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ORIGINAL RESEARCH

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Predictors of anatomical and functional outcomes following tympanoplasty: A retrospective study of 413 procedures

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Abstract

Objectives: To identify the predictors of anatomical and functional outcomes following tympanoplasty.

Study Design: A retrospective cohort study.

Methods: Patients with chronic suppurative otitis media (CSOM) who underwent a tympanoplasty at Peking Union Medical College Hospital from January 1, 2015 to December 31, 2019 were retrospectively included. Outcome measures included graft success and postoperative pure tone audiometry air-bone gap (PTA-ABG) at last follow-up (≥6 months). PTA-ABG and MERI were calculated. Descriptive, univariable, and multivariable logistic regression analyses were conducted to evaluate the predictors of the graft and hearing outcomes.

Results: During the study, 385 patients (167 male, 218 female, median age 44 years) undergoing 413 procedures were studied. Out of this, 219 ears underwent tympanoplasty, 45 ears had tympanoplasty with canal wall up mastoidectomy, and 149 ears had tympanoplasty with canal wall down mastoidectomy. At the last follow-up, the overall graft success rate was 91.3% (377/413) and the overall hearing success rate was 40% (165/413). Multivariable analysis results showed that the obstructed aditus ad antrum (OR 2.67, 95%CI 1.13-6.30; $P = .025$) was an independent prognostic factor for graft failures. Moreover, the obstructed aditus ad antrum (OR 2.18, 95%CI 1.16-4.08; $P = .015$) and MERI >3 (OR 6.53, 95%CI 3.55-12.02; $P < .001$) were independent predictors of hearing failures (PTA-ABG > 20 dB).

Conclusions: Aditus ad antrum patency was an independent predictor of both graft and hearing success among patients following tympanoplasty. MERI score greater than three was found to be a significant predictor of postoperative hearing and could serve as a useful tool for assisting clinicians in perioperative risk assessment.

Level of Evidence: 4.

KEYWORDS
aditus ad antrum patency, middle ear risk index, prognostic factors, tympanoplasty

1 | INTRODUCTION

Tympanoplasty is a surgical procedure to repair the tympanic membrane and to reconstruct the ossicular chain. The surgery's primary goal is to eradicate the disease and restore tympanic aeration,[1] while the secondary purpose is to reconstruct a sound-transformer mechanism.[1] Since Zollner[2] and Wullstein[3] introduced tympanoplasty in 1956 for the first time, it has been regarded as a safe and practical surgical intervention for middle ear disease, with the reported success rates varying from 64% to 98%.[4-7] Consequently, many clinical studies have evaluated the factors that impact the success rate of tympanoplasty. There have been previous studies reporting prognostic factors in predicting the outcomes following tympanoplasty.[8,9] A lack of standardization, however, has hindered the comparison of results across institutions. Kartush,[10] in 1994, proposed a numeric scoring system, middle ear risk index (MERI), by incorporating ossicular chain status (Austin/Kartush), otorrhea (Belluci), and other significant factors. They later added smoking in 2001.[11] MERI 2001 included several prognostic variables such as otorrhea, presence of perforation, cholesteatoma, ossicular status, middle ear granulations or effusion, previous surgery, and smoker (Table 1). The score points ranged from 0 to 16. Based on the MERI score, patients were classified into low- (0-3), intermediate- (4-6), and high- (≥7) risk groups.

To date, there has been little agreement on the predictive role of this scoring system. Previous studies have considered the relationship between postoperative hearing and MERI scores or MERI risk catogories.[12] Conflicting results have been reported, however, in predicting the graft success following tympanoplasty. Some demonstrated that a high-risk MERI group had a lower graft success rate than a low/intermediate-risk group,[13,14] whereas others did not find any significant difference between different risk groups.[15] Previous studies have not yet fully explored the reasons behind this difference.

