



Endoscopic transcanal versus conventional microscopic tympanoplasty in treatment of anterior tympanic membrane perforations

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Abstract

Purpose To compare the surgical outcomes of endoscopic transcanal tympanoplasty (ETT) and conventional microscopic tympanoplasty (CMT) in repairing anterior tympanic membrane perforations (ATMPs).

Methods We retrospectively analyzed the graft success rate, hearing outcomes, operative time, hospitalization period and complications in patients who underwent ETT and CMT between October 2015 and July 2018. In addition, the authors investigated whether anterior canal wall protrusion (ACWP) affects the graft success rate and operative time.

Results The graft success rates for ETT and CMT were 93.7% (30 out of 32 patients) and 91.4% (32 out of 35 patients), respectively ($p = 0.640$). There was no significant relationship between ACWP and graft success rates in either the endoscopic ($p = 0.685$) and microscopic ($p = 0.894$) group. The mean operative time was significantly shorter in the ETT group (37.2 ± 3.1 min) than in the CMT group (52.9 ± 9.2 min) ($p < 0.001$). Regarding operative time, there was no statistically significant difference between patients with and without ACWP (38.3 versus 36.3 min, respectively ($p = 0.124$)) in the ETT group. However, the mean operative time of patients with ACWP in the CMT group was significantly longer than patients without ACWP [62.3 versus 48.8 min, respectively ($p < 0.001$)].

Conclusions ETT offering fewer complication rates and shorter duration of surgery may serve as a reasonable alternative to CMT in repairing ATMPs, with comparable graft success rates.

Keywords Tympanoplasty · Endoscopic ear surgery · Chondroperichondrial graft · Tympanic membrane · Perforation · Anterior

Introduction

The main objectives of tympanoplasty include the closure of the tympanic membrane perforation and restoration of hearing, and various surgical techniques and graft materials have been used for that purpose thus far [1, 2]. Endoscopy was first used in chronic otitis surgery in the 1990s and has become increasingly popular in recent years [2, 3]. Endoscopes, as a primary or auxiliary device, can be used

on various types of middle ear surgeries, including chronic otitis surgery, otosclerosis surgery, and cochlear implant surgery [4, 5]. At present, microscopes with considerable advantages, such as a stereoscopic view and two-handed surgery, are widely used in tympanoplasty operations. However, due to the narrow-angle view and straight field of view, microscopes may not be sufficient to entirely visualize the concealed areas in the middle ear space and ATMPs without bone curettage or anterior canalplasty [6, 7]. Endoscopes, particularly angled types, ensure direct access to the concealed areas that might be difficult to directly view with microscopes, such as facial recess, sinus tympani, and ATMPs [7]. Furthermore, endoscopes offer considerable benefits such as panoramic vision, magnification without resolution loss, and simplicity in achieving appropriate zoom and exposure via simple back-and-forth endoscope movement. In addition, the endoscopic approach is minimally

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invasive, and enables an almost painless postoperative period and achieves satisfactory cosmetic results [8].

The conventional microscopic retroauricular approach is the most preferred method by many otolaryngologists for ATMPs [8, 9]. However, even with the conventional microscopic retroauricular approach, anterior marginal perforations of the tympanic membrane may often require anterior canalplasty in patients with anterior canal wall protrusion (ACWP) [9]. In the present study, authors aimed to compare the surgical and functional outcomes of endoscopic transcanal tympanoplasty (ETT) and conventional microscopic tympanoplasty (CMT) in patients with ATMPs.

Materials and methods

In this retrospective study, between October 2015 and July 2018, 67 patients (29 females, 38 males) who underwent ETT ($n = 32$) and CMT ($n = 35$) at a private hospital and tertiary referral centre were enrolled to study. Informed consent was obtained from all patients and the local ethics committee approved the study. Perforations not crossing beyond a line extended along the manubrium mallei were accepted as ATMP. The database of the digital patient record software (FileMaker Pro 9, Claris International Inc., USA) was scanned, and all ATMP (including anterior-inferior and/or anterior–superior quadrant, and anterior marginal perforation) patients who underwent endoscopic transcanal and microscopic retroauricular tympanoplasty using chondroperichondrium composite graft included into this study. According to our digital patient record software database scan, we excluded the patients with a history of prior chronic otitis media surgery, history of mastoidectomy, inadequate follow-up, and perforations not localized at the anterior quadrant of the tympanic membrane from the study. Cases in which the anterior margin of the perforation could not be visualized entirely with the otoscopic examination were considered as patients with ACWP.

Parameters such as graft success rate, operative time and complications were recorded and analyzed retrospectively. Also, authors aimed to investigate whether ACWP affects the duration of surgery and graft success rate. Grafting was considered to be successful in patients with the intact tympanic membrane at 6 months after surgery. Reperforation and medialization of the graft during the follow-up period were indicative of graft failure.

