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Double layer crescent graft technique for endoscopic tympanoplasty

M. Aslan[1], U. Düzenli[2]

[1]Mardin State Hospital, Department of Otorhinolaryngology; [2]Yüzüncü Yıl University, Faculty of Medicine, Department of Otorhinolaryngology.

Key words: Chronic otitis media; tympanoplasty; perichondrium-cartilage composite graft; double-layer graft

Abstract. *Objectives:* The main aim of this study was to present the surgical and functional outcomes of tympanoplasty performed using the crescent graft technique.
Methodology: In this research, we used an underlay crescent cartilage-perichondrium composite graft and overlay perichondrium graft to repair tympanic membrane perforation. Pre-operative and post-operative tympanic membrane examinations and hearing evaluations were performed.
Results: A total of 155 patients were included in this retrospective study. The pre-operative hearing threshold was 12.95 ± 3.85 dB and the post-operative threshold 5.7 ± 4.1 dB. The improvement was significant ($p<0.05$). Reperforation was observed in nine patients, graft lateralization in five patients, and graft retraction in four patients at the 1-year follow-up.
Conclusion: Double-layer crescent graft tympanoplasty yielded successful functional and hearing outcomes.

Introduction

Tympanoplasty was first described as reconstruction of the tympanic membrane by Wullstein and Zöllner.[1,2] Partial and/or full thickness skin grafts were initially used for reconstruction but led to skin shedding and scaling. Mesenchymal-derived grafts, such as fascia, perichondrium, and periosteum, were used for reconstruction of the tympanic membrane.[3] Fascia, perichondrium, and cartilage grafts have become more popular over time.

The fascia and perichondrium graft closure rates are undesirably low in cases of adhesive otitis media and eustachian tube dysfunction. Hard durable graft materials have been preferred in these cases.[4] The first use of cartilage in middle ear surgery with ossicular chain reconstruction was announced by Utech.[5] The use of cartilage grafts in revision surgeries has increased. In addition, cartilage grafts have been used with total/partial ossicular replacement prostheses to reduce extrusion rates.[6,7]

Tos described several cartilage tympanoplasty techniques using conchal and tragal cartilage. The overlay, underlay, and inlay techniques were described according to associations between the graft position and tympanic annulus.[8] The different placement techniques have been used together, and this surgical procedure has been described as a sandwich technique.[9] A double-layer graft technique had high success rates.[9]

In our clinical practice, we place a tragal crescent chondroperichondrial graft under the manubrium and tragal perichondrial graft over the manubrium and under the annulus. In the present research, we describe a novel double-layer graft placement technique and demonstrate its outcomes.

Material and methods

This retrospective study was carried out using the medical records of patients who underwent tympanoplasty between January 2015 and April 2017. All procedures involving human participants were performed in accordance with the ethical standards of the institutional and/or national research committee, and with the 2000 Helsinki Declaration

The authors declared that this study received no financial support. No conflict of interest is declared by the authors. Informed consent was obtained from all individual participants included in the study. All procedures performed in studies involving human participants were performed in accordance with the ethical standards of the institutional and/or national research committee and with the 2000 Helsinki Declaration and its later amendments or comparable ethical standards.

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All 155 patients who underwent tympanoplasty were included in this research. The patients were referred to our clinic due to hearing loss and/or persistent draining. The patients had dry ear at least 3 months before surgery. Patients who had middle ear mucosa disease, an ossicular chain problem, cholesteatoma, or tympanic membrane retraction were not included in the study. Each patient underwent pre-operative microscopic and endoscopic ear examination, hearing evaluation, and radiological imaging of the temporal bone. All perforations were central or subtotal type. Closure of the tympanic membrane perforation was performed with a double-layer crescent graft. The surgical procedure was performed by an endoscopic approach without tympanomeatal flap elevation.