This article aimed to identify the potential predictors of graft and hearing outcomes after tympanoplasty and better understand the underlying mechanisms.

TABLE 1 Middle ear risk index (MERI) 2001

Variables	
Otorrhea	
I-Dry	0
II-Occasionally wet	1
III-Persistently wet	2
IV-Wet, cleft palate	3
Perforation	
None	0
Present	1
Cholesteatoma	
None	0
Present	2
Ossicular status	
M+I+S	0
M+S+	1
M+S−	2
M−S+	3
M−S−	4
Ossicular head fixation	2
Stapes fixation	3
Middle ear: granulations or effusion	
No	0
Yes	2
Previous surgery	
None	0
Staged	1
Revision	2
Smoker	
No	0
Yes	2

Abbreviations: M, malleus; S, stapes.

2 | MATERIALS AND METHODS

2.1 | Study design and participants

The research was a single-center retrospective cohort study comprising adult patients who underwent tympanoplasty between January 1, 2015, and December 31, 2019 at Peking Union Medical College Hospital, Beijing, China. The diagnosis was confirmed in all patients through histological examination. The sample adult patients had confirmed chronic suppurative otitis media (CSOM) or cholesteatoma. Patients with less than 6 months of follow-up and missing data on pure tone audiometry (PTA) records were excluded. This study was approved by the Ethics Committee of Peking Union Medical College Hospital (S-K1501).

Demographics and clinical data were collected retrospectively and extracted from electronic medical records and charts by one author. Variables included age, sex, medical history of systemic diseases (hypertension, diabetes mellitus, hyperlipidemia, coronary artery disease, rheumatoid arthritis, and thyroid dysfunction), smoking status, duration of the dry period, preoperative otorrhea, size and location of tympanic membrane (TM) perforation, aditus ad antrum patency on computed tomography (CT), mastoid type, contralateral ear status, tympanosclerosis, adhesive otitis media, cholesteatoma, middle ear granulation or discharge, surgical technique, types of graft, canalplasty, mastoidectomy, ossicular status (Austin/Kartush), and history of previous surgery. Patients with a known history of severe systemic diseases or with concurrent acute infection were excluded. For each patient, the MERI score was calculated using MERI 2001. According to the MERI score, the patients were classified into three risk categories: low-risk group (MERI equal to or less than 3), intermediate-risk (MERI of 4-6), and high-risk (MERI equal to or greater than 7).[11] The PTA audiogram recorded at the last visit before the surgery was used as the preoperative PTA records. In all cases, the extracted data were independently verified by another senior surgeon.

2.2 | Surgical technique

All surgeries were performed under general anesthesia. Underlay and overlay (or inlay) tympanoplasty techniques were used with either the postauricular or transcanal approach. Canalplasty is defined as the widening of the bony external auditory canal (EAC) to have a better view of the tympanic annulus by eliminating overhanging bones, particularly anteriorly and inferiorly.[16] Before canalplasty, the soft tissues had been elevated to expose the EAC. We normally elevated a meatal spiral skin flap about 2 mm away from the annulus and the spiral skin flap was laterally and anterior-inferiorly pedicled. The bony overhangs were gradually drilled until the entire tympanic annulus could be seen in a single view through the microscope. Temporalis fascia, perichondrium, or cartilage-perichondrium grafts were used in myringoplasty. Ossiculoplasty was performed with titanium prosthesis (partial ossicular replacement prosthesis, PORP, or total ossicular replacement prosthesis, TORP) or autologous cartilage as needed. The canal wall up (CWU) or canal wall down (CWD) mastoidectomy was conducted according to preoperative and intraoperative conditions. All surgeries were performed by senior surgeons.

