouped according to their location on the tympanic membrane. Anterior and posterior parts of the manibrium mallei on the tympanic membrane are named the frontal and back quadrants. Perforations in both quadrants are referred to as central perforations.

The temporal bone was evaluated via axial computed tomography a few days before each procedure. Demographic data were recorded, and audiograms were acquired at one week preoperatively and at six months postoperatively.

Surgery

The perichondrium was dissected from the region of the tragal cartilage furthest from the ear canal, retaining the thin perichondrium of the underside. A chondroperichondrial island flap was constructed. Cartilage was removed using a round knife to produce an eccentric disc about 7 to 9 mm in diameter, which was used for total reconstruction of the tympanic membrane. A posterior perichondrial flap was created that was ultimately draped over the posterior canal wall. Next, an intact strip of tissue (2 mm in width) was removed vertically from the center of the cartilage to accommodate the entire handle of the malleus. Creation of two cartilage islands is essential to enable the reconstructed tympanic membrane to bend, which allows assumption of the normal conical shape. The entire graft was placed in an underlay manner; the malleus was placed into the groove and the graft was pressed down into, and conformed with, the perichondrium. The cartilage was placed toward the promontory, together with the perichondrium that lay immediately adjacent to the remnant tympanic membrane; both lay medial to the malleus. Gelfoam (Pharmacia and Upjohn Company, Kalamazoo, Michigan, USA) was packed into the middle ear space underneath the anterior annulus to support the graft, and the posterior perichondrial flap (please see above) was draped over the posterior canal wall. Another piece of Gelfoam was placed lateral to the reconstructed tympanic membrane. Antibiotic-containing ointment was placed in the ear canal.

Study protocol

Sixty patients undergoing type 1 tympanoplasty to treat chronic otitis media were enrolled. The patients were randomized into two groups, a perichondrium graft (PER) group (n=30) and a cartilage graft (CG) group (n=30). Type 1 tympanoplasty was performed employing a postauricular incision and the underlay technique. Middle Ear Risk Index (MERI) scores were calculated and evaluated as described by Kartush.[7]

All patients were followed-up for six months and underwent otoscopy and otomicroscopy when necessary. Patients were checked weekly for three weeks postoperatively. Audiograms recorded at one and six months postoperatively were studied. The audiograms revealed airway conduction thresholds, air-bone gaps (ABGs), and bone conduction thresholds at 500, 1,000, 2,000, and 3,000 Hz. The anatomical extents of graft involvement and the MERI scores were also compared between the two groups. An anatomically intact graft evident at six months postoperatively was considered a successful outcome.

Table 1. Data on pre- and postoperative air-bone gaps

	PER group			CG group				
	Mean±SD (dB)	Median (dB)	Min-Max	Mean±SD (dB)	Median (dB)	Min-Max	Z	*p*
Preoperative ABG	24.8±10.8	23	6.5-46.5	21.1±9.7	20.5	3-39.5	-1.154	0.249
Postoperative ABG	15.3±8.4	14.25	6-39	13.0±8.4	12.75	1-31	-1.140	0.254
Pre- to postoperative ABG gain	9.6±9.4	9.5	-14 - 26	8.1±8.3	8	-12.5 - 26	-0.281	0.779

PER group: Perichondrium graft group; CG group: Cartilage graft group; SD: Standard deviation; Min: Minimum; Max: Maximum; Mann-Whitney U-test; ABG: Air-bone gap.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics Version 22.0 (IBM Corp., Armonk. NY, USA). Pearson chi-square and Fisher's exact tests were used to compare categorical variables between the groups. The Mann-Whitney U-test and the Kruskal-Wallis H-test (the Mann-Whitney U-test with post hoc Bonferroni correction) were employed for comparisons of continuous variables because these parameters were not normally distributed. The Kolmogorov-Smirnov, Shapiro-Wilk, and Wilcoxon signed rank tests were used to compare pre- and postoperative data using the "two-factor variance analysis for repeated measures" method. A p-value <0.05 was considered to reflect statistical significance.

RESULTS

Perforations in both groups had similar placement on the tympanic membrane. There were 10 (33%) frontal quadrant perforations and two (0.06%) total perforations in the PER and CG groups. There were six (20%) back quadrant perforations in the PER group and eight (26%) in the CG group. There were 12 (40%) central quadrant perforations in the PER group and 10 (33%) in the CG group.

