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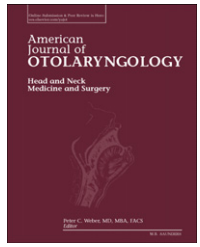

# Evaluation of the anatomical and auditory outcomes of minimally invasive cartilage myringoplasty: Our technique and experience☆

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ABSTRACT

The purpose of this study was to assess closure rates in tympanic membrane perforations of various dimensions using the tragal cartilage-perichondrium composite graft and its effect on hearing values and also to present our own experiences.

**Materials and methods:** Sixty-one patients presenting to our clinic in 2014–2015 and diagnosed with tympanic membrane perforation were included in the study. Otomicroscopic and otoendoscopic examinations were performed preoperatively and at the 12th month postoperatively. Patients were divided into three groups depending on perforation diameter. Pure tone audiometry was performed at 500, 1000, 2000, and 4000 Hz (Hz) preoperatively and at the 12th month postoperatively, air-bone values were recorded, and air-bone gap (ABG) was calculated. Surgery was performed under local anesthesia usıng the transcanal, push-through (transperforation) technique. Perichondrium supported by thinned cartilage graft obtained from the tragal cartilage was used for tympanic membrane repair.

**Results:** Graft acceptance levels after 12 months in small, medium, and large perforations were 100%, 93.5%, and 93.75%, respectively, and 95% on average. Preoperative air-bone gap values were 18.64 ± 9.63 decibel (dB), 22.51 ± 9.66 dB, and 28.43 ± 11.36 dB, respectively, and 23.18 ± 11.36 dB on average, while 12th month postoperative air-bone gap values were 9.14 ± 8.27 dB, 11.25 ± 6.73 dB, and 17.37 ± 9.22 dB, respectively, and 12.37 ± 8.28 dB on average. The difference between pre- and postoperative 12th month air-bone gap values was statistically significant ($p < 0.005$).

**Conclusion:** The use of thinned cartilage-supported perichondrial grafts in patients with all sizes of tympanic membrane perforation is safe and effective in terms of both anatomical healing and restoration of hearing and can represent a first-choice technique that is easy to perform and involves minimal morbidity.



☆ The authors declare that they have no conflict of interest. Informed consent was obtained from all individual participants included in the study.

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## 1. Introduction

Tympanic membrane perforation is a clinical condition that can result from chronic otitis media and trauma and that has an adverse impact on patients' quality of life. The primary approach for surgical reconstruction is type 1 tympanoplasty, otherwise known as myringoplasty, first described by Wullstein and Zollner [1–5].

Various surgical techniques and large numbers of graft materials are today used in myringoplasty surgery. Grafts used for myringoplasty include the temporal muscle fascia, perichondrium, periosteum, and cartilage tissue. The most popular grafts are fascia and cartilage grafts. The characteristics of the graft to be selected represent the most important factors in successful outcomes in both anatomical and auditory terms. The graft must be easy to harvest, durable, preserve membrane stability in the long term, compatible with normal body tissues, and contribute to hearing [5–8]. The surgical technique to be used must be minimally traumatic with minimal morbidity. Other factors that can affect the success of the operation in addition to these surgical factors include the condition of the ear to be operated, Eustachian tube function, and the experience and ability of the surgeon. Many studies have shown that operations using cartilage graft in repair of tympanic membrane perforations are effective in terms of both graft stability and auditory outcomes and involve minimal morbidity [3,7,9].

The purpose of this study was to investigate the auditory and anatomical healing success of the thinned tragal cartilage-supported perichondrial graft in tympanic membrane perforations.

## 2. Materials and methods

The study was performed in 2014–2015 following receipt of our hospital ethical committee approval. Patients with tympanic membrane perforation and conductive-type or mixed-type hearing loss, with dry ears and no ear discharge for at least 3 months, and with normal middle ear mucosa and no ossicular chain defect were included in the study. Detailed ear, nose, and throat examinations were performed, and detailed anamnesis was taken. Complete blood count, full biochemistry and hepatitis, HIV and syphilis tests were performed on all patients. Patients with suppurative otitis and ossicular chain pathology, poor mastoid aeration in the temporal bone tomography, with a history of disease that might delay healing such as anemia, granulomatous diseases, tuberculosis, malignancy, aged below 15 or over 70, or with a previous history of ear surgery were excluded. Sixty-one patients, 37 female and 24 male, were enrolled. Patients were divided into three groups on the basis of preoperative perforation diameters, those with perforations smaller than 1/3 of the area of the tympanic membrane, those between 1/3 and 2/3 of the area of the tympanic membrane, and those with perforations larger than 2/3 of the area of the tympanic membrane.