2.3 | Outcome measures

Patients were followed up at one, two, four weeks, three to six months postoperatively, and semi-annually or annually thereafter. During the follow-up, all patients underwent clinical examination along with otoscopy and audiometry to assess the general conditions and postoperative hearing. This study defined graft success as intact graft healing with the absence of atelectasis at their most recent follow-up visit. Hearing success was considered as a PTA average air-bone gap (PTA-ABG) of 20 dB or less on the audiogram at the last follow-up. The PTA was calculated as the average thresholds at four frequencies (0.5 kHz, 1 kHz, 2 kHz, and 4 kHz). The follow-up was performed at the outpatient clinic.

2.4 | Statistical analysis

Descriptive statistics were used to summarize the demographic and clinical characteristics. Continuous variables were presented as means ± SD, and categorical variables were reported as number (percentage), unless stated otherwise. Comparisons of the preoperative and the postoperative PTA-ABG between low-, intermediate-, and high-risk groups were conducted using one-way analysis of variance (ANOVA) with post hoc test for multiple comparisons. The correlation between the MERI risk categories and postoperative hearing (Kartush classification) was analyzed using the Spearman rank correlation test.

Univariable logistic regression analysis was applied for all potentially prognostic variables for preliminary screening, and only variables with significance ($P < .1$) were then included in the multivariable regression analysis. This method was used to identify independent association factors. A value of $P < .05$ was selected as statistically significant. Statistical analysis was done using the SPSS software 26.0 (IBM SPSS Statistics).

3 | RESULTS

The study included 385 patients (study period between January 1, 2015 and December 31, 2019) with a median age of 44 years (range 19-85), and 55.6% of the study patients were female. Table 2 displays patients' characteristics. Of the 385 patients, 43 had hypertension, 13 had diabetes, 9 had hyperlipidemia, 6 had coronary heart disease, and 18 had a personal history of other systemic diseases. Fifty-four patients had a smoking history of more than 10 pack-year. A total of 385 patients underwent 413 tympanoplasty procedures with a median follow-up time of 19 months (range 6-53). Table 3 presents the surgical parameters. Twelve patients underwent bilateral surgeries, and 16 underwent reoperation or revision surgeries. Of the 413 procedures, 53% (219 ears) were tympanoplasty without mastoidectomy, 11% (45 ears) were CWU mastoidectomy, and 36% (149 ears) were CWD mastoidectomy. The postoperative pathology showed that 247 ears had chronic suppurative otitis media (CSOM), 118 had cholesteatoma, 40 had tympanosclerosis, and 8 had adhesive otitis media.

The overall graft success rate was 91.3% (377 of 413). The graft success rate was 89.6% (121 of 135) in the low-risk group, 91.0% (142 of 156) in the intermediate-risk group, and 93.4% (114 of 122) in the high-risk group, retrospectively. The graft success rate did not differ significantly among the three groups ($\chi^2 = 1.192$, $P = .551$).

TABLE 2 Characteristics of patients

Variable	Number (n = 385)
Age, y (median, range)	44 (19-85)
≤60	333 (86.5%)
>60	52 (13.5%)
Female	214 (55.6%)
BMI (kg/m^2, mean ± SD)	23.7 ± 3.6
Smoker	54 (14.0%)
Hypertension	43 (11.2%)
Diabetes	13 (3.4%)
Hyperlipidemia	9 (2.3%)
Coronary heart disease	6 (1.6%)
other systemic diseases	18 (4.7%)
Nasal disease	44 (11.4%)

Abbreviations: BMI, body mass index; CWU, Canal Wall Up; CWD, Canal Wall Down; MERI, Middle Ear Risk Index.

The overall mean pre- and postoperative PTA-ABG was 31.5 ± 11.0, 25.8 ± 13.6 dB, retrospectively. Table 4 shows the mean pre- and postoperative PTA-ABG in the three risk categories. The mean postoperative PTA-ABG was 18.3 ± 10.8 dB in the low-risk group, 26.5 ± 13.6 dB in the intermediate-risk group, and 32.5 ± 12.6 dB in the high-risk group. Patients in the low-risk group had a smaller post-operative ABG closure compared with the patients in the intermediate- (P < .001) and the high-risk groups (P < .001). A significant difference was also observed in the postoperative PTA-ABG between the intermediate- and the high-risk groups (P = .018).

