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ORIGINAL ARTICLE

Endoscopic transcanal transtympanic myringoplasty vs. endoscopic transcanal tympanoplasty: 1-year follow-up study

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Abstract

Background: Endoscopic transcanal transtympanic myringoplasty (ETTM) is a relatively easier technique than endoscopic transcanal tympanoplasty (ETT) for repairing tympanic membrane perforations. No studies have compared the outcomes of these two procedures with tragal perichondrium after 1-year. Furthermore, there is no evidence-based stratification according to variations in perforation size in endoscopic ear surgery. Therefore, we compared the 1-year outcomes of ETTM and ETT stratified according to perforation size.

Methods: Patients who underwent ETT and ETTM to repair eardrum perforations with a tragal perichondrium graft were identified. Pure-tone audiometric tests and otoscopic examination were performed to assess hearing outcomes and perforation sizes both preoperatively and at least 1 year postoperatively.

Results: In total, 158 patients (159 ears) were included. ETT was performed on 83 ears, and ETTM was performed on 76 ears. The ETTM procedure time was 10-minutes shorter than that for ETT ($p < 0.001$). Perforation size was significantly correlated with graft take-rate. For large perforations, the ETT success rate was significantly higher than that of ETTM (91.7% vs. 78.9%). Success rates for small-medium perforations were comparable for both methods ($p > 0.05$). However, for medium perforations, the graft take-rate of ETT reached a plateau after 6 months, while that of ETTM gradually declined during the 12-month follow-up. Both groups had a comparable mean postoperative air-bone gap gain ($p = 0.666$).

Conclusion: ETTM is suitable for repairing small perforations, whereas ETT is preferred for large perforations. Both methods, and particularly ETTM, should be employed cautiously for medium perforations.

Keywords: Endoscopic ear surgery; Myringoplasty; Tragal perichondrium; Transcanal; Tympanoplasty

1. INTRODUCTION

Microscopic tympanoplasty can be used to repair any size perforation; canalplasty may be performed. As the endoscope offers greater accessibility to the narrow external auditory meatus, exclusive endoscopic tympanoplasty has become more popular in recent years.[1–6] Tympanoplasty can be done with overlay or underlay techniques according to the graft position. Underlay techniques consist of two major approaches: type 1 tympanoplasty with an elevation of the tympanomeatal flap and transtympanic myringoplasty.[7,8] There are multiple factors, such as age, perforation size, perforation location, graft material, infection and technique, that influence the take-rate after surgeries. Only a few articles have discussed the graft take-rate in correlation with perforation sizes and different techniques, especially in endoscopic ear surgeries.

Alzoubi et al. used temporal fascia for microscopic transcanal tympanoplasty (MTT) and microscopic transcanal transtympanic myringoplasty (MTTM) in 61 cases, reporting that both techniques had comparable graft take-rates and hearing outcomes in patients with small to medium perforations; however, patients with large perforations were not included in the study.[9] Tseng et al. observed similar results when investigating endoscopic transcanal tympanoplasty (ETT) and endoscopic transcanal transtympanic myringoplasty (ETTM) for repairing medium perforations.[10] Additionally, Atchariyasathian et al. compared 21 and 19 cases of ETT and ETTM, respectively, for repairing medium and large tympanic membrane perforations. They reported that the outcome of ETTM was comparable to that of ETT, regardless of perforation size.[7] However,

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these studies reported only short-term (3–6 months) results for a limited number of cases, whereas the success rate of tympanic membrane perforation repair can change in the long term.

Moreover, the temporal fascia and perichondrium tend to atrophy over time.[11] Therefore, the long-term graft success rate may decline. We have used tragal perichondrium graft for exclusive endoscopic ear surgery since 2011 because of better cosmetics concerns and wound care. To review the literature, there are few references to exclusive endoscopic ear surgery for tympanic membrane perforation repair with a follow-up of more than 12 months.[1] Furthermore, there is no consensus regarding the long-term outcomes of ETT and ETTM with tragal perichondrium for repairing perforations of different sizes. Thus, the present study aimed to compare the anatomical and auditory outcomes of ETT and ETTM in patients with tympanic membrane perforations of various sizes during a follow-up of at least 1 year.

2. METHODS

2.1. Subjects

The Joint Institutional Review Board of Chang Gung Memorial Hospital approved (No. 202000200B0C501) the study. From January 2014 to December 2019, a retrospective chart review was performed on all patients who underwent endoscopic surgeries (ETT or ETTM) with tragal perichondrium grafts via the underlay technique. All surgeries were performed by the same senior surgeon (C.K.C.). Pure-tone audiograms were conducted prior to surgery. Patients with an air-bone gap (ABG) of <30 dB were included. The exclusion criteria were patients with cholesteatoma and an abnormal mastoid radiograph on a high-resolution computed tomography scan of the temporal bone. In addition, this study did not include subtotal eardrum perforations or a small tragus due to limited tragal perichondrium size. The age, sex, operative time, perforation size, perforation location, hearing threshold, otorrhea, smoking comorbidities, and graft take-rate were all recorded for further analysis.