Written consent forms were obtained from all patients. All patients were operated under local anesthesia using an otomicroscope by the transcanal route. Patients were discharged on the 1st day postoperatively. Ear tampons were removed on the 7th day. Otomicroscopic and otoendoscopic examinations were performed before surgery and on the 12th month postoperatively. Simultaneous 500–4000 Hz pure tone audiograms were requested. Air-bone hearing values were recorded, and air-bone gap (ABG) values calculated. Patient records were established using these data. At the end of the study, anatomical success was defined as graft healing without perforation, retraction, lateralization, or medialization. Auditory success was defined using statistical analysis of the difference between preoperative ABG values and those at the 12th month postoperatively.

### 2.1. Statistical analysis

We performed all statistical analyses on SPSS for Windows, version 17.0, software. Unless otherwise stated, results are expressed as mean ± SD. We used the Mann–Whitney *U* test or independent sample *t* test for comparisons between two subject groups and also the Pearson correlation test or Spearman correlation test, as appropriate. We used multiple regression analysis to exclude possible confounding effects of other variables in the results from each correlation analysis and considered a result of $p < 0.05$ as statistically significant.

### 2.2. Surgical technique

All patients were operated under local anesthesia following sedoanalgesia. Following preoperative preparation with a sterile covering, anesthesia was administered with 2 ml/100.000 subcutaneous lidocaine and adrenalin to the tragal cartilage and four quadrants of the skin of the outer ear passage of the ear to be operated. We then waited for 10 min. The tympanic membrane was visualized with an aural speculum under an otomicroscope. An otoendoscope was used for areas difficult to visualize with a microscope, and the perforated membrane was de-epithelialized with a pick. The diameter of the perforation was calculated approximately using a Rosen round-tipped knife. An incision of approximately 1 cm was made to the skin of the tragal cartilage, and a graft with its convex face covered by perichondrium equivalent to the diameter of the perforation was harvested. A portion of approximately 4 mm was left in order to avoid compromising the cosmetic appearance of the tragal cartilage dome. The graft with one layer of perichondrium was left to dry by stripping the perichondrium. A 2-mm triangular section matching the manubrium malleus on the cartilage portion was removed, and the flexibility of the cartilage was increased with gentle thinning. Absorbable sponge was inserted into the middle ear in order to improve contact between the graft and the remnant membrane. The cartilage graft was held with the help of an alligator forceps, and underlay was inserted medially to the tympanic membrane remnant and the annulus fibrosus by adjusting the section that would coincide with the malleus manubrium by the transcanal and transperforation route. The skin of the external ear canal in those parts of the marginal perforation with no annulus fibrosus and the remnant of the tympanic membrane was elevated and inserted at the level of the tympanic sulcus. The prepared perichondrium was placed as underlay such as to support the remnant membrane not in contact with the cartilage. In cases in which the cartilage was placed at the level of the tympanic

sulcus, the margins of the perichondrium were tucked beneath the skin of the external ear passage. Complete closure was thus achieved (Figs. 1, 2). The cutaneous incision in the tragal region was then sutured. No canaloplasty or general anesthesia was required in any case. A tampon was inserted into the outer ear passage. This was removed 1 week later. Prophylactic amoxicillin + clavulanic acid therapy was given to all patients for 1 week.

## 3. Results

Sixty-one patients were enrolled, 37 (60.7%) female and 24 (39.3%) male. Ages ranged between 15 and 70, with a mean age of 32 ± 10. The numbers of patients with small, medium, and large perforations were 14 (22.9%), 31 (50.9%), and 16 (26.2%), respectively. All patients were operated under local anesthesia via the transcanal-transperforation route. Mean duration of surgery was 40 ± 15 min. Mild postoperative dizziness occurred in 6 (10%) patients, resolving spontaneously with no need for treatment within 4–5 h. No pain sufficiently serious as to cause discomfort was encountered in any patient. All patients were discharged on the 1st day postoperatively.

Residual perforation was observed in three patients on the 12th month of monitoring. These patients later underwent revision surgery with the remaining perichondrial layer. No lateralization, medialization, or retraction was observed. Graft acceptance rates after 12 months in small, medium, and large perforations were 100%, 93.5%, and 93.75%, respectively, and 95% on average.

