A comparative study of endoscopic tympanoplasty versus microscopic tympanoplasty in simple chronic otitis media

Jun-Liang Li[1], Kuang-Hsi Chang[2], Hung-Min Chang[1], Anthony Li[1], Min-Cheng Ko[1], Stella Chin-Shaw Tsai[1,3*]

[1]Department of Otolaryngology, Tungs' Taichung MetroHarbor Hospital, Taichung, Taiwan,
[2]Department of Medical Research, Tungs' Taichung MetroHarbor Hospital, Taichung, Taiwan,
[3]Department of Post-Baccalaureate Medicine, College of Medicine, National Chung Hsing University, Taichung, Taiwan

Abstract

Background: Otologic surgeries previously used microscopes, requiring large incisions. Recent advances in medical optical resolutiosn allows the introduction of the otologic endoscope as a less invasive alternative, providing better visualization and accessibility. Endoscopic surgery is now preferred for type 1 tympanoplasty and cholesteatoma treatment. **Objectives:** This study aims to compare the outcomes between patients who underwent endoscopic tympanoplasty and those who underwent microscopic tympanoplasty without ossiculoplasty or mastoidectomy. **Methods:** We retrospectively examined the data of 191 patients (201 ears) who underwent tympanoplasty without ossiculoplasty or mastoidectomy using either an endoscope or a microscope in the Department of Otolaryngology, Tungs' Taichung MetroHarbor Hospital, Taichung, Taiwan, from July 1, 2014 to June 30, 2019. We compared the surgical and functional outcomes between the two approaches. We also analyzed the relationship between the two approaches and the size of the perforated tympanic membrane. **Results:** Endoscopic and microscopic tympanoplasties were performed in 67 and 134 ears, respectively. The preoperative pure tone average or air-bone gap values between the two groups were not statistically significant. The tympanic membrane healing rates for the four subgroups were classified according to the perforation size (Q1 : ≤ 25%, Q2 : > 25% & ≤ 50%, Q3 : > 50% & ≤ 75%, and Q4 : > 75% & ≤ 100%) were 90.9%, 94.1%, 95.0%, and 87.5% (P = 0.893), respectively, for the endoscopic group, and 97.0%, 86.4%, 97.1%, and 72.7% (P = 0.011), respectively, for the microscopic group. The postoperative improvement in the air-bone gap and pure tone average values between the two groups was not statistically significant. When considering the perforation size, the improvement in air-bone gap values was significantly different among the endoscopic groups (−1.0, −11.1, −3.9, and −7.8 dB, P = 0.002 for Q1, Q2, Q3 and Q4, respectively). Additionally, the procedure was markedly shorter in cases that underwent endoscopic surgeries for tympanic membrane perforation size of <25% (P = 0.007). **Conclusion:** Patients who underwent endoscopic and microscopic tympanoplasties without ossiculoplasty or mastoidectomy showed similar surgical and functional outcomes. Moreover, the procedural duration was markedly shortened in cases that underwent endoscopic surgeries, especially for those with small-sized perforations of the tympanic membrane.

Keywords: Chronic otitis media, endoscopic, microscopic, tympanoplasty

Introduction

Otologic surgeries were initially performed with the aid of a microscope in the 1920s.[1] Owing to the need for a direct line of vision, the use of a microscope required a large surgical incision to allow adequate exposure of the operative field. Thus, some complementary techniques, such as canaloplasty, and post-auricular approach, were developed. However, these techniques had demonstrated early and late adverse effects. Due to a large incision wound, increased wound pain and infection rates were observed postoperatively. Moreover, a wide incision on the auricular cartilage or post-auricular area could potentially distort the cartilaginous shape and contribute to scar formation. Therefore, the introduction

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Address for correspondence: Dr. Stella Chin-Shaw Tsai, Department of Otolaryngology, Tungs' Taichung MetroHarbor Hospital, No. 699, Sec. 8, Taiwan Blvd., Wuqi Dist., Taichung 43503, Taiwan.
E-mail: t5722@ms3.sltung.com.tw

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of the endoscope was appealing to the surgeons.[2] Using a transcanal approach, an endoscope could be navigated through the twisted and narrow external auditory meatus transcanally and could provide a wide-angled and high-resolution view under magnification. The angled-scope could assist in examining the areas inaccessible by a microscope, including the facial recess, epitympanum, and antrum.[2]

Previously, the application of an endoscope in mastoidectomy or ossiculoplasty for cholesteatoma treatment has been investigated.[3-6] Attributed to its advantages in terms of increased accessibility to otherwise difficult-to-access areas and a wide-angled and high-resolution view under magnification, endoscopic surgery has gradually become the preferred method for type 1 tympanoplasty, even extending to patients with cholesteatoma.