The perforation sizes were recorded according to the percentage of the pars tensa area involved: small (size <25%), medium (25–50%), and large (>50%), as Srinivasan et al. proposed.[12]

2.2. Surgical techniques

All patients underwent exclusive transcanal endoscopic ear surgery without canalplasty. The tragal perichondrium graft was harvested from the inner surface of the tragus. The size of the graft was approximately 1 cm × 1 cm but varied according to the tympanic membrane perforation size. The tragal perichondrium graft was flattened using a fascia press and preserved on Gelfoam to keep it dry, thin, and sufficiently larger than the perforation size. Two types of surgical techniques, namely ETT and ETTM, were used to repair these perforations. We completed surgeries using a high-definition three-chip camera system and a rigid endoscope (3 mm/2.7 mm diameter, 0° angled lens, 14-cm length; Karl Storz, Tuttlingen, Germany) with similar standard ear instruments.

2.2.1. Endoscopic transcanal tympanoplasty (with elevation of the tympanomeatal flap, ETT)

With the introduction of the endoscope, we first trimmed the perforation edges and estimated the perforation size. An incision was made, and the tympanomeatal flap was elevated. In ETT, we were able to inspect and palpate the middle ear structures, including the ossicles, facial recess, and Eustachian tube orifice. We then removed any abnormal tissues, fibrotic bands, or granulation in the middle ear cavity, if present. The tragal perichondrium graft was placed underneath the tympanomeatal flap and lateral to the malleus to cover the medial side of the perforation. We packed antibiotic-soaked Gelfoam into the mesotympanum, especially in the anterior-superior area and the bony orifice of the Eustachian tube, to avoid medialization of the graft. The tympanomeatal flap was then returned to its original position.

2.2.2. Endoscopic transcanal transtympanic myringoplasty (without tympanomeatal flap elevation, ETTM)

After freshening the appropriate margin, we evaluated the estimated size of the perforation. Next, we placed several pieces of antibiotic-soaked Gelfoam into the mesotympanum beneath the perforation to form a supportive plane for the graft.[13] The tragal perichondrium graft was trimmed to a size larger than the perforation in diameter and placed through the perforation to cover it medially.

After placing the graft via the underlay technique with ETT or ETTM, the external auditory canal was packed with antibiotic-soaked Gelfoam to the level of the tragus wound. Finally, we placed a dry sterilized cotton ball over the orifice of the canal to keep the surgical wound clean. The operation time was calculated as the interval from the initial infiltration of epinephrine in the canal to the complete packing of the ear canal with the gelatin sponge.

2.2.3. Postoperative follow-up

Postoperatively, patients were 1-day admitted for monitoring of any complications, including dizziness, tinnitus, hearing loss, wound pain, and infection of the incision sites. After discharge, patients were followed up at an outpatient department weekly for the first month. All patients were followed up for at least 1 year postoperatively. The graft take-rate was recorded at 3, 6, and 12 months using a video otoscope. Hearing outcomes included air and bone conduction threshold, the mean ABG at 0.5, 1, 2, and 4 kHz, and word recognition scores were recorded 6 months postoperatively.

2.3. Statistical analysis

Statistical analysis was performed using Statistical Package for Social Science version 22.0 (SPSS, Inc., Chicago, IL, USA; IBM Company, New York, USA). Significance was set at $p < 0.05$. Continuous variables are expressed as the mean and SD, while categorical variables are expressed as the number of cases (%). Effect sizes with 95% confidence intervals (CIs) were calculated for all variables. Independent Samples t-tests were used to compare differences in age, operation time, sex, perforation ear, perforation size, and pure-tone auditory results between the ETT and ETTM groups. Categorical variables were analyzed using Pearson's χ^2 test. The Mann-Whitney U test was used to compare non-normally distributed continuous variables. We calculated the graft take-rate using the log-rank test and Kaplan–Meier survival analysis. Sex, perforation side, perforation size, and existing comorbidity were identified as confounding factors and included covariates in a Cox regression model for multivariate analysis.

3. RESULTS

3.1. Patient characteristics

A total of 158 patients (159 ears) were completely followed up for at least 1 year (12–32 months). There were 83 patients (31 men and 52 women, 83 ears) in the ETT group and 75 patients (31 men and 44 women, 76 ears) in the ETTM group. The mean ages of patients in the ETT and ETTM groups were 52.8 ± 13.2 and 50.2 ± 14.7 years, respectively. The patient numbers showed a slightly asymmetric distribution, particularly in the large perforations subgroup, that is, more patients with large perforations in ETT group because these cases with no remnant of eardrum for ETTM, but there was no significant difference between the two groups. There were no significant differences in age, sex, perforation size, perforation side, perforation location, preoperative ABG, or comorbidity between groups (Table 1).

3.2. Operative time

As shown in Table 1, the mean operative times were 53.2 ± 18.4 min and 43.7 ± 10.1 min in the ETT and ETTM groups, respectively (Cohen's d, 0.64; 95% CI, 4.85-14.06; $p < 0.001$, t-test). Thus, the operative time was significantly shorter in the ETTM group than in the ETT group.

3.3. Graft take-rate

Potential confounding factors affecting graft take-rates were controlled using a Cox regression model for multivariate analysis (Table 2), which verified that perforation size was significantly correlated with the graft take-rate (odds ratio [OR], 2.13; 95% CI, 1.05-4.31; $p = 0.035$). However, perforation site, sex, otorrhea, smoking, and comorbidity (diabetes, hypertension, chronic kidney disease) were not correlated with the graft take-rate ($p > 0.05$).