Neither sex nor age significantly differed between the groups (male/female: PER group 16/14; CG group 18/12; age: PER group 35.3; CG group 38.43 years). The mean MERI score of both groups was 3.38±1.08.

On six-month follow-up, four patients still exhibited perforated tympanic membranes

Table 2. Pre- and postoperative data on air-bone thresholds and mean Middle Ear Risk Index scores

	PER group			CG group				
	Mean±SD (dB)	Median (dB)	Min-Max	Mean±SD (dB)	Median (dB)	Min-Max	Z	*p*
Preoperative bone conduction threshold	16.6±12.1	13	5-49.5	20.3±16.3	14.25	5-58	-0.526	0.599
Postoperative bone conduction threshold	14.7±11.5	10.5	3-47.5	18.8±16.5	12.25	3-64	-0.548	0.584
Pre- to postoperative bone conduction gain	1.9±7.1	1.75	-11.5 - 21	1.4±4.2	1.5	-8.5 - 13	-0.304	0.761
Preoperative air conduction threshold	41.4±17.0	38.75	18.5 - 92.5	41.3±16.4	41	14-83.5	-0.185	0.853
Postoperative air conduction threshold	29.9±14.2	25.75	11.5-61.5	31.8±20.1	26.5	4.5-82	-0.007	0.994
Pre- and postoperative airway gain	11.5±11.8	10.75	-10 - 32	9.6±8.9	9.5	-15 - 26	-0.341	0.733
Middle Ear Risk Index	3.3±0.8	3	2-5	3.4±1.3	3	2-7	-0.062	0.951

PER group: Perichondrium graft group; CG group: Cartilage graft group; SD: Standard deviation; Min: Minimum; Max: Maximum.

(PER group three; CG group one). Thus, the anatomical success rates were 90% (n=27) in the PER group and 96.7% (n=29) in the CG group; these numbers did not differ significantly (p=0.746). The pre- to postoperative ABG gains did not differ significantly between the two groups (PER group 9.55±9.44 dB; CG group 8.13±8.28 dB; p=0.779; Table 1).

The PER group had a preoperative average bone conduction threshold of 16.58±12.12 dB; the postoperative threshold was 14.65±11.47 dB. The preoperative average bone conduction threshold of the CG group was 20.25±16.27 dB and the postoperative threshold was 18.83±16.44 dB. The average bone conduction gain (preoperative value minus postoperative value) did not differ significantly between the two groups (PER group 1.93±7.12 dB; CG group 1.42±4.2 dB; p>0.05; Table 2).

The PER group had a preoperative average air conduction threshold of 41.42±17.01 and a postoperative threshold of 29.93±14.21 dB. The values for the CG group were 41.33±16.42 dB and 31.78±20.06 dB, respectively. The postoperative airway gains did not differ significantly between the two groups (PER group 11.48±11.84, CG group 9.55±8.87 dB; p>0.05; Table 2).

DISCUSSION

Various autograft and homograft materials have been used to close tympanic membrane perforations. Autograft materials are preferred because they are readily accessible; the use of homograft materials is also associated with a risk of prion infection. Recently, both perichondrial and cartilage graft materials have become popular, but temporal muscle fascia remains the most frequently used graft material.[8-10]

Temporal fascia can be prepared to any required size and can be formed easily during application. However, the elastic fibers that it contains cause graft shrinkage during healing. If any negative prognostic factors are evident (an advanced middle-ear pathology, a large perforation, Eustachian tube dysfunction, a retraction pocket, or middle-ear atelectasis), and if revision tympanoplasty is being performed, temporal fascia grafting is associated with a low success rate regardless of the placement technique used. Thus, graft materials that exhibit better compatibility with the tympanic membrane and that are more resistant to shrinkage should be used for membrane reconstruction in such patients.[11]

Perichondrial grafting is common today; tissue is obtained from the tragal or conchal cartilage. Perichondrium is more shrinkage-resistant than temporal fascia. However, only a limited amount of tissue is available; this is a disadvantage.[11]