In this study, we focused on the application of an endoscope in tympanoplasty and discussed the outcomes of type 1 tympanoplasty without ossiculoplasty, using either an endoscope, or a microscope, taking into consideration the size of the perforated tympanic membrane for different operative methods.

Materials and Methods

Patients

This retrospective study reviewed the medical records of patients who underwent tympanoplasty at the Department of Otolaryngology, Tungs' Taichung MetroHarbor Hospital, Taichung, Taiwan, from July 1, 2014 to June 30, 2019. The patients treated before 2018 underwent a conventional microscopic tympanoplasty, whereas those treated after January 2018 underwent an endoscopic surgery. The present study was approved by the Institutional Review Board of the hospital (IRB#108076).

Exclusion criteria

Patients with other middle ear pathologies, such as cholesteatoma or otosclerosis, or those who had undergone other additional ear operations, such as mastoidectomy, or ossiculoplasty, were excluded. Moreover, patients who were treated using a combination of endoscopic and microscopic methods, or those for whom the method was changed (from endoscopic to microscopic, or vice versa), were excluded.

Preoperative survey

All the patients underwent a pure tone audiometry analysis preoperatively and at 1 month postoperatively. The pure tone average air conduction values and air-bone gap values were calculated by setting the hearing thresholds at 500, 1000, 2000, and 4000 Hz.

Operative setting

This study included only patients who underwent tympanoplasty without ossiculoplasty or mastoidectomy. Patients from both groups were admitted to the hospital to undergo the procedures under general anesthesia. All the patients were placed in a supine position with head turned to the contralateral side for ear surgery. All the procedures were performed by four surgeons in our department. A full endoscopic transcanal tympanoplasty approach was performed using rigid endoscopes (Spiggle & Theis, Medizintechnik GmbH, Overath, Germany) with 3 mm in diameter, 11 cm in length, and 0° and 30° angles of view for the endoscopic group. The microscope group all underwent endaural tympanoplasty approach with the use of a surgical microscope (Carl Zeiss Meditec AG, OPMI-VAEIO/S8, Goeschwitzer Strasse, Germany). The autologous graft material used in both groups was either the temporalis fascia or the areolar tissue, depending on the surgeon's preference. All fasciae were obtained by endaural incision. The operative time referred to the duration of the surgical procedure, excluding the time taken for induction, intubation, awakening, and recovery.

Postoperative follow-up and outcomes

All the patients were followed up postoperatively at our outpatient clinic once per week until fascial uptakes were confirmed and the postoperative pure tone audiometry tests were performed. The ear packing was removed in the second week, and a pure tone audiometry test was performed at 1 month postoperatively.

The surgical outcomes were presented with two perspectives. One focused on the comparison of endoscopic and microscopic surgeries, whereas the other included the operative results according to the perforation size of the tympanic membrane. The healing rates of the tympanic membranes were surveyed with respect to the perforation sizes (presented in percentage = [perforation size]/[total tympanic membrane area] × 100%, divided into the following four groups: Q1 : ≤ 25%, Q2 : > 25% & ≤ 50%, Q3 : > 50% & ≤ 75%, and Q4 : > 75% & ≤ 100%.

Statistical analyses

All statistical analyses were performed using the Statistical Package for the Social Sciences for Windows (version 17.0; SPSS Inc., Chicago, IL, USA). The baseline data for the endoscopic and microscopic groups are presented as frequency, with percentages given for categorical variables and means with standard deviations for continuous variables. *T*-tests and χ^2 tests were used to describe the differences in the values for the categorical and continuous variables, respectively, between the endoscopic and microscopic groups.