The graft take-rates of differently sized perforations as calculated using the log-rank test and Kaplan–Meier estimator at 3, 6, and >12 months are shown in Table 3 and Fig. 1. The overall success rates after at least 1-year of follow-up in the ETT and ETTM groups were 94.0% and 86.8%, respectively (OR, 4.03; 95% CI, 10.87-11.55; $p = 0.045$, log-rank) (Fig. 1A). The success rates for small and medium perforations were comparable for both methods (OR, 0.00; 95% CI, 0.00; $p = 0.352$ and OR, 4.49; 95% CI, 0.10-2.39; $p = 0.447$, log-rank) (Fig. 1B and C). However, for large perforations, the success rate of ETT was significantly higher than that of ETTM (Fig. 1D, OR, 0.40; 95% CI, 0.10-1.59; $p = 0.013$, log-rank). Overall, the graft take-rate declined over time in both groups, decreasing by 4.8% and 9.2% in the ETT and ETTM groups (ETT: from 98.8% to 94.0%, ETTM: from 97.4% to 86.8%), respectively. Thus, the graft take-rate of large perforations declined gradually in both groups over the 1-year follow-up. However, for medium perforations, the graft take-rate of ETT decreased in the first 6 months and remained stable through the remainder of the 1-year follow-up; however, that of ETTM gradually declined over the 1-year follow-up.

3.4. Audiologic outcomes

The mean pre- and postoperative ABGs at 1 year were 17.4 ± 5.9 dB and 7.6 ± 4.8 dB (Cohen's d, 1.82; 95% CI, 7.97-11.57; $p < 0.001$, paired t-test) and 16.7 ± 7.4 dB and 7.4 ± 4.9 dB (Cohen's d, 1.48; 95% CI, 7.61-10.87; $p < 0.001$, paired t-test) in the ETT and ETTM groups, respectively (Table 1). The mean ABG gain values were 9.7 ± 7.9 dB and 9.2 ± 6.8 dB in the ETT and ETTM groups, respectively. Both groups had comparable postoperative mean ABG gains (Cohen's d, 0.07; 95% CI, –1.89 to 2.96; $p = 0.666$, t-test).

Table 1

Demographic and preoperative data of the ETT and ETTM groups

Variable	ETT (n = 83 ears)	ETTM (n = 76 ears)	Effect size/OR (95% CI)[a]	*p*
Age, mean (SD), y	52.8 (13.2)	50.2 (14.7)	0.19 (–1.81 to 6.90)	0.250
Operation time, mean (SD), mins	53.2 (18.4)	43.7 (10.1)	0.64 (4.85 to 14.06)	<0.001*
Sex, n (%)				0.540
Male	31 (37.3)	31 (41.3)	1.51 (1.38 to 1.63)	
Female	52 (62.7)	44 (58.7)	1.46 (1.36 to 1.56)	
Perforation side, n (%)				0.820
Right	43 (51.8)	38 (50.0)	1.47 (1.36 to 1.58)	
Left	40 (48.2)	38 (50.0)	1.49 (1.37 to 1.60)	
Perforation location				0.092
Central	79 (95.2)	66 (86.8)	1.10 (0.99 to 1.21)	
Marginal	4 (4.8)	10 (13.2)	0.37 (0.12 to 1.12)	
Perforation size, n (%)				0.053
Small	13 (15.7)	15 (19.7)	0.18 (–7.11 to –2.22)	
Medium	34 (41.0)	42 (55.3)	0.27 (–1.29 to 5.25)	
Large	36 (43.3)	19 (25.0)	0.48 (–1.03 to 10.57)	
Preoperative PTA, mean (SD), dB				
AC	40.3 (17.1)	39.6 (17.9)	0.04 (–5.06 to 6.41)	0.816
BC	21.5 (14.5)	23.6 (16.1)	0.14 (–7.14 to 2.89)	0.403
ABG	17.4 (5.9)	16.7 (7.4)	0.10 (–1.50 to 2.90)	0.530
Postoperative PTA, mean (SD), dB				
AC	30.2 (15.6)	32.7 (17.8)	0.15 (–8.00 to 2.99)	0.369
BC	22.6 (14.2)	25.0 (16.3)	0.16 (–7.42 to 2.58)	0.340
ABG	7.6 (4.8)	7.4 (4.9)	0.04 (–1.41 to 1.75)	0.831
ABG gain	9.7 (7.9)	9.2 (6.8)	0.07 (–1.89 to 2.96)	0.666
Comorbidity				
Diabetes mellitus, n (%)	7 (8.4)	8 (10.7)	1.28 (0.44 to 3.71)	0.633
Hypertension, n (%)	16 (19.3)	19 (25.3)	1.40 (0.66 to 2.96)	0.360
Chronic Kidney Disease, n (%)	1 (1.2)	2 (2.6)	0.46 (0.04 to 4.95)	0.607

ABG = air-bone gap; AC = air conduction; BC = bone conduction; CI = confidence intervals; dB = Decibel; ETT = endoscopic transcanal tympanoplasty; ETTM = endoscopic transcanal transtympanic myringoplasty; OR = odds ratio; PTA = pure-tone auditory.