Surgical procedure

The patients were treated with surgical asepsis and readied for surgery after general anesthesia. Infiltration with 2% lidocaine and 1:100,000 adrenaline was applied to the tragus. A rigid 0-degree telescope (18 cm long, 4.00 mm; Karl-Storz, Tuttlingen, Germany) was used in all operations. Ossicular chain integrity and mobility were checked endoscopically. The sclerotic perforation margin was removed with a pick. In subtotal perforations, we preferred to bleed the middle ear side of the tympanic membrane with an angled pick instead of removal of the sclerotic perforation margin. The manubrium mallei was de-epithelialized and the tympanic membrane limitedly separated from the manubrium mallei. The separation limit was determined based on perforation size. In subtotal perforations, we only peeled the epithelium on the manubrium mallei. In central perforations, in order to place the perichondrium graft between the manubrium and tympanic membrane, we gently separated the tympanic membrane from the manubrium mallei using a pick. This separation was performed in an area that would fit the graft. A tragal incision was made and the cartilage-perichondrium composite graft and perichondrium graft harvested separately (Figure 1). The cartilage part of the composite graft was thinned for graft preparation. Next, we prepared a crescent cartilage in which the convex side was formed according to manubrium diameter. The middle ear space was filled with gel foam (GelFoam®; Pfizer, New York, USA). The crescent cartilage-perichondrium composite graft was laid under the manubrium and bony annulus (Figure 2) and the perichondrium graft over the manubrium

Figure 1

Separate preparation of the crescent-shaped perichondrium-cartilage composite graft and perichondrium graft.

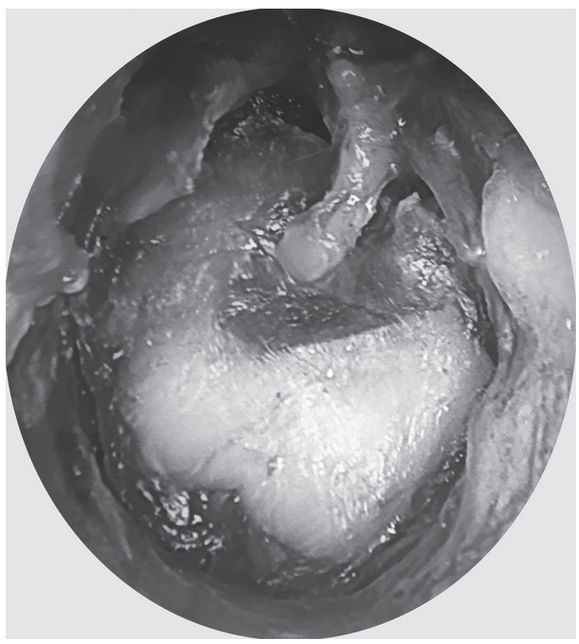

Figure 2

Placement of the crescent-shaped perichondrium-cartilage composite graft under the manubrium and bony annulus.

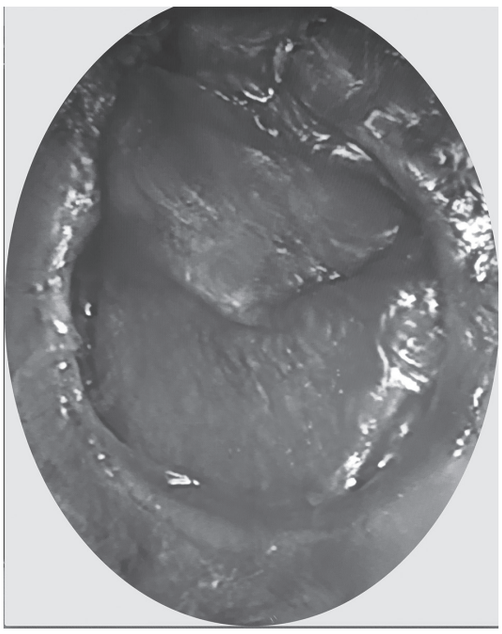

Figure 3

Placement of the perichondrium graft over the manubrium and under the remnant membrane.

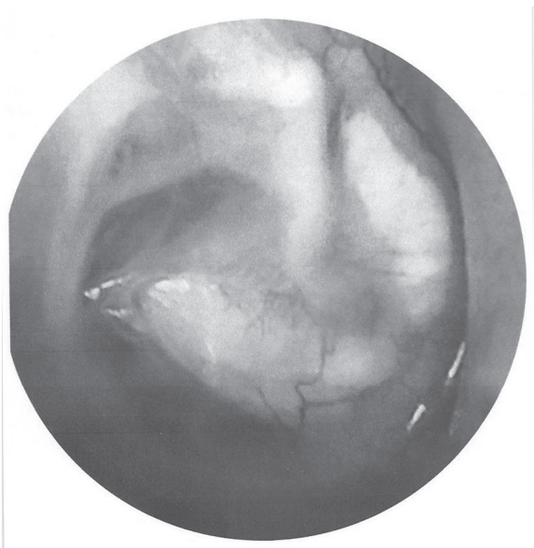

Figure 4

Post-operative 1 year evaluation of the intact tympanic membrane.