Results

This retrospective study included 201 ears (right: 115, left: 86) from 191 patients who underwent tympanoplasty without ossiculoplasty. Specifically, endoscopic and microscopic tympanoplasties were performed in 67 and 134 ears, respectively [Table 1]. The patients' ages ranged

Table 1: Comparison of the demography within the endoscopic and the microscopic groups according to the perforated area of the tympanic membrane

Area		Endoscope				*P*	Microscope				*P*
		≤25%	> 25% & ≤ 50%	> 50% & ≤ 75%	> 75% & ≤ 100%		≤25%	> 25% & ≤ 50%	> 50% & ≤ 75%	> 75% & ≤ 100%	
Sex	F	9	11	14	5	0.240	13	28	22	7	0.021*
		40.9%	64.7%	70.0%	62.5%		39.4%	63.6%	62.9%	31.8%	
	M	13	6	6	3		20	16	13	15	
		59.1%	35.3%	30.0%	37.5%		60.6%	36.4%	37.1%	68.2%	
Side	L	10	10	15	5	0.280	21	25	17	12	0.660
		45.5%	58.8%	75.0%	62.5%		63.6%	56.8%	48.6%	54.5%	
	R	12	7	5	3		12	19	18	10	
		54.5%	41.2%	25.0%	37.5%		36.4%	43.2%	51.4%	45.5%	
TM healed	N	2	1	1	1	0.893	1	6	1	6	0.011*
		9.1%	5.9%	5.0%	12.5%		3.0%	13.6%	2.9%	27.3%	
	Y	20	16	19	7		32	38	34	16	
		90.9%	94.1%	95.0%	87.5%		97.0%	86.4%	97.1%	72.7%	

F = female, M = male, L = left, R = right, TM = tympanic membrane, N = fail, Y = success

*$P < 0.05$

from 6 to 85 years (mean, 54.2 ± 15.7 years); 45.8% were male patients and 54.2% were female patients. The patients' demographic characteristics are presented in Tables 1 and 2. The baseline hearing ability was assessed using pure audiometry test [Table 3]. The differences in the preoperative pure tone average values or preoperative average air-bone gap values between the two groups were not statistically significant.

Surgical outcomes

The healing rates of the tympanic membranes that were classified into four groups according to perforation size in the endoscopic and microscopic groups were 90.9%, 94.1%, 95.0%, and 87.5% ($P = 0.893$), respectively, and 97.0%, 86.4%, 97.1%, and 72.7% ($P = 0.011$), respectively [Table 1]. In the microscopic group, the difference in the healing rates of the tympanic membranes was statistically significant among the different perforation-size groups. However, this phenomenon was not observed in the endoscopic group [Table 1], nor was a significant difference was observed in each of the four perforation-size subgroups between the endoscopic and microscopic groups [Table 2]. We found no statistical significance in the healing rates of the tympanic membranes between the two surgical methods and among different perforation sizes in the endoscopic group [Tables 1 and 2].

The mean operative times for the endoscopic and microscopic groups were 67.03 ± 22.0 and 69.39 ± 22.53 min ($P = 0.427$), respectively [Table 3], showing no statistically significant difference. However, the operative time was significantly different among the four perforation-size subgroups in the endoscopic group ($P = 0.010$). A statistically significant difference in the operative time was also detected between the endoscopic and microscopic groups for the subgroup with a perforation size of ≤25% ($P = 0.007$) [Table 4].

Functional outcomes

The restoration of hearing ability was evaluated by pure tone audiometry testing. A statistically significant difference in the improvement in air-bone gap values improvement or pure tone average values was not observed between the two groups with respect to Table 3. Similar to the comparison among the different perforation-size subgroups, we found that there was no statistically significant difference in the improvement of the pure tone average values between the two groups. However, the improvement in the air-bone gap was statistically significant among the four perforation-size subgroups in the endoscopic group (−1.0, −11.1, −3.9, and −7.8 dB [$P = 0.002$] for Q1, Q2, Q3 and Q4, respectively, with the negative values indicating an improvement) [Table 5].