Cartilage grafts can be placed with or without perichondrial tissue; being rigid, such grafts are more resistant to retraction in patients with Eustachian tube dysfunction. It might be assumed that cartilage is an inappropriate graft material because of its thickness, poor sound conduction ability, because cartilage does not vibrate, and the fact that placement of cartilage renders it difficult to detect residual or recurrent middle-ear cholesteatoma. However, to the best of our knowledge, no study has claimed that postoperative hearing problems in patients with cartilage grafts are any worse than those in patients treated via placement of other graft materials. The use of perichondrial island grafts featuring cartilage palisades has been recommended to avoid the abovementioned perceived problems and to increase graft vibration.[12,13]

Cartilage grafts obtain nutrients largely via diffusion, and are highly compatible with the tympanic membrane. Both animal and human studies have shown that cartilage grafts become softer over time, but the matrix remains intact.[14] The thick rigid structure of cartilage renders the tissue resistant to resorption and/or retraction, even when chronic Eustachian tube dysfunction is in play. Therefore, cartilage is preferred not only to treat advanced middle ear pathologies but also in high-risk situations such as patients with atelectatic ear infections, anterior membrane perforations, large perforations greater than 50% of the tympanic membrane, bilateral tympanic membrane perforations, and those requiring revision surgery or surgery on an ear with otorrhea.

Both cartilage graft thickness and the mode of graft preparation can affect hearing. Zahnert et al.[15] showed that the acoustic properties of cartilage island grafts were better than those of palisade and plate grafts, and based on laser Doppler interferometry the first resonance frequency was almost the same as that of perichondrial grafts. Mürbe et al.[16] showed that a sheet of thinned cartilage palisade combined with an island flap <1 mm in depth exhibited even better acoustical properties.

Tympanoplasty with cartilage graft placement might negatively affect middle-ear volume because the graft is thick. However, Aarnisalo et al.[17] found no stroboscopically evident change in middle-ear volume. One pediatric study found that composite cartilage grafts were better than temporal fascia grafts.[18] We obtained similar results in six pediatric patients (aged 10-16 years). In another study, type 1 tympanoplasty was performed in 120 subjects >15 years old without cholesteatoma. A retrospective comparison of temporal muscle fascia, island cartilage, and palisade cartilage grafting revealed that cartilage grafts were optimal in terms of high-level graft incorporation and healing.[19]

Many criteria for graft success have been suggested. Some authors evaluate only membrane grafting, whereas others score membrane robustness with no retraction, a healthy middle-ear cavity, and hearing recovery.[20,21] Here, we considered that perforation closure by six months postoperatively reflected anatomical success. The hearing success criterion was closure of the ABG. We found that the CG group exhibited the best anatomical success rate (almost 97%; the figure for the PER group was 90%). However, the success rates in the two groups did not differ significantly.

We found no significant between-group differences in postoperative improvements in air-bone conduction thresholds or gains, which implies that the use of cartilage does not compromise sound transmission.

Eustachian tube insufficiency is an important cause of postoperative graft failure, as is chronic otitis media. Unfortunately, no definitive method is yet available by which preoperative data can be used to predict early or late postoperative prognoses in terms of mastoid ventilation and middle-ear function. Any blockage, mucosal hypertrophy, or mucoid secretion at the mouth of the Eustachian tube evident during surgery implies Eustachian tube dysfunction. In addition, bilateral chronic otitis media, uncontrolled rhinosinusitis, chronic serous otitis media in the contralateral ear, a cleft palate, and/or other skull base anomalies are indirect markers of poor Eustachian tube function.

The MERI system can be used to assess the prognosis of patients undergoing surgery to treat chronic otitis media. MERI scores do not significantly differ between patients who develop perforated tympanic membranes postoperatively and those who enjoy anatomical and functional success, regardless of the graft type used. Although we lack adequate data, we suggest that MERI scoring is important in terms of prognosis.

A limitation of our study is that, although the success rates in the two groups were similar, the follow-up time was relatively short. The success rates after grafting with perichondrium or island cartilage did not differ. The cartilage graft afforded the same hearing gain as the other graft. We suggest that island cartilage grafts can routinely be placed in cases undergoing standard tympanoplasty, not only in risky cases. The fact that we had very few operative failures rendered us unable to explore whether any failure was attributable to the use of inappropriate graft material.

Declaration of conflicting interests

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