Preoperative air conduction values in small, medium, and large perforations were 32.50 ± 9.95 dB, 40.09 ± 12.39 dB, and 50.12 ± 13.25 dB, respectively, and 40.98 ± 13.47 dB on average. Air conduction values at the 12th month postoperatively were 20.21 ± 8.82 dB, 26.83 ± 15.52 dB, and 35.00 ± 13.40 dB, respectively, and 27.45 ± 14.48 dB on average.

Preoperative bone conduction values in small, medium, and large perforations were 13.21 ± 4.96 dB, 17.96 ± 9.63 dB, and 21.68 ± 10.52 dB, respectively, and 17.85 ± 9.40 dB on average, while 12th month postoperative values were 11.50 ± 2.98 dB, 15.58 ± 10.96 dB, and 16.62 ± 8.73 dB, respectively, and 14.91 ± 9.21 dB on average.

Preoperative ABG values in small, medium, and large perforations were 18.64 ± 9.63 dB, 22.51 ± 9.66 dB, and 28.43 ± 14.13 dB, respectively, and 23.18 ± 11.36 dB on average, while 12th month postoperative ABG values were 9.14 ± 8.27 dB,

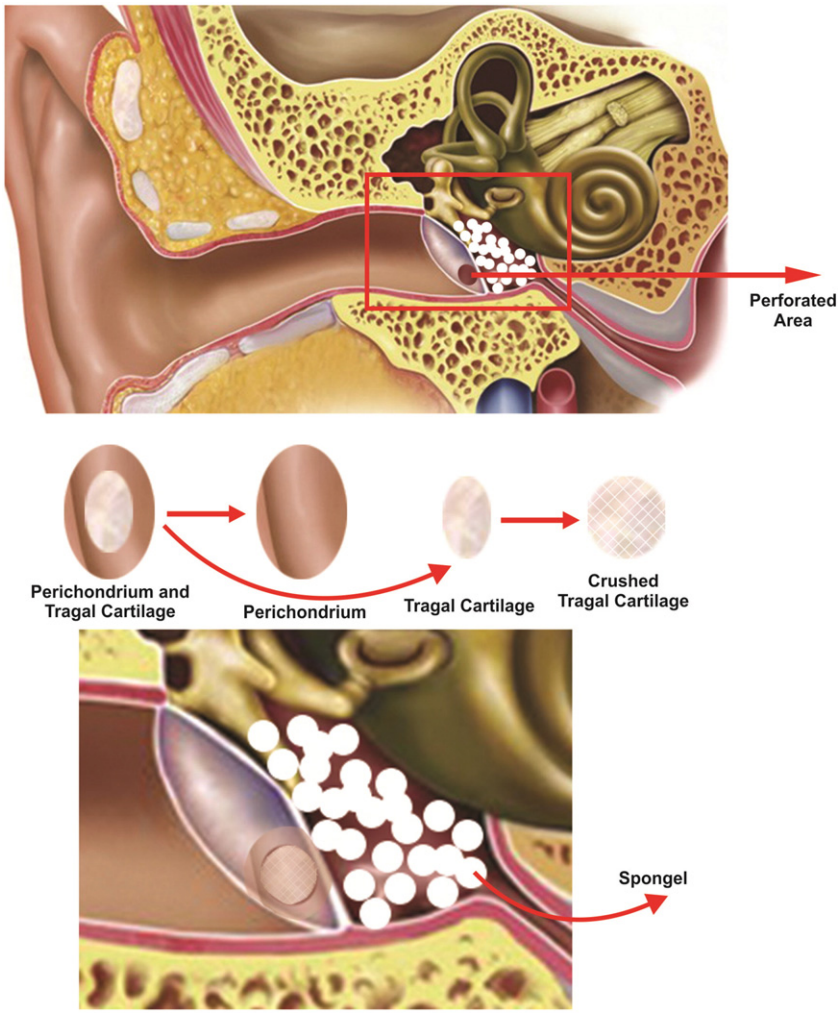


**Fig. 1 – Drawing our surgical technique.**

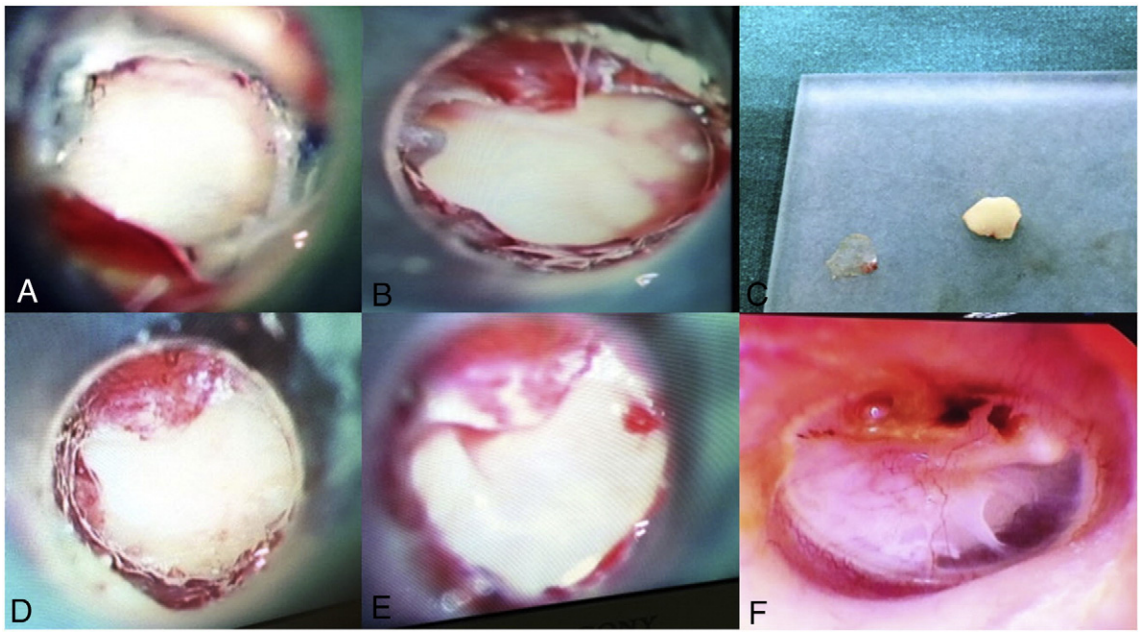


**Fig. 2 – (A) Preoperative otomicroscopic view of the perforation. (B) Appearance of the after perforation edge de-epithelialization. (C) Preparation of graft; one side-coated pericondrium tragal cartilage separated perichondrium and thinned with cartilage crusher. (D) Appearance after cartilage graft application to perforated area. (E) Appearance after pericondrium graft application on the cartilage. (F) Otoendoscopic view after postoperative 6th month.**

11.25 ± 6.73 dB, and 17.37 ± 9.22 dB, respectively, and 12.37 ± 8.28 dB on average. The difference between pre- and postoperative 12th month ABG values was statistically significant ($p < 0.005$) (Tables 1-2).