and under the remnant membrane (Figure 3). The gel foam was placed on the tympanic membrane to stabilize the graft. Post-operative follow-up of the patients was performed at 1, 3, 6, and 12 months (Figure 4). Ear examinations performed with an otomicroscope and endoscope were repeated, and hearing thresholds determined. The presence of reperforation, graft lateralization, and tympanic membrane retraction was recorded.

Audiological evaluation

Pure-tone audiometric analysis was performed according to the American Academy of Otolaryngology-Head and Neck Surgery guidelines (0.5, 1, 2, 3, and 4 KHz). Pre-operative and post-operative hearing thresholds in year 1 were calculated for each patient.

Statistical analysis

The distributions of the variables were evaluated using the Shapiro-Wilk test. Changes in dependent non-parametric variables were analyzed by the Wilcoxon signed rank test using software (SPSS16.0; IBM Corp., Chicago, USA).

Results

A total of 92 (59.35%) women and 63 men (40.64%) were included in this study. The mean age was 25.55 ± 10.40 years in women and 29.82 ± 9.12 years in men. The age range for the whole sample was 11 to 55 years.

Pre-operative hearing thresholds were 19.20 ± 5.35 dB (range 10-42 dB) at 500 Hz, 17.40 ± 5.10 dB (10-42 dB) at 1,000 Hz, 11.80 ± 3.40 dB (8-34 dB) at 2,000 Hz, and 3.45 ± 1.60 dB (0-15 dB) at 4,000 Hz (Figure 5). The average hearing threshold was 12.95 ± 3.85 dB. The average operation time was 30.2 ± 5.2 minutes. At 1-year follow-up, we observed reperforation in 13 (8.38%) patients, graft lateralization in 9 (5.80%) patients, and graft retraction in 4 (2.58%) patients (Table 1). Post-operative hearing thresholds were 7.60 ± 5.40 dB (range 0-15 dB) at 500 Hz, 7.10 ± 5.10 dB (0-

Table 1

Post-operative tympanic membrane evaluation of the double layer crescent tympanoplasty (n:155).

	Reperforation	*Graft Lateralization*	*Graft Retraction*
1st Month	*0*	*0*	*0*
3rd Month	*8*	*5*	*0*
6th Month	*11*	*9*	*1*
12th Month	*13*	*9*	*4*

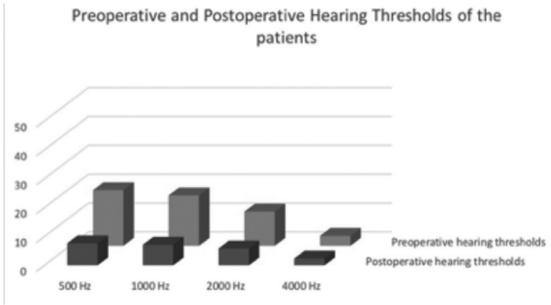

Figure 5

Pre-operative (orange) and post-operative (blue) hearing thresholds of the patients.

14 dB) at 1,000 Hz, 5.85 ± 4.60 dB (0-10 dB) at 2,000 Hz, and 2.35 ± 1.46 dB (0-15 dB) at 4,000 Hz (Figure 5). Hearing improvement was observed after surgery at all frequencies. The changes were significant at 500 Hz, 1,000 Hz, and 2,000 Hz ($p < 0.05$) but not at 4,000 Hz ($p > 0.05$).

Discussion

Temporal muscle fascia, cartilage, and perichondrium are the most commonly used graft materials in tympanoplasty.[10] The advantages of cartilage grafts are high mechanical stability and high graft success rates in cases of eustachian dysfunction, adhesive otitis media, and large perforations.[10] Cartilage grafts provide acceptable acoustic conduction relative to fascia and perichondrium grafts.[10] *Surgeons mostly use tragal or* conchal cartilage for tympanic membrane repair. Tragal cartilage is approximately 1-mm-thick and is an easy-to-shape material for ear surgery.