Out of the 413 procedures, 40.4% (167/413) reported hearing success. The hearing success rate was 73.3% (99/135) in the low-risk group, 32.7% (51/156) in the intermediate-risk group, and 13.9% (17/122) in the high-risk group. Table 5 shows the postoperative PTA-ABG classification (Kartush) based on the MERI risk categories. Patients in the low-risk group had a higher hearing success rate than the intermediate- (χ^2 = 46.2, P < .001) and the high-risk group (χ^2 = 88.9, P < .001). Compared with the high-risk group, the patients in the intermediate-risk group had better hearing results (χ^2 = 12.0, P < .001). A moderate correlation was found between risk categories and PTA-ABG (Kartush classification) (Spearman r = 0.474, P < .001).

The number and rates of simple tympanoplasty without mastoidectomy, CWU and CWD mastoidectomy in three MERI risk categories are shown in Table 6. We compared the rates of CWD mastoidectomies in three risk categories and found that the rates increased with MERI risk category, with the lowest in the low-risk category (1.5%), whereas it was higher in the intermediate-risk group (41.7%) and highest rates in the high-risk category (67.2%).

TABLE 3 Surgical parameters

Variables	Number (n = 413)	Percentage (%)
Surgical technique		
Underlay	386	93.5
Overlay	21	5.1
Inlay	6	1.4
Types of graft		
Temporalis fascia	298	72.2
Perichondrium	36	8.7
Cartilage-perichondrium	79	19.1
Mastoidectomy		
No	219	53.0
CWU	45	10.9
CWD	149	36.1
Canalplasty	113	27.4
Revision surgery	16	8.0
Pathology		
CSOM	247	59.8
Cholesteatoma	118	28.6
Tympanosclerosis	40	9.7
Adhesive otitis media	8	1.9
Characteristic of MERI		
Mean (±SD)	5.0 (±2.8)	
Median (range)	5 (1-14)	
MERI ≤3	135	32.7
3 < MERI ≤6	156	37.8
MERI >6	122	29.5

Abbreviations: BMI, body mass index; CWU, Canal Wall Up; CWD, Canal Wall Down; CSOM, chronic suppurative otitis media; MERI, Middle Ear Risk Index.

3.1 | Factors affecting the graft outcome

Table 7 summarizes the results of univariable and multivariable aggression analyses of patients. Univariable analysis indicated that a blocked aditus ad antrum (OR 2.96, 95%CI 1.26-6.92; P = .012), and canalplasty (OR 2.31, 95%CI 1.15-4.64; P = .019) predicted a graft failure with statistical significance. Moreover, in the multivariable analysis, only a blocked aditus ad antrum (OR 2.67, 95%CI 1.13-6.30; P = .025) was confirmed as a significant independent predictor of the graft outcome.

3.2 | Factors affecting the hearing outcome

In the univariable analysis, smoking (OR 2.37, 95%CI 1.23-4.57; P = .010), preoperative dry ear period >3 months (OR 0.63, 95%CI

TABLE 4 Mean comparisons of preoperative and postoperative PTA-ABG (dB HL) between three groups: low, intermediate, and high-risk MERI (middle ear risk index) categories

	Low (n = 135)	Intermediate (n = 156)	High (n = 122)	P-value[a]		
				Low vs intermediate	Intermediate vs high	Low vs high
Preoperative PTA-ABG	27.3 ± 9.4	32.3 ± 10.9	34.5 ± 11.6	0.016*	0.686	0.001*
Postoperative PTA-ABG	18.3 ± 10.8	26.5 ± 13.6	32.5 ± 12.6	<0.001*	0.018*	<0.001*

Note: Data shown are mean ± SD.
Abbreviations: MERI, middle ear risk index; PTA-ABG, pure tone audiometry average air-bone gap.
*Significant statistical difference with P < .05. [a]Adjusted P-value using a Bonferroni correction.

