Endoscopic Suspended Cartilage Myringoplasty for the Repair of Central Tympanic Membrane Perforation

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Introduction
Chronic tympanic membrane perforation (TMP) associated with chronic otitis media (COM) is commonly seen in otolaryngology clinics. Typically, TMPs are repaired using either the underlay or overlay techniques. The underlay technique is easier to perform but has a high failure rate in anterior perforation. The overlay grafting technique has been reported to have a higher take rate but has a significantly higher risk of graft lateralization and cholesteatoma formation.¹-⁴ Many techniques and modifications have been developed for the repair of TMPs to improve the graft take rate, including over-under myringoplasty,⁵,⁶ sandwich graft tympanoplasty,⁷,⁸ the double graft technique,¹⁰ and the loop underlay technique,¹¹ which involves the elevation of the tympanomeatal flap and the insertion of a graft either medially or laterally to the fibrous tympanic membrane annulus. Each technique has its own application, advantages, and complications.

In this study, we investigated suspended cartilage myringoplasty, a novel modified over-underlay technique for the reconstruction of central TMPs using perichondrium and cartilage graft. This technique combines the ease of the underlay technique with the higher success rate of the overlay approach for this kind of perforation. Our aims were to study suspended cartilage underlay grafting using the single-sided perichondrium graft surgical technique and to evaluate its success rate for central TMP secondary to mucosal COM.

Materials and Methods

Ethical Considerations
The study protocol was reviewed and approved by the institutional ethical review board of Yiwu Central Hospital in Yiwu, Zhejiang, China. Informed consent was obtained from all participants.

Patients and methods
Our prospective, controlled study was performed between January 2014 and December 2016. The inclusion criteria were central TMP associated with mucosal COM, no suspicion of an ossicular chain defect, conductive hearing loss no greater than 40 dB in any frequency, and dry ears for at least 3 months prior to surgery. The exclusion criteria included ossicular chain abnormalities, suspicious cholesteatoma, revision cases, and the presence of fungal otitis externa. Perforation size was classified as subtotal (involving more than 75% of the eardrum area), large (involving more than 50% of the eardrum area), medium (involving 25%–50% of the eardrum area), or small (involving less than 25% of the eardrum area).

We defined operative time as the duration from the beginning of the marginal refreshment of the perforation to the external auditory canal (EAC) packing. Preoperative temporal bone computed tomography/magnetic resonance imaging (MRI) was performed to exclude ossicular chain abnormalities and middle ear cholesteatoma. The mean of the thresholds at frequencies 0.5, 1, 2, and 3 kHz was used to form a four-tone pure-tone average. The air-bone gap (ABG) was defined as the four-tone pure-tone average for air conduction minus the same average for bone conduction before surgery and 3 months after surgery. For convenience, the ABGs in bins were grouped as follows: 0 to 10 dB, 11 to 20 dB, 21 to 30 dB, and >30 dB.¹²

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Surgical Technique

Patients were placed in the supine position with the head elevated 30° and rotated away from the surgeon, and video equipment was placed opposite the surgeon. All patients were operated under general anesthesia using a standard 18 cm, 0° standard endoscope with a diameter of 4 mm. The perforation edges were visualized and de-epithelialized with an angled pick.

Cartilage from a single-sided perichondrium graft was harvested from the ipsilateral tragus. The cartilage-perichondrium graft was trimmed to fit the perforation. The lateral perichondrium was dissected circularly and rolled up, keeping the pedicle at the center of the cartilage intact. The cartilage was trimmed circularly to a size larger than the perforation and not thinned, and the reserved free perichondrium was at least 2 mm larger than the cartilage graft. A notch was made in the cartilage, but not the perichondrium, to accommodate the exposed malleus handle, if any.

Under endoscopy, the middle ear was tightly packed with biodegradable Nasopore soaked in antibiotic ointment to the level of the perforation. The cartilage graft was pushed through the perforation and placed medial to the remnant tympanic membrane and annulus (F). The free edge of the lateral perichondrium was elevated and placed lateral to the malleus, remnant tympanic membrane, and annulus (G and H). Black arrows indicate the remnant tympanic membrane and annulus, red arrows indicate the malleus, black oval indicates the cartilage graft, and black triangle indicates the lateral perichondrium graft.

Postoperative Follow-Up

All patients received a course of antibiotics (amoxicillin) after the surgery. The packing gauze soaked in antibiotic ointment was removed from the EAC 14 days after the surgery, and biodegradable Nasopore fragments were aspirated from the EAC 4 weeks after the surgery (Figure. 2), which allowed the graft to be visualized. All patients were followed up in the ear, nose, and throat outpatient department 2 weeks, 1 month, 3 months, and 6 months after the surgery, and endoscopic otological examinations were performed. In addition, temporal bone MRI was performed to monitor cholesteatoma formation at 12 months after surgery. The primary outcomes were the ABG gain at 3 months and the graft take rate at 6 months. The secondary outcomes were complications and cholesteatoma formation at 12 months.