In the present research, we performed double-layer crescent tympanoplasty and observed 91.6% graft success rates at the 1-year follow-up. We noted that reperforations occurred as a result of perichondrium resorption. Reperforation was detected in five of nine graft lateralization cases. Most of the patients with graft lateralization (n = 6) were in the group in which the technique was first applied; therefore, the problem could be explained by surgical inexperience. Pre-operative hearing thresholds increased at 500 and 1000 Hz compared to 2,000 and 4,000 Hz. Thus, the hearing gain after surgery was more significant at 500 and 1000 Hz. The graft success rate was similar to other studies. In addition, the double-layer crescent technique shortened the surgical time because of non-elevation of the tympanomeatal flap.

Dawes et al.[11] reported a 90% success rate for an onlay graft technique. Failures were due to inadequate/incorrect preparation of the graft material, graft location, incorrect/incomplete insertion, post-operative infection, or inappropriate patient selection. The success rates for fascia grafts have been reported to be 78-92% in various studies.[12-14] Boone et al.[15] reported that the success rate of cartilage tympanoplasty was 94.7% in a series of 90 revision tympanoplasties. In this study, the chance of success was reduced in patients with a perforation rate >50% but increased by using cartilage grafts.[15] *Kazikdaş et al.*[16] reported a 95.7% success rate using the palisade cartilage graft technique and a 75% success rate with the temporal muscle fascia graft technique.

Zahnert *et al.*[10] designed an experimental tympanic membrane model to evaluate the acoustic gains conferred by cartilage grafts. They reported that conchal and tragal cartilage were equally effective. In the same report, the authors suggested that the acoustic gain would be improved if the thickness of the existing cartilage graft was reduced. The graft success rates in cartilage tympanoplasty have been reported to be > 90%,[17,18] though one author reported a 100% success rate with cartilage grafts.[12] On the other hand, Kalcioglu et al.[19] reported that the functional outcomes were similar with cartilage and temporalis muscle fascia grafts.

Cartilage grafts increase mechanical stability compared to fascial grafts because of their hardness and thickness. Although the functional results of cartilage grafts were predicted to be good, the hearing results were inferior to those with other grafts.[20] However, De Seta et al.[21] reported no significant difference in hearing outcome in a study of cartilage and temporal muscle fascia grafts. Dornhoffer et al.[12] reported similar acoustic gain between cartilage and facial grafts, but with the use of cartilage grafts having the disadvantage of concealing pathologies that may develop in the middle ear, such as cholesteatoma. In the present study, we detected no cholesteatoma in microscopic ear evaluations.

We described a double-layer crescent technique comprising the placement of two different graft materials under and over the manubrium. We placed the perichondrium-crescent cartilage composite graft under the manubrium, and the perichondrium graft over the manubrium and under the remnant membrane. With our technique, the

cartilage graft is placed under the bone annulus (underlay) as a crescent shape, and mechanical stability is planned along the wall of the anterior-inferio-posterior line of the annulus and tympanic membrane. In addition, underlay placement of the shaped cartilage leads to transmission toward the handle of the annulus malleus; we aimed to shape a concave-to-inward cone anatomy of the tympanic membrane. Perichondrial grafts can be placed on the existing cartilaginous grafts and manubrium, which may decrease problems, such as thinning of the perichondrium in the long-term and perforation. We think that this repair most closely replicates the layered histological structure of the tympanic membrane. The membrane resistance may also be increased with this technique.

There were some limitations to our study. First, we used a retrospective design, whereas a prospective analysis could provide more meaningful information on the double-layer crescent graft technique. Second, the number of patients was relatively low, and we did not compare the outcomes with tympanoplasty performed using another graft material.

Conclusion

In this study, the functional and hearing outcomes of double-layer crescent tympanoplasty were considered successful. The crescent-shaped composite graft was supported by a separate perichondrium graft, which provided mechanical stability and maintained the elasticity of the graft. Taken together, the findings indicate that double-layer crescent tympanoplasty is a suitable technique for preserving ear anatomy and physiology. More studies with long-term follow-up are needed to further explore this technique.

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Ufuk Düzenli, M.D.
Van Yüzüncü Yıl University,
Faculty of Medicine,
Department of Otorhinolaryngology,
Bardakçı Village,
Van, Turkey
Phone: +905466968609
E-mail: drufukd35@hotmail.com