## 4. Discussion

The basic aim in myringoplasty surgery is the repair of the perforated ear membrane and improvement of hearing. The first operations for that purpose began with tympanoplasties by Zollner [1] and Wullstein [2], after which grafts with various different tissue structures were employed in various operations [4,6,7]. The most frequently employed graft materials in recent times are temporal muscle fascia, perichondrium, and cartilage grafts. Cartilage grafts have acquired particular popularity due to their anatomical stability and resistance to retraction and also due to their being easy to obtain and the contribution they make to auditory levels [3,4,6,7,9,10].

**Table 1 – Preoperative and postoperative audio values.**

| Perforation size | Preoperative ABG | Postoperative ABG | *p* |
|---|---|---|---|
| Small | 18.64 ± 9.63 dB | 9.14 ± 8.27 dB | 0.00 |
| Medium | 22.51 ± 9.66 dB | 11.25 ± 6.73 dB | 0.00 |
| Large | 28.43 ± 14.13 | 17.37 ± 9.22 dB | 0.00 |
| Average | 23.18 ± 11.36 dB | 12.37 ± 8.28 dB | 0.00 |

ABG - air-bone gap, dB - decibel.

Although the hardness of cartilage grafts protects against the negative pressure in the middle ear and against reperforation, the greater the thickness and hardness, the worse the impact on the auditory component [5,8–10]. One study employed a cartilage graft of 0.2 mm in thickness with the help of a chondrotome and achieved positive auditory outcomes compared with full-thickness cartilage. Preoperative mean ABG was 29.70 ± 2.74 dB, and postoperative ABG was 9.93 ± 2.07 dB [5]. Another study using a cartilage splitter reported that a 0.1- to 0.5-mm cartilage graft produced very good anatomical and auditory results at 2-year follow-up. Preoperative mean ABG was 30.68 ± 4.77, mean postoperative 1-year ABG was 7.13 ± 3.2 dB, mean postoperative 2-year ABG was 7.06 ± 3.39 dB, and the anatomical