*$p < 0.05$, statistically significant differences between the groups.

[a] For continuous variables, the effect size is the median of the difference of medians between the groups, and the 95% CI around that difference was calculated using the method of Cohen's d for t-test. For categorical variables, the effect size is the difference between proportions of the groups with relative 95% CIs calculated around that difference.

Table 2

Cox regression analysis of factors of Failure-Rate

	ETT (*n*=83)	ETTM (*n*=76)		
Factors	**Events, n**	**Events, n**	**Effect size/OR (95% CI)**[a]	***p***
Sex	1 (ref)	2.32 (0.79–6.79)		0.125
Male	2 (2.4)	4 (5.3)	1 (ref.)	
Female	3 (3.6)	6 (8.0)	1.00 (0.35 to 2.80)	0.993
Perforation side	1 (ref)	2.33 (0.80–6.82)		0.123
Right	3 (3.6)	6 (8.0)	1 (ref.)	
Left	2 (2.4)	4 (5.3)	0.68 (0.24 to 1.90)	0.459
Perforation location	1 (ref)	2.40 (0.82–7.07)		0.112
Central	5 (6.0)	9 (11.8)	1 (ref.)	
Marginal	0 (0.0)	1 (1.3)	0.61 (0.08 to 4.68)	0.632
Perforation size	1 (ref)	2.13 (1.05–4.31)		0.035*
Small	0 (0)	1 (1.3)	1 (ref.)	0.136
Medium	2 (2.4)	5 (6.6)	3.77 (0.88 to 16.19)	0.074
Large	3 (3.6)	4 (5.3)	4.56 (1.03 to 20.23)	0.046*
Diabetes mellitus	1 (ref)	2.23 (0.76–6.55)		0.144
No	3 (3.6)	9 (11.8)	1 (ref.)	
Yes	2 (2.4)	1 (1.3)	2.31 (0.65 to 8.22)	0.196
Hypertension	1 (ref)	2.30 (0.78–6.75)		0.129
No	4 (4.8)	7 (9.2)	1 (ref.)	
Yes	1 (1.2)	3 (3.9)	1.14 (0.36 to 3.59)	0.824
Chronic Kidney Disease	1 (ref)	2.36 (0.81–6.90)		0.117
No	5 (6.0)	10 (13.2)	1 (ref.)	
Yes	0 (0.0)	0 (0.0)	0.00	0.987
Otorrhea	1 (ref)	2.22 (0.75–6.53)		0.149
No	2 (2.4)	9 (11.8)	1 (ref.)	
Yes	3 (3.6)	1 (1.3)	0.67 (0.21 to 2.12)	0.494
Smoking	1 (ref)	2.32 (0.79–6.80)		0.124
No	5 (6.0)	9 (11.8)	1 (ref.)	
Yes	0 (0.0)	1 (1.3)	1.08 (0.14 to 8.21)	0.943

CI = confidence intervals; ETT = endoscopic transcanal tympanoplasty; ETTM = endoscopic transcanal transtympanic myringoplasty; OR = odds ratio.

*$p < 0.05$.

Hearing outcomes were also expressed as a scattergram relating the average pure-tone threshold (in dB HL) to word recognition score (in %) (Fig. 2). Preoperatively, 63 (76%) and 58 (76%) patients in the ETT and ETTM groups, respectively, had a mean air threshold <50 dB. Postoperatively, most patients got a 10 to 20 dB improvement in hearing in both groups (Fig. 2B and D).

4. DISCUSSION

This study is aimed to compare the clinical outcomes of ETT and ETTM over a 1-year follow-up period with stratification based on different perforation sizes. Our results showed that the perforation size was significantly correlated with the graft take-rate. For small and medium perforations, both groups had a similar graft take-rate. ETTM is easier, faster, less traumatic than ETT and is thus more favorable in restoring small eardrum perforations. For medium perforations, the graft take-rate of ETT reached a plateau after 6 months, but that of ETTM gradually declined over the 1-year follow-up. For large perforations, ETT had a higher graft take-rate over the 1-year follow-up period. We found that the decline in graft take-rate was lower by almost two-fold in the ETT group (4.8%) than in the ETTM group (9.2%).

Table 3

Graft success rates of different-sized tympanic membrane perforations in the ETT and ETTM groups over various follow-up periods

Perforationsize	Small			Medium			Large			Overall		
follow-up period	**ETT**	**ETTM**	***p***[a]	**ETT**	**ETTM**	***p***[a]	**ETT**	**ETTM**	***p***[a]	**ETT**	**ETTM**	***p***[a]
3 months	100% (13/13)	100% (15/15)	0.352	97.1% (33/34)	97.6% (41/42)	0.447	100% (36/36)	94.7% (18/19)	0.013*	98.8% (82/83)	97.4% (74/76)	0.045*
6 months	100% (13/13)	93.3% (14/15)		94.1% (32/34)	92.9% (39/42)		94.4% (34/36)	89.5% (17/19)		95.2% (79/83)	92.1% (70/76)	
12 months	100% (13/13)	93.3% (14/15)		94.1% (32/34)	88.1% (37/42)		91.7% (33/36)	78.9% (15/19)		94.0% (78/83)	86.8% (66/76)	

ETT = endoscopic transcanal tympanoplasty; ETTM = endoscopic transcanal transtympanic myringoplasty.