Discussion

Tympanoplasty is performed to prevent recurrent middle ear infections and to restore hearing functions.[3,7,8] Earlier, microscopes were conventionally used for ear surgeries. The advantages of using a microscope include the freedom to perform two-handed manipulation and a stereoscopic surgical view. However, during transcanal tympanoplasty, the view provided by a microscope could often be blocked due to a crooked or stenotic external auditory canal. Certain sites have been recognized as areas with difficult access, such as the anterior margin of the tympanic membrane, sinus tympani, or facial recesses.[2,8-10] Canaloplasty or post-auricular approaches were used for expanding the operative field and better visualization. However, the drawbacks of these techniques included soft tissue damage and need for wider incision wounds, thus requiring a greater dose

Table 2: Comparison of the demography and tympanic membrane hearing rates between the endoscopic and the microscopic groups according to different perforated tympanic membrane area categories

Area		≤25%				P	> 25% & ≤ 50%				P	> 50% & ≤ 75%				P	> 75% & ≤ 100%				P
		Endoscope		Microscope			Endoscope		Microscope			Endoscope		Microscope			Endoscope		Microscope		
Sex	F	9	40.9%	13	39.4%	1.000	11	64.7%	28	63.6%	1.000	14	70.0%	22	62.9%	0.809	5	62.5%	7	31.8%	0.210
	M	13	59.1%	20	60.6%		6	35.3%	16	36.4%		6	30.0%	13	37.1%		3	37.5%	15	68.2%	
Side	L	10	45.5%	21	63.6%	0.292	10	58.8%	25	56.8%	1.000	15	75.0%	17	48.6%	0.104	5	62.5%	12	54.5%	1.000
	R	12	54.5%	12	36.4%		7	41.2%	19	43.2%		5	25.0%	18	51.4%		3	37.5%	10	45.5%	
TM healed	N	2	9.1%	1	3.0%	0.557	1	5.9%	6	13.6%	0.661	1	5.0%	1	2.9%	1.000	1	12.5%	6	27.3%	0.638
	Y	20	90.9%	32	97.0%		16	94.1%	38	86.4%		19	95.0%	34	97.1%		7	87.5%	16	72.7%	

Area = eardrum perforation area, F = female, M = male, L = left, R = right, TM = tympanic membrane, N = fail, Y = success

$^*P < 0.05$, Fisher's Exact Test was used when more than 20% of expected counts are less than 5

of analgesics during postoperative care.[8-10] Endoscopic surgery avoided the abovementioned drawbacks; however, unlike the microscopic approach, endoscopy allowed the use of only one hand during the operation, which could be difficult in some situations. Another disadvantage of the surgery was uncontrollable hemorrhage. In previous literature, the role of pure tympanoplasty without ossiculoplasty and the effects of different perforation sizes of the tympanic membrane on the healing rates have seldom been emphasized. Thus, in this study, we sought to analyze similar cases treated at our hospital to investigate the clinical details regarding these aspects.

Surgical outcomes

In this study, the tympanic membrane healing rates were similar in both groups. All microscopic surgeries were performed using the endaural approach, as compared with previous studies.[3,11,12] In one case, the chorda tympani was sacrificed due to hindrance of fascia placement during surgery. However, during the 6-month follow-up at the clinic, the patient did not complain of persistent dysgeusia. No other complications mentioned in the reports by Huang *et al.*,[13] Kuo *et al.*,[14] and Tseng *et al.*[15] were observed in our cases. We did not observe any statistically significant difference in the surgical outcomes between the endoscopic and microscopic surgical procedures. However, taking the perforation area of the tympanic membrane into consideration, we observed a statistically significant decrease in the healing rates of tympanic perforations with the extension of the perforation area in the microscopic group, but not in the endoscopic group. This may reflect the benefit of endoscopic surgery in evaluating and manipulating large perforations of the tympanic membrane (perforation area > 75%) [Table 1], although it showed no significance in the subgroup comparison [Table 2]. It may be related to the unequal number of cases in the subgroups, limiting its ability to detect a statistical significance. Different angled reflective mirrors may be selected to suit the clinical demands of endoscopy, which is especially advantageous when the perforation size is large or the operation involves a particular difficult-to-access location. The cutoff was a diameter of >3 mm or a size of >50% of the tympanic membrane.[15] Marginal and posterior perforations were reported to be associated with a poor prognosis, but this is still a controversial viewpoint and further clarification is needed.[3,16] All our patients were treated under general anesthesia and no statistically significant difference were found in the operative time between the endoscopic and microscopic groups, which contradicts the results reported by Kuo *et al.*[14] and Manna *et al.*[17] When the results were analyzed taking into consideration the size of the perforated tympanic membrane, a statistically significant difference was detected in the operative time in the subgroup with the smallest perforation size. Endoscopic

Table 3: Comparison of the pre- and post-operation audiometry and operative time for both groups

	Microscope (n = 134)		Endoscope (n = 67)		*P* value
	Mean	SD	Mean	SD	
Age	56.13	16.01	53.9	15.88	0.424
PrePTA	50	23.08	43.16	18.63	0.055
Mean (preB500/1000/2000/4000)	32.83	15.97	27.01	13.37	0.021*
PostPTA	42.97	23.98	38.41	20.04	0.223
Mean (posB500/1000/2000/4000)	31.74	16.81	27.01	14.52	0.079
PreABG	17.17	11.35	16.15	10.2	0.532
PostABG	11.23	10.57	11.4	9.63	0.691
ABG impro	-5.94	9.7	-4.75	8.56	0.394
PTA impro	-7.03	20.6	-4.75	7.88	0.176
OP time	69.69	22.53	67.03	22.0	0.427

Pre- and post-ABG = preoperative and postoperative air-bone gap, impro = improvement, PTA = pure tone audiometry(average of air conduction), OP = operation, PrePTA = preoperative air conduction at 500, 1000, 2000, 4000 Hz, PostPTA = postoperative air conduction at 500, 1000, 2000, 4000 Hz, PreB500/100/2000/4000 = preoperative bone conduction at 500, 1000, 2000, and 4000 Hz, PosB500/100/2000/4000 = postoperative bone conduction at 500, 1000, 2000, 4000 Hz, SD = standard deviation

* Indicates $P < 0.05$, statistical significance

Table 4: Inter-group comparisons of the operative duration according to different perforated tympanic membrane area categories

Area	Operative time (minutes)						*P*
	Endoscopy			Microscopy			
	N	Mean	SD	*N*	Mean	SD	
≤25%	22	55.14	19.31	33	72.15	23.84	0.007*
> 25% & ≤ 50%	17	69.94	19.78	44	67.36	22.46	0.680
> 50% & ≤ 75%	20	77.00	24.97	35	72.11	22.55	0.461
> 75% & ≤ 100%	8	68.63	10.34	22	66.82	21.30	0.821

Area = eardrum perforation area, N = number, SD = standard deviation

*Denotes *P* value < 0.05

surgeries required less time for the management of smaller perforations in our study.

In the previous studies, the average success rate of endoscopic tympanoplasty without ossiculoplasty ranged from 93% to 98%.[11-14] Both endoscopic and microscopic approaches produced similar results in terms of hearing function restoration and graft success rate. The primary benefit of endoscopy was to provide a better surgical view. The statistical findings in this study are comparable with those obtained by previous studies.[17-19] Our results indicated that endoscopic surgery might be a good approach for performing tympanoplasty without ossiculoplasty.

Functional outcomes

One of the chief reasons for patients to opt for tympanoplasty is the restoration of hearing functions. In our study, no statistically significant difference was observed in this regard between the endoscopic and microscopic groups. However, in the endoscopic group, the air-bone gap value improvement varied significantly among the different perforation-size categories. Our results suggested that the recovery of hearing function was not depended on the perforation size.

The number of patients in each of the four subgroups in the endoscopic group was 22, 17, 20, and 8 (Q1, Q2, Q3 and Q4 respectively). Therefore, the small sample sizes may limit us from deducing the accurate relationship between the perforation size and hearing function improvement.

Limitations

This study had certain limitations. The decision about the surgical methods used in the patients was made on a temporal basis (before or since 2018). Moreover, the bias caused by the operator could be reduced further. Furthermore, the details about the perforation sites on the tympanic membranes were unavailable in the clinical records. In the future, we recommend to archive these data as images to enable objective estimations of the exact perforation size and location with an analytic software, thereby preventing subjective discrepancies. Furthermore, the shorter operative time in the endoscopic group may be attributed to the maturation effect of the operators' surgical skills since the procedures in the microscopic group were performed earlier. Another limitation was the patient's compliance with the postoperative follow-up at the outpatient clinic. Therefore, we could not record the long-term complications, especially that some patients only underwent follow-up at 1 month postoperatively and

Table 5: Intra-group comparison results of the pre-, post-operation audiometry and operation time

Area	Endoscope													Microscope												
	≤25%			> 25% & ≤ 50%			> 50% & ≤ 75%			> 75% & ≤ 100%			*P*	≤25%			> 25% & ≤ 50%			> 50% & ≤ 75%			> 75% & ≤ 100%			*P*
	N	Mean	SD	*N*	Mean	SD	*N*	Mean	SD	*N*	Mean	SD		*N*	Mean	SD	*N*	Mean	SD	*N*	Mean	SD	*N*	Mean	SD	
Age	22	53.6	15.2	17	49.8	14.1	20	55.9	16.7	8	57.9	16.4	0.572	33	52.1	15.8	44	53.8	14.7	35	56.1	16.6	22	56.0	17.8	0.714
OpTime	22	55.1	19.3	17	69.9	19.8	20	77.0	25.0	8	68.6	10.3	0.01*	33	72.2	23.8	44	67.4	22.5	35	72.1	22.6	22	66.8	21.3	0.658
PreABG	19	10.1	9.0	16	15.2	9.7	19	16.6	7.9	8	28.1	8.7	0.000*	32	10.9	10.3	42	15.1	12.1	34	20.6	10.1	22	22.2	8.0	0.000*
PostABG	17	9.3	8.5	12	5.8	5.7	14	12.2	8.6	8	20.3	7.2	0.002*	21	9.6	10.5	28	10.0	9.6	24	12.8	10.1	17	15.1	13.9	0.340
ABGimpro	15	–1.0	5.9	12	–11.1	5.3	13	–3.9	8.5	8	–7.8	6.4	0.002*	21	–1.8	6.9	28	–5.2	8.2	24	–7.8	11.1	17	–8.1	12.7	0.147
PrePTA	15	37.2	10.3	12	39.2	11.8	13	41.3	18.1	8	61.9	27.6	0.010*	21	41.3	23.0	29	50.0	24.2	25	51.0	17.8	17	58.7	22.6	0.123
PostPTA	15	34.3	14.1	12	30.1	15.2	13	38.3	20.8	8	55.3	26.2	0.032*	21	39.3	27.0	28	41.3	23.2	24	44.4	21.9	17	51.3	27.6	0.469
PTAimpro	15	–2.9	7.5	12	–9.1	7.6	13	–3.0	9.1	8	–6.6	5.1	0.141	21	–2.0	14.1	28	–9.9	10.3	23	–13.3	37.0	16	–6.6	10.0	0.355

Area = eardrum perforation area, OpTime = operation time, Pre = preoperative, Post = postoperative, ABG = air-bone gap, impro = improvement, PTA = pure tone audiometry (average of air conduction), *N* = number of cases, SD = standard deviation

* Indicates $P < 0.05$, statistical significance

they only completed pure tone audiometry testing. Thus, late complications, such as recurrent infection, or delayed fascia failure, may not have been detected in our study. The number of patients evaluated in this study was relatively small to obtain strong evidence to claim the effectiveness of our results. Further studies with a larger sample size are, therefore, necessary. In this study, an audiometric analysis using the speech reception threshold or speech discrimination score was notused. However, in previous studies, the hearing quality or discrimination ability was also an important prognostic assessment tool.[20,21] We plan to utilize this approach in further studies and extend it to patients undergoing ossiculoplasty.

Conclusion

Our results revealed that endoscopic surgery to be an effective method for tympanoplasty without ossiculoplasty, compared with microscopic surgery. However, this study was performed at a single regional hospital. To elucidate the clinical applications of endoscopes in ear surgery, further prospective studies should be conducted in the future.

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Conflicts of interest

Prof. Stella Chin-Shaw Tsai, an editorial board member at *Tungs' Medical Journal*, had no role in the peer review process of or decision to publish this article. The other authors declared no conflicts of interest in writing this paper.

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