**Table 2 – Preoperative and postoperative data of audio values.**

| Perforation size | Conduction | Preoperative audiometric evaluation (dB) | Postoperative audiometric evaluation (dB) | *p* value |
|---|---|---|---|---|
| Small | Air | 32.50 ± 9.95 | 20.21 ± 8.82 | 0.00 |
| | Bone | 13.21 ± 4.96 | 11.50 ± 2.98 | 0.20 |
| | ABG | 18.64 ± 9.63 | 9.14 ± 8.27 | 0.00 |
| Medium | Air | 40.09 ± 12.39 | 26.83 ± 15.52 | 0.00 |
| | Bone | 17.96 ± 9.63 | 15.58 ± 10.96 | 0.07 |
| | ABG | 22.51 ± 9.66 | 11.25 ± 6.73 | 0.00 |
| Large | Air | 50.12 ± 13.25 | 35.00 ± 13.40 | 0.00 |
| | Bone | 21.68 ± 10.52 | 16.62 ± 8.73 | 0.03 |
| | ABG | 28.43 ± 14.13 | 17.37 ± 9.22 | 0.00 |

ABG - air-bone gap, decibel - dB.

healing rate was 98.2% [9]. The cartilage we used in this study was thinned with a tissue crusher. Our total anatomical healing rate at the end of 12 months was 95%. Preoperative ABG was 23.18 ± 11.36 dB, which decreased to 12.37 ± 8.28 dB after 12 months, the difference being statistically significant ($p < 0.0005$).

Some recent studies in which the cartilage shield graft was employed have shown that operations in which temporal muscle fascia is placed over the cartilage are advantageous in both anatomical and auditory terms [3,6,7,11–15]. However, a wider incision is made for these operations, and tissues from two different areas have to be used. We applied a cartilage graft covered in one layer of perichondrium taken from the tragus in all cases in the study. The primary advantage of our technique was that we perform the graft with a small incision and that no other incision is required. Our removing the perichondrium on one side only made it easy to perform the technique by the transperforation route, by increasing cartilage flexibility. In addition, the perichondrium graft we stripped offered the advantage of being used for the purpose of later establishing contact between the cartilage and the remnant tympanic membrane not in contact with it. The remaining single layer of perichondrium could be used in cases requiring subsequent revision.

Endoscopic tympanoplasty has become popular in recent times. Compared with the results of myringoplasty using an otomicroscopic technique, endoscopic tympanoplasty has been reported to exhibit the same auditory and anatomical improvement as myringoplasty but with a shorter operation time [14–19]. Endoscopy is advantageous in terms of permitting a transcanal approach by including areas that are difficult to visualize with an otomicroscope. In a study of 32 patients with anterior quadrant perforation, Celik et al. reported graft success rates of 87.5% after a mean 12.4-month follow-up in patients undergoing endoscopic push-through (transperforation) myringoplasty and determined a significant difference between pre- and postoperative ABG [15]. In a 22-patient study, Garcia et al. reported 86.4% graft success at 3-month follow-up after endoscopic myringoplasty, as well as significant preoperative and postoperative success in auditory values [14]. The incision area is not restricted with transcanal myringoplasty, and the need to lift the tympanomeatal flap is obviated. The disadvantage of the otoendoscopic approach is the difficulty of working with one hand and low-depth perception [14,15]. We not only used the otomicroscopic technique in this study but also employed an otoendoscope as an assistant tool for the purpose of increasing the field of vision in patients with a narrow external ear canal in anterior quadrant perforation and subtotal marginal perforations. We observed that the use of an otoendoscope in patients with a narrow external ear and anterior quadrant perforations in particular was especially useful during de-epithelialization of the perforation margins and graft placement.

In operation selection, the most practical and efficient method, with a short healing time and minimal morbidity, must be employed [3,4,9]. All patients in this study were operated by the transcanal-transperforation route under local anesthesia following sedoanalgesia. Our establishing patient cooperation during surgery enabled us to visualize all parts of the tympanic membrane by adjusting patients' head positions. It also prevented actions such as coughing and the Valsalva maneuver that may result in perioperative graft mobilization.

### 4.1. *Study limitations*

There are a number of limitations to this study, such as the relatively short follow-up time and the low patient number. Further studies with larger patient groups and longer follow-up periods are now needed regarding effective and minimal invasive surgical technique employed in this study.

## 5. Conclusion

The use of the cartilage-supported perichondrial graft in the repair of all sizes of tympanic membrane perforation is safe and effective in terms of anatomical healing and auditory improvement and is also easy to perform. It may also represent a first-choice approach due to shortness of hospitalization and postoperative comfort.

The authors declare that they have no conflict of interest. Informed consent was obtained from all individual participants included in the study.

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