*$p < 0.05$, statistically significant differences between the groups.

[a] Estimated using the Kaplan-Meier of survival analysis.

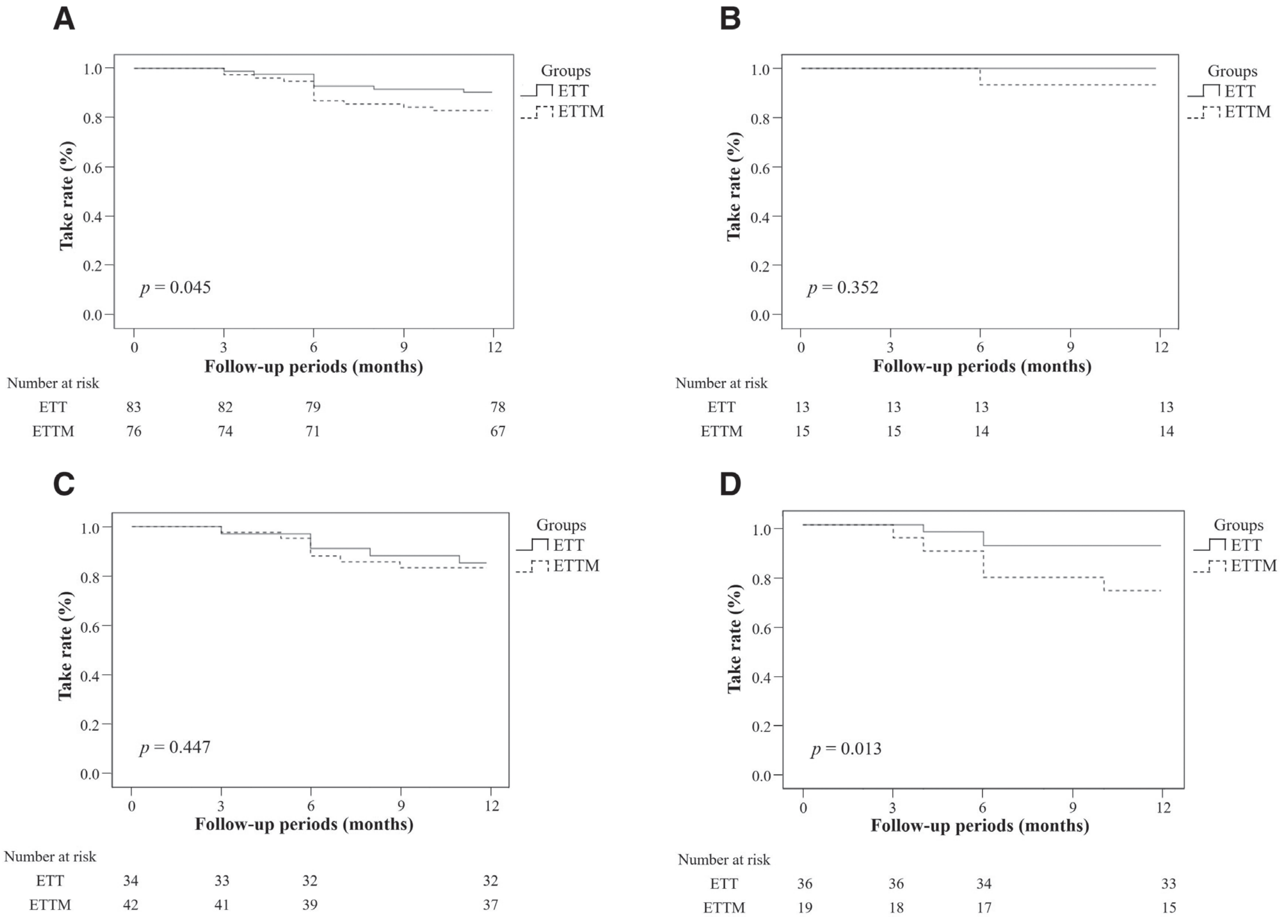


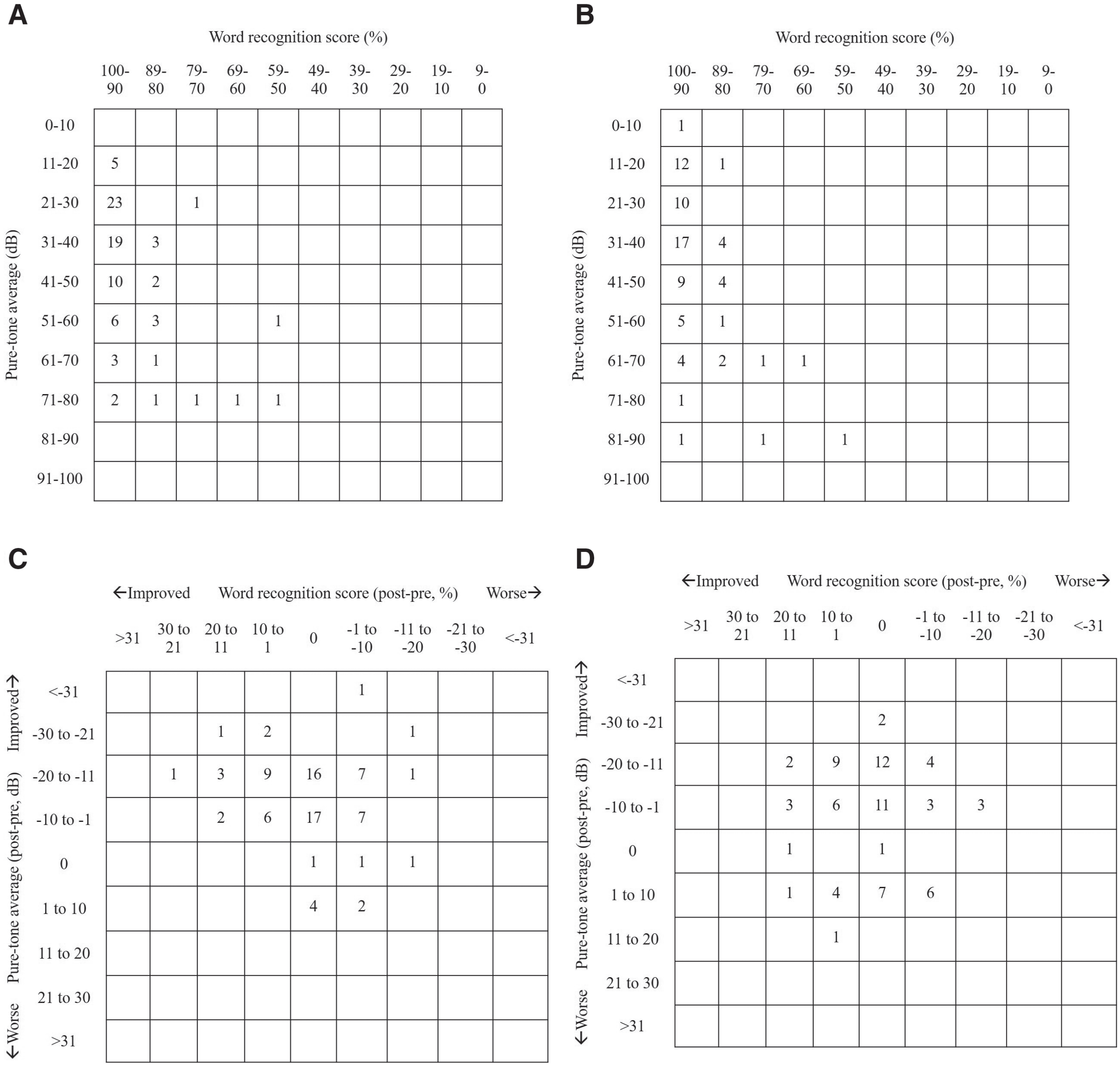
Fig. 1 Graft take-rates of differently sized perforations in the ETT and ETTM groups as calculated using the Kaplan–Meier method. (A) overall; (B) small-sized perforation; (C) medium-sized perforations; (D) large-sized perforations. ETT = endoscopic transcanal tympanoplasty; ETTM = endoscopic transcanal transtympanic myringoplasty.

In transtympanic myringoplasty, a graft is inserted directly into the tympanic membrane perforation without elevation of the tympanomeatal flap, which reduces connective tissue injury, reduces the need for hemostasis, and shortens the operation time.[14] Alzoubi et al. reported that the operation using MTTM was 9 min shorter than the one using MTT.[9] Our study indicated that procedure time for ETTM was 10 min shorter than that for ETT ($p < 0.001$, t-test), consistent with the findings of Tseng et al.[10] Moreover, El-Hennawi et al. found that the mean duration of ETTM was 37 min, whereas that of MTT was 107 min, in 10 out of 28 patients (36%) who underwent canalplasty.[8] Due to the panoramic magnification of the tympanic membrane with the introduction of an endoscope, all cases can be easily visualized without canalplasty.[2]