Statistical Analyses

Statistical analyses were performed with SPSS version 20 (IBM Inc., Chicago, IL, USA). The data are expressed as means (standard deviation) and percentages (%). We tested differences between preoperative and postoperative ABGs using the
Wilcoxon signed-rank test. $P < .05$ was considered to indicate statistical significance.

**Results**

**Demographic Data**

The study included 63 patients (44 females and 19 males; average age, 49.6 ± 13.7 years) with unilateral chronic TMP associated with COM. In total, 37 patients had left-side involvement and 26 had right-side involvement, and the mean duration of perforation was 17.3 ± 9.6 years. Perforations were small in 2 (3.2%) patients, medium in 49 (77.8%) patients, and large in 12 (19.0%) patients. The mean operative time was 36.2 ± 10.7 min. A notch of the cartilage was made to accommodate the malleus handle in 37 (58.7%) patients. The tragal incision had healed by postoperative week 2 in all patients.

**Graft Take Rate and Hearing Gain**

The perichondrium overlay graft gradually became necrotic and yellow by postoperative week 4 and formed a black crust 2 to 3 months after surgery. Subsequently, the black crust migrated toward the EAC, and the morphology of the healed eardrum was normal (Figures 2 and 3).

All patients were followed up for at least 6 months. At 6 months, the graft success rate was 100% (63/63), and no residual perforations were observed (Figures 2 and 3). Three patients had mild myringitis, which resolved following silver nitrate cauterization and oral antibiotic treatments. A Wilcoxon signed-rank test revealed that the mean preoperative ABG (25.14 ± 6.13 dB) was significantly greater than the mean postoperative ABG (11.17 ± 4.36 dB; $P < .05$) at 3 months. Of the 63 patients, 29 (46.0%) had ABG closure of 0 to 10 dB, 32 (50.8%) achieved closure of 11 to 20 dB, and 2 (3.2%) patients had closure of 21 to 30 dB.

**Complications**

No complications, including iatrogenic sensorineural hearing loss, altered taste, facial nerve palsy, vertigo, or tinnitus, were observed during the follow-up period. No cases of graft lateralization or significant blunting or atelectasis were found (Figures 2 and 3). Furthermore, 41 (65.08%) of 63 patients were followed up for 12 to 26 months, and the average follow-up time was 18.3 ± 6.8 months. No incidences of epithelial pearl formation, inclusion cysts, or middle ear cholesteatoma were observed in the temporal bone MRI in 41 patients.

**Discussion**

Myringoplasty using either the underlay or the overlay technique is the term used to describe the surgical repair of a perforated tympanic membrane. The underlay technique is the standard used to describe the surgical repair of a perforated tympanic membrane. The underlay technique may fall away resulting in reperforation, and the overlay technique has a serious risk of graft lateralization. However, these

**Figure 2.** Preoperative middle tympanic membrane perforation (A). The edges of the perforation were refreshed (B). The perichondrium graft was placed lateral to the remnant tympanic membrane and annulus (C). The external auditory canal (EAC) was packed with Nasopore at postoperative week 4 (D). The Nasopore was removed at postoperative week 4 (E) and postoperative 2 months (F). Red triangle indicates the Nasopore; black arrows indicate the perichondrium.
problems have been managed by a variety of surgical tech-
niques. Nevertheless, these techniques may be more tech-
nically challenging, requiring the elevation of the tym-
panomeatal flap and the excision of outer squamous epithe-
lium layer of the tympanic membrane.

In this study, we introduced a suspended cartilage technique that involves using the free edge of the attached perichondrium to support the cartilage graft. The perichondrium graft is placed directly over the surface of the tympanic membrane and annulus. Because endoscopy provides an excellent view, allowing clear observation of the entire remnant tympanic membrane and middle ear structure, this technique does not require elevation of the tympanomeatal flap.

Various groups have reported graft success rates of 94.9% using the over-under technique, 96.23% using sandwich graft tympanoplasty, and 99.3% using the loop underlay technique. In contrast, the graft success rate was 100% (63/63) at 6 months in the present study. In our technique, the lateral perichondrium may help the centripetal migration of the outer epithelium of the remnant tympanic membrane and support the cartilage graft to prevent displacement. In addition, the connection between the perichondrium and cartilage retained the close contact between the cartilage and the remnant tympanic membrane, thus preserving the temporary blood supply to the perichondrium through the cartilage. The results of a previous study suggested that a large perichondrial flap that comes into contact with the vascular strip and undersurface of the tympanic membrane preserves cartilage viability, possibly because the low metabolic rate in the central portion of the cartilage with minimal activity increases cartilage viability, whereas higher activity in the periphery may cause early proliferation of blood vessels.