TABLE 5 Postoperative PTA-ABG (Kartush classification) based on low, intermediate, and high-risk categories

MERI categories (scores)	n	0-10 dB (excellent)	11-20 dB (good)	21-30 dB (fair)	>30 dB (poor)	Spearman rank coefficient	P-value
Low (0-3)	135	12 (8.9)	87 (64.4)	25 (18.5)	11 (8.1)	0.440	<.001
Intermediate (4-6)	156	10 (6.4)	41 (26.3)	66 (42.3)	39 (25.0)		
High (≥7)	122	0 (0.0)	17 (13.9)	69 (56.6)	36 (29.5)		

Note: Data shown are number (%).
Abbreviations: MERI, middle ear risk index; PTA-ABG, pure tone audiometry average air-bone gap.

TABLE 6 Types of surgical procedures regarding the MERI risk categories

MERI categories (scores)	No mastoidectomy	CWU	CWD
Low (0-3)	123 (91.1)	10 (7.4)	2 (1.5)
Intermediate (4-6)	75 (48.0)	16 (10.3)	65 (41.7)
High (≥7)	21 (17.2)	19 (15.6)	82 (67.2)

Note: Data shown are number (%).
Abbreviations: CWU, Canal Wall Up; CWD, Canal Wall Down; MERI, middle ear risk index.

0.43-0.94; $P = .024$), abnormal contralateral ear (OR 1.58, 95%CI 1.04-2.39; $P = .033$), blocked aditus ad antrum (OR 4.38, 95%CI 2.79-6.89; $P < .001$), mastoid type, mastoidectomy, and MERI score > 3 (OR 8.49, 95%CI 5.31-13.58; $P < .001$) were significant predictors of the hearing failure (PTA-ABG >20 dB). In the multivariable analysis, the blocked aditus ad antrum (OR 2.18, 95%CI 1.16-4.08; $P = .015$) and MERI score > 3 (OR 6.53, 95%CI 3.55-12.02; $P < .001$) were the only independent predictors of the hearing outcome.

4 | DISCUSSION

In the present study, aditus ad antrum patency was found to be an independent predictor of both graft and hearing outcomes. High resolution computed tomography (HRCT) is a reliable method for predicting aditus patency.[17] Therefore, in our study, we defined patients with a patent or blocked aditus on HRCT scan of the temporal bone. We found that patients with a patent aditus had greater graft and hearing success rates. Similar results were reported by Kurien et al.[18] However, whether an obstructed aditus ad antrum is the cause or consequence of dysventilation of epitympanum remains uncertain. Some believe that aditus ad antrum plays a critical role in the aeration of the mastoid air cell system (MACS). An obstructed aditus ad antrum might contribute to dysventilation of the MACS, reduce the transmucosal gas exchange function and disrupt regulation of middle ear pressure, thus affecting graft and hearing success adversely.[19]

MERI was an independent predictor of the hearing outcome after tympanoplasty. Our findings were consistent with some previous studies in which MERI was calculated using the seven variables reported by Becvarovski et al.[11] In a study by Pinar et al,[20] a total of 231 cases were evaluated, and a low MERI score was found to be an important prognostic factor of tympanoplasty success. Shishegar et al[15] found that the success rate was higher in the low-risk group than both intermediate- and high-risk groups. In our study, patients in the low-risk category had the best hearing results. In terms of graft success, our findings were inconsistent with those of the previous studies.[13,20] Sevil et al reported that the tympanoplasty success rate was 92.5% in the low- or intermediate-risk groups and 57.1% within the high-risk group. However, the three groups did not differ significantly in the graft success rates. In our study, the graft success rates also did not differ significantly among the three risk categories. A possible explanation could be that all three risk groups' graft success rates were high (88.3%-90.4%). The graft failure might be too infrequent to detect minor differences among the three groups.