At the 1-year follow-up, the graft take-rates of ETTM and ETT in our study were 78.9–93.3% and 91.7–100%, respectively. This result is consistent with those of previous studies.[7–10] El-Guindy reported a 91.7% success rate (small: 20/21, large: 13/15) with ETTM.[15] Atchariyasathian et al. conducted a randomized clinical trial to compare surgical outcomes of 21 ETTM cases and 19 ETT cases.[7] Similarly, they reported the 3-week and 6-month take-rates as 100% and 95.2% in the ETTM group and 94.6% and 89.5% in the ETT group and concluded that ETTM was suitable for repairing perforations of any size.[7] However, Srinivasan et al. and Singh et al., both investigating MTTM, reported a better take-rate in patients with small perforations than in those with medium perforations.[12,14] Alzoubi et al. suggested the use of MTTM to repair small and medium, but not large, eardrum perforations.[9] However, in their study, the effect of perforation size on graft survival was not statistically significant. In this study, our results indicated that the two groups exhibited comparable graft take-rates for small and medium perforations; however, ETT resulted in higher graft take-rates for large perforations (OR, 0.40; 95% CI, 0.10–1.59; $p < 0.05$, Table 2 and Fig. 1D). Therefore, we concluded that for large perforations, ETT with tympanomeatal flap elevation should be advised.