The present technique is different from the over-under technique or overlay technique. In the over-under or overlay technique, only a single-layer temporalis fascia or tragal perichondrium graft is placed lateral to the handle of the mal-
leus and then medial to the remaining drum. In contrast, a double layer graft was used in this study. The present technique is similar to the butterfly technique, in which the cartilage grafts appear similar to the wings of a butterfly. However, rather than splitting the cartilage in this study, the “lateral wing” is a perichondrium graft that is used to support the cartilage graft of the “medial wing.” Nevertheless, the butterfly technique requires the precise measurement of the perforation size and shape and meticulous sizing of the cartilage graft, which increases the technical difficulty of the procedure.

Some authors have described a double layer graft technique in recent years. In Nemade et al’s technique, the temporalis fascia graft is underlaid medial to the handle of the malleus, and the areolar fascia graft is overlaid lateral to the handle of the malleus and the fibrous layer of the tympanic membrane. In Bedri et al’s technique, the cartilage island grafts or the perichondrium single layer are placed over the manubrium and under the fibrous layer of the remnant of the tympanic membrane. The cartilage graft is laid laterally upon the malleus handle without a groove cut for the handle. However, in the present technique, the lateral perichondrium graft is placed directly over the outer squamous epithelium layer but not the fibrous layer of the remnant tympanic membrane, and the cartilage graft is placed medial to the remnant tympanic membrane and annulus, with a groove cut for the exposed handle if present. This technique does not require elevation of the tympanomeatal flap and the epithelial layer of the tympanic membrane remnant.

**Figure 3.** Preoperative middle tympanic membrane perforation (A). The perichondrium graft at 1 month after surgery (B). The perichondrium graft formed a black crust at postoperative week 6 (C) that remained at postoperative week 10 (D). The black crust began to fall away by 4 months after surgery (E) and was removed at 8 months after surgery (F) and postoperative 18 months (G).
The mean preoperative ABG (25.14 ± 6.13) was significantly higher than the mean postoperative ABG at 3 months (11.17 ± 4.36 dB), and 96.8% of the patients had an ABG closure of 0 to 20 dB. Because there was significantly better hearing in the preoperative assessment compared with the 3-month postoperative assessment, we did not evaluate the ABG gain at 6 months. No cases of graft lateralization, significant blunting, or atelectasis were detected by endoscopy at 6 months. In addition, postoperative cholesteatoma is another issue of concern, the physical examination of the cholesteatoma behind the cartilage graft is difficult to understand. We performed temporal bone MRI to evaluate cholesteatoma formation. Of the 63 patients, 41 patients were followed up for at least 12 months; the average follow-up time was 18.3 ± 6.8 months. No incidences of epithelial pearl formation, inclusion cysts, or middle ear cholesteatoma were observed in the 41 patients. Our technique is similar to modified over-underlay myringoplasty. Stage and Bak-Pederson22 performed over-underlay myringoplasty in 39 ears and reported no incidences of cholesteatoma or epithelial pearl formation. Kartush et al23 reported small epithelial pearls on the tympanic membrane but no cases of middle ear cholesteatoma. Some authors have reported a few graft cholesteatomas, which were treated easily in the office with excision or exteriorization.1,3,5,7,24 However, more recent studies have not reported cholesteatoma formation in the middle ear following use of the over-underlay or double-layer graft techniques.6,9,10 Butterfly myringoplasty involves creating a groove along the cartilage at least 1 mm deep; thus, at least 1 mm of the epithelial layer at the perforation edge may be encased by the lateral wing, which theoretically increases the risk of middle ear cholesteatoma formation. Nevertheless, these authors did not report the occurrence of middle ear cholesteatoma.1,9-21 With the present technique, we found that the lateral perichondrium gradually became necrotic and formed a crust over time, thereby avoiding middle ear cholesteatoma and epithelial pearl formation. We speculated that the lateral perichondrium only provides a scaffold of epithelial migration and prevents displacement of the cartilage. However, the exact action mechanisms and prognosis of the lateral perichondrium require further study. The limitations of our study include the small sample size and the fact that it was a prospective case series design rather than a randomized controlled trial.

Conclusions

Endoscopic suspended cartilage myringoplasty is a feasible and simple technique with excellent postoperative outcomes and a high graft success rate. This technique is similar to the butterfly technique; however, rather than splitting the cartilage, the perichondrium is used to support the cartilage graft.

Authors’ Note

The English in this document has been checked by at least 2 professional editors, both native speakers of English. For a certificate, please see: http://www.textcheck.com/certificate/4cpoxK

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