According to Fisch,[16] canalplasty is a surgical technique used to widen the bony portion of EAC. Numerous studies have reported the benefits of canalplasty in tympanoplasty, pointing out that adequate canalplasty are essential to visualize the tympanic annulus and facilitate graft healing.[21,22] In contrast, our study demonstrated that canalplasty was a predictor of graft failure. It was also observed that the graft success rate was about two times higher in patients without canalplasty than in patients that underwent canalplasty. One possible explanation for this discrepancy is that canalplasty are mostly performed in anterior or subtotal perforations, which might introduce selection bias. Another speculation is that canalplasty may reduce vascular supply to the tympanic membrane, thereby adversely affecting successful grafting. Therefore, further investigation of this point is still required.

Previous studies have reported smoking to be of prognostic importance, and it was added in MERI 2001.[11] In our study, smoking was a predictor for the hearing outcome following tympanoplasty. The rate of hearing failure was two times higher in patients with more than 10 pack-year history of smoking than those without a significant smoking history. These results were similar to those reported by Becvarovski et al.[11] The reasons why smoking impacted the hearing

TABLE 7 Predictors of graft and hearing outcomes

Variables	Number (n)	Risk of patients with graft failure				Risk of patients with PTA-ABG > 20			
		Univariable analysis		Multivariable analysis		Univariable analysis		Multivariable analysis	
		OR (95%CI)	*P* value	OR (95%CI)	*P* value	OR (95%CI)	*P* value	OR (95%CI)	*P* value
Age (>60)	57	0.33 (0.16-1.84)	.544			1.56 (0.86-2.83)	.144		
Male sex	167	1.10 (0.55-2.20)	.790			0.95 (0.64-1.42)	.810		
Smoking	54	1.08 (0.40-2.91)	.880			2.37 (1.23-4.57)	.010	1.58 (0.76-3.27)	.219
Dry ear period >3 mo	180	1.04 (0.52-2.07)	.913			0.63 (0.43-0.94)	.024	1.25 (0.76-2.04)	.382
Abnormal Contralateral ear	149	1.47 (0.74-2.93)	.276			1.58 (1.04-2.39)	.033	1.61 (0.98-2.66)	.060
Blocked aditus ad antrum	164	2.96 (1.26-6.92)	.012	2.67 (1.13-6.30)	0.025	4.38 (2.79-6.89)	<.001	2.18 (1.16-4.08)	.015
Mastoid type									
Pneumatic	175	Reference	.101			Reference	.011	Reference	.284
Diploic	170	0.75 (0.37-1.52)	.424			1.53 (0.99-2.35)	.053	0.64 (0.37-1.11)	.113
Sclerotic	68	0.12 (0.02-0.88)	.037			2.38 (1.30-4.37)	.005	0.75 (0.35-1.59)	.449
Size of perforation (>50%)	330	1.17 (0.88-1.55)	.276			1.00 (0.83-1.22)	.974		
Tympanosclerosis	40	1.18 (0.40-3.54)	.762			1.46 (0.73-2.92)	.284		
Types of graft									
Temporalis fascia	298	Reference	.511			Reference	.105		
Perichondrium	36	1.76 (0.63-4.93)	.281			0.59 (0.30-1.19)	.141		
Cartilage-perichondrium	79	0.89 (0.36-2.27)	.819			0.64 (0.39-1.06)	.081		
Mastoidectomy									
No	219	Reference	.162			Reference	<.001	Reference	.777
CWU	45	1.38 (0.52-3.62)	.516			2.73 (1.38-5.42)	.004	1.32 (0.61-2.89)	.482
CWD	149	0.51 (0.22-1.17)	.113			4.51 (2.81-7.25)	<.001	1.13 (0.58-2.19)	.729
Canalplasty	113	2.31 (1.15-4.64)	.019	2.02 (1.00-4.11)	.051	0.99 (0.63-1.53)	.945		
MERI score > 3	278	0.74 (0.37-1.50)	.408			8.49 (5.31-13.58)	<.001	6.53 (3.55-12.02)	<.001