Overall, the two groups had comparable graft take-rates after 6 months (95.2% in the ETT group and 92.1% in the ETTM group). However, ETT had a higher success rate than ETTM after the 1-year follow-up (ETT vs. ETTM: 94.0% vs. 86.8%, OR, 4.03; 95% CI, 10.87–11.55; p = 0.045). ETTM without elevation of the tympanomeatal flap is a simpler procedure than ETT. However, ETTM may miss debris or fibrotic bands obstructing the middle ear cavity ventilation, inflammation during upper respiratory infection, and chronic silent otitis media. ETT with tympanomeatal flap elevation provides clarity to surgeons regarding the anatomic variations in the middle ear cleft. The surgeon can usually see if there are mucosal adhesions or bands in need of lysis and restore the middle ear ventilation pathway by removing any fibrotic bands or granulation tissue. Hence, this may explain the increased effectiveness of ETT for long-term graft take when compared to ETTM, especially for medium and large perforations.

Based on our results, the graft take-rate declined over time, and the overall success rate declined by approximately 6.9%



A

Pure-tone average (dB) × Word recognition score (%)

	100-90	89-80	79-70	69-60	59-50	49-40	39-30	29-20	19-10	9-0
0-10										
11-20	5									
21-30	23		1							
31-40	19	3								
41-50	10	2								
51-60	6	3			1					
61-70	3	1								
71-80	2	1	1	1	1					
81-90										
91-100										

B

Pure-tone average (dB) × Word recognition score (%)

	100-90	89-80	79-70	69-60	59-50	49-40	39-30	29-20	19-10	9-0
0-10	1									
11-20	12	1								
21-30	10									
31-40	17	4								
41-50	9	4								
51-60	5	1								
61-70	4	2	1	1						
71-80	1									
81-90	1		1		1					
91-100										

C

←Improved Word recognition score (post-pre, %) Worse→

Pure-tone average (post-pre, dB): Improved→ … ←Worse

	>31	30 to 21	20 to 11	10 to 1	0	-1 to -10	-11 to -20	-21 to -30	<-31
<-31						1			
-30 to -21			1	2			1		
-20 to -11		1	3	9	16	7	1		
-10 to -1			2	6	17	7			
0					1	1	1		
1 to 10					4	2			
11 to 20									
21 to 30									
>31									

D

←Improved Word recognition score (post-pre, %) Worse→

Pure-tone average (post-pre, dB): Improved→ … ←Worse

	>31	30 to 21	20 to 11	10 to 1	0	-1 to -10	-11 to -20	-21 to -30	<-31
<-31									
-30 to -21					2				
-20 to -11			2	9	12	4			
-10 to -1			3	6	11	3	3		
0			1		1				
1 to 10			1	4	7	6			
11 to 20				1					
21 to 30									
>31									

Fig. 2 Scattergram of hearing outcomes. Preoperative hearing status: (A) ETT group; (B) ETTM group. Postoperative pure-tone average and word recognition score change: (C) ETT group; (D) ETTM group. ETT = endoscopic transcanal tympanoplasty; ETTM = endoscopic transcanal transtympanic myringoplasty.

(4.8% in ETT and 9.2% in ETTM) at 1-year. These results are similar to the findings of previous studies.[7,16] Andersen et al. reported a decline in the graft take-rate from 93.0% at 2–6 months to 86% at >12 months, with a decline in the average long-term take rate of approximately 6% when compared with the short-term result.[16]

Long-term graft success rates may be affected by multiple cofactors, such as graft type,[17] middle ear condition, Eustachian tube function, infection, and trauma. In our study, we used a tragal perichondrium graft to ensure the same operative exposure in exclusive endoscopic ear surgeries. The tragal perichondrium is derived from the mesoderm and is naturally thicker and stiffer than fascia.[18] It also avoids cutting through and repositioning the retro-auricular soft tissue, is easy to introduce, is not associated with scarring or auricular deformation, and leads to less donor-site morbidity in patients undergoing transcanal ear surgeries.[1] As per literature review, the graft success rate of tragal perichondrium was high. Goodhill et al. achieved a nearly 100% success rate in underlay tympanoplasty.[19] Strahan et al. recorded a graft uptake of 86%.[20]

Both groups exhibited significant auditory improvement after surgery (Cohen's d, 1.39; 95% CI, 0.75-1.00; $p < 0.001$; paired t-test), in accordance with previous findings.[7–10] Both groups also had a comparable postoperative mean ABG gain (Cohen's d, 0.07; 95% CI, –1.89 to 2.96; $p = 0.666$, t-test). Alzoubi et al. found no significant difference in the postoperative hearing improvement between the MTTM and MTT groups after the repair of small and medium perforations.[9] Tseng et al. used tragal perichondrium grafts to repair medium perforations and found that improvements in ABG were comparable for ETT and ETTM.[10] However, using temporal fascia as a graft for repairing medium and large tympanic membrane perforations, Atchariyasathian et al. recorded that the percentage of patients with postoperative ABG <10 dB was significantly higher in the

ETTM group (20 of 21 patients, 95.2%) than in the ETT group (16 of 19 patients, 84.2%).[7] In our study, the incidence of postoperative ABGs <10 dB, 10–20 dB, and >20 dB (95% CI, p = 0.775) were comparable in both groups, regardless of the perforation size.