Surgical technique

In both groups, the external auditory canal was infiltrated with a diluted adrenaline (1:100 000) solution containing lidocaine (2%) (Jetokain, Adeka, Turkey) to reduce bleeding during the tympanomeatal flap elevation stage. In the

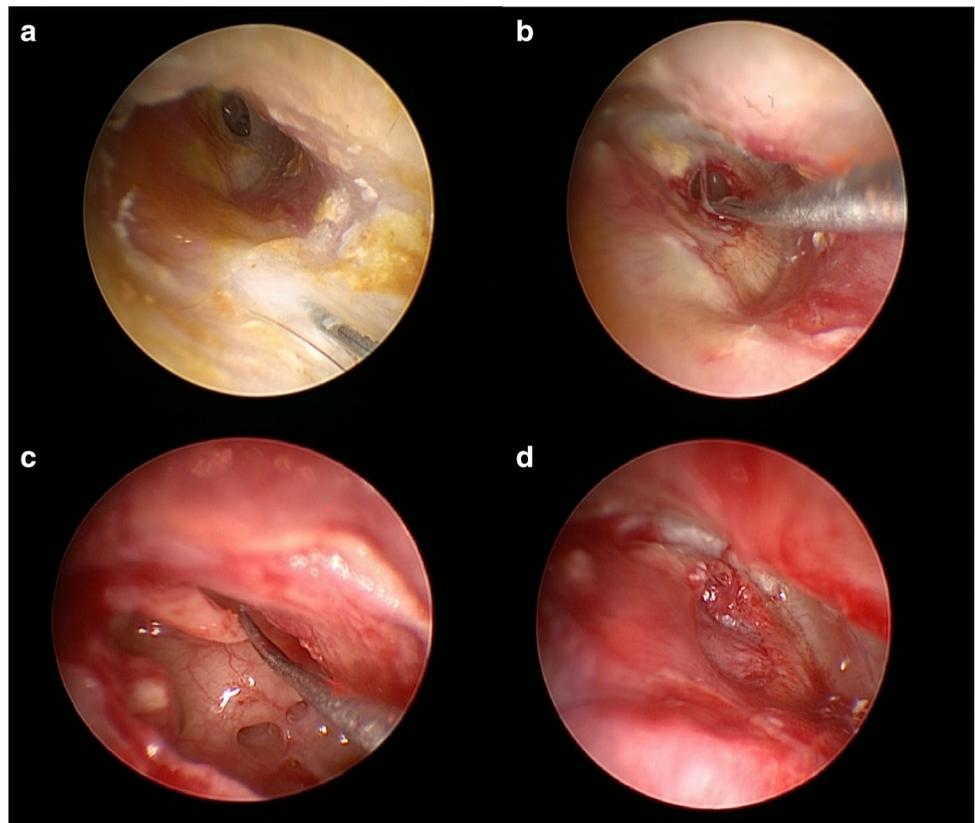
ETT group, the endomeatal incisions were performed for tympanomeatal flap elevation whereas conventional retroauricular approach was used in the CMT group. The margins of the perforations were circumferentially freshened via a curved needle. Anterior canalplasty was required in 8 out of 10 patients with ACWP in the CMT group. After the tympanomeatal flap was elevated, the middle ear structures inspected, and the ossicular chain integrity and mobility assessed. Chondroperichondrial composite graft (comprising one-side perichondrium) was used for repairing the perforation in the ETT and CMT group both. The chondroperichondrial graft was harvested from the tragus by preserving the rim of tragal cartilage via an incision medial to the tragus. A notch corresponding to malleus manubrium was created on the chondroperichondrial graft. In both groups, the over-underlay (over the manubrium and under the annulus) technique used for grafting (Fig. 1). A mucosal flap was created in a retrograde manner from tympanic sulcus in patients with anterior marginal perforation, where the tympanic membrane remnant is not sufficient, to secure the graft anteriorly. Thereafter, Gelfoam® (Pfizer Inc, New York, USA) pieces were placed underneath the graft to prevent medialization. The tympanomeatal flap in both groups and flap created for anterior canalplasty in CMT group patients with ACWP were placed in the original position and tightly supported with Gelfoam®. Ear drops (Siprogut®, Bilim, Turkey) containing ciprofloxacin were then applied to Gelfoam® pieces that was placed in the external auditory canal. Absorbable suturing was used to close the tragal incisions in either ETT and CMT group and to close the retroauricular incisions in CMT group. The mastoid dressing was applied in all patients who underwent CMT for 7 days. In the endoscopic group, tragal incision and external auditory canal covered using a small gauze dressing. Our routine follow-up policy included an assessment in the first and second week, and at 1, 3, and 6 months after surgery.

The first surgeon in the present study had 5 years of experience in endoscopic ear surgery, and has performed various types of otologic procedures, including chronic otitis surgery, otosclerosis surgery, and cochlear implantation. All operations included in this study were performed by the same surgeon (first author).

Instrumentation

An 11-cm long, 2.7-mm diameter, 0° or 30° rigid endoscope (Karl Storz, Tuttlingen, Germany) was used for the ETT procedures. Images were obtained from a high-definition (HD) camera (Karl Storz, Germany) connected to the endoscope, and were transferred to an HD monitor (Karl Storz, Germany) placed in front of the surgeon. A light emitting diode (LED) light source was used for the illumination of the surgical field. An Opmi Vario S88 surgical microscope

Fig. 1 Steps of the endoscopic transcanal tympanoplasty **a** infiltration of external auditory canal with a diluted adrenaline solution **b** circumferentially freshening of the perforation edges **c** assessment of the ossicular chain integrity and mobility **d** chondroperichondral grafting



(Carl Zeiss, Oberkochen, Germany) was used for the CMT procedures.

Statistical analysis

The Statistical Package for Social Science (SPSS) software version 22.0 was used for analysis of the data. Normality of data was checked before each statistical analysis and the appropriate test was chosen. Categorical variables between groups were compared using the χ^2 test. Student's *t*-test was utilized for analyzing the normally distributed data. Mann–Whitney