Abbreviations: CI, confidence interval; CWU, Canal Wall Up; CWD, Canal Wall Down; MERI, Middle Ear Risk Index; OR, odds ratio.

outcomes negatively might be 2-fold: One—the long-term tobacco exposure may impair mucociliary clearance function[23]; two—the vasoconstrictor effects of nicotine possibly compromised the blood supply of the newly grafted drum. Considering the cumulative effect of smoking, we believe that the impact of smoking on graft success may take many years to appear. Further long-term follow-up studies are needed, including the possible effect on long-term hearing performance.

A dry ear period for more than 3 months is of predictive value in hearing success. Previous studies showed that patients without otorrhea could have a better hearing threshold after tympanoplasty.[24] Vignadutt et al[25] have reported that dry ears were more associated with graft success. However, Gamra et al[26] found no significant difference for graft success and hearing gain between dry and wet ears. In our study, a dry ear period for more than 3 months was a predictor for hearing success, consistent with the findings of Hayati et al.[24] Preoperative treatment might play a crucial role in a better outcome, or even influence surgical decision-making and help to define the right time for surgical intervention.

Contralateral ear status as a prognostic factor has been reported in earlier research. Sevil et al[14] found that patients with healthy opposite ears had a higher graft success rate than those with abnormal opposite ears. However, no significant differences were observed in the reported success rates between the two groups. Pinar et al[20] observed that the success rate of tympanoplasty was greater when the opposite ear did not have a perforation or atelectasis. In our study, patients with an abnormal contralateral ear had 1.6 times higher rate for hearing failure than patients with a healthy opposite ear. Patients with a healthy contralateral ear were more likely to have proper Eustachian tube function, which may contribute to the faster recovery of the middle ear.

Previous studies have reported inconsistent results on the role of mastoidectomy in tympanoplasty success. Callioglu et al[7] found that mastoidectomy did not affect the graft and hearing success. In contrast to their findings, a study by Sevil et al[14] reported a much higher graft success rate in patients undergoing mastoidectomy. In the present study, patients who underwent CWD had 4.5 times higher hearing failure rate than patients who underwent simple tympanoplasty. The reason for this difference was currently not apparent as the difference did not seem to result from the type of surgical procedure. Shishegar et al[15] found that the patients in the CWD group had the highest MERI score, suggesting that individuals with higher MERI scores had higher risk factors and required a CWD surgery. This discrepancy very likely stems from the lesion's size and nature, thereby suggesting that the size and nature of the lesion rather than surgical approaches account for the discrepancy.

The present study still has several limitations. First, we have only analyzed the parameters that have been described in the published literature; some parameters have not been included in this article. Second, it is a retrospective single-center study, and some patients had to be excluded because they could not come for follow-up due to transportation problems. We only analyzed the patients with complete records; patients with incomplete data were excluded. Considering the baseline similarities between the included patients and those excluded, we believe that this would not bias our results. Further prospective studies from multiple centers are required to confirm our study findings. Regardless of the limitations mentioned above, the present study confirmed the prognostic importance of MERI in hearing outcomes after tympanoplasty.

5 | CONCLUSION

Aditus ad antrum patency was an independent predictor of both graft and hearing outcomes following tympanoplasty. A MERI score greater than three was also an independent predictor of hearing outcome and could be an effective tool assisting in perioperative risk assessment.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interests.

AUTHOR CONTRIBUTIONS

Xiao-Hui Zhu designed research, performed research, and wrote the article. Yong-Li Zhang and Ruo-Yan Xue collected and analyzed data; the remaining authors discussed the results and revised the article.

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