This study had some limitations, including its retrospective design and small sample size, which may have limited the power of the study. In addition, patients with subtotal eardrum perforations or a small tragus due to limited tragal perichondrium size were not included. In this study, we focused on the outcomes of ETT and ETTM with tragal perichondrium. The outcomes may be different if other grafting materials are applied. Further prospective, randomized controlled trials with larger sample sizes and longer follow-up periods are required to determine appropriate selection criteria for surgery and minimize surgical complications.

In conclusion, ETTM with a tragal perichondrium graft is advantageous due to its lack of tympanomeatal flap elevation, shorter duration, and reliability of long-term results in the repair of small tympanic membrane perforations. For large eardrum perforations, ETT may be associated with a better long-term take-rate than ETTM. In both groups, ABGs were comparable pre- and postoperatively, irrespective of the perforation size. For medium perforations, both methods must be performed cautiously due to decreases in the take-rate (especially for ETTM) during the 1-year follow-up. Further long-term follow-up studies are required.

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REFERENCES

1. Chen CK, Hsieh LC. Clinical outcomes of exclusive transcanal endoscopic tympanoplasty with tragal perichondrium in 129 patients. *Clin Otolaryngol* 2018;**43**:1624–8.
2. Ayache S, Beltran M, Guevara N. Endoscopic classification of the external auditory canal for transcanal endoscopic ear surgery. *Eur Ann Otorhinolaryngol Head Neck Dis* 2019;**136**:247–50.
3. Presutti L, Marchioni D. *Endoscopic Ear Surgery: principles, indications, and techniques*. Stuttgart, New York: Thieme; 2014.
4. Migirov L, Wolf M. Endoscopic transcanal stapedotomy: how I do it. *Eur Arch Otorhinolaryngol* 2013;**270**:1547–9.
5. Tarabichi M, Ayache S, Nogueira JF, Al Qahtani M, Pothier DD. Endoscopic management of chronic otitis media and tympanoplasty. *Otolaryngol Clin North Am* 2013;**46**:155–63.
6. Kozin ED, Lee DJ. Transcanal endoscopic ear surgery: a new era of otologic surgery? *Hear*. 2015;**68**:8–9.
7. Atchariyasathian V, Suwannajak R, Plodpai Y, Pitathawatchai P. A comparison of endoscopic transtympanic myringoplasty and endoscopic type I tympanoplasty for repairing medium- to large-sized tympanic membrane perforation: a randomized clinical trial. *Eur Arch Otorhinolaryngol* 2020;**277**:2199–207.
8. El-Hennawi DEM, Ahmed MR, Abou-Halawa AS, Al-Hamtary MA. Endoscopic push-through technique compared to microscopic underlay myringoplasty in anterior tympanic membrane perforations. *J Laryngol Otol* 2018;**132**:509–13.
9. Alzoubi FQ, Tarifi AA, Khader Y, de Carpentier J. Comparison between transtympanic and elevation of tympanomeatal flap approaches in tympanoplasty. *Otol Neurotol* 2010;**31**:773–5.
10. Tseng CC, Lai MT, Wu CC, Yuan SP, Ding YF. Comparison of endoscopic transcanal myringoplasty and endoscopic type I tympanoplasty in repairing medium-sized tympanic perforations. *Auris Nasus Larynx* 2017;**44**:672–7.
11. Buckingham RA. Fascia and perichondrium atrophy in tympanoplasty and recurrent middle ear atelectasis. *Ann Otol Rhinol Laryngol* 1992;**101**:755–8.
12. Srinivasan V, Toynton SC, Mangat KS. Transtympanic myringoplasty in children. *Int J Pediatr Otorhinolaryngol* 1997;**39**:199–204.
13. Chen CK, Lee YC. Transcanal myringoplasty using perichondrium. *J Taiwan Otolaryngol Head Neck Surg* 2002;**37**:108–12.
14. Singh GB, Sharma A, Singh N. Role of transtympanic myringoplasty in modern otology. *J Otolaryngol* 2006;**35**:408–12.
15. el-Guindy A. Endoscopic transcanal myringoplasty. *J Laryngol Otol* 1992;**106**:493–5.
16. Andersen SA, Aabenhus K, Glad H, Sørensen MS. Graft take-rates after tympanoplasty: results from a prospective ear surgery database. *Otol Neurotol* 2014;**35**:e292–7.
17. Trakimas DR, Ishai R, Ghanad I, Black NL, Kozin ED, Cheng JT, et al. Otopathologic evaluation of temporalis fascia grafts following successful tympanoplasty in humans. *Laryngoscope* 2018;**128**:E351–8.
18. Eviatar A. Tragal perichondrium and cartilage in reconstructive ear surgery. *Laryngoscope* 1978;**88**(8 Pt 2 Suppl 11):1–23.
19. Goodhill V, Harris I, Brockman SJ. Tympanoplasty with perichondral graft. A Preliminary Report. *Arch Otolaryngol* 1964;**79**:131–7.
20. Strahan RW, Acquarelli M, Ward PH, Jafek B. Tympanic membrane grafting. Analysis of materials and techniques. *Ann Otol Rhinol Laryngol* 1971;**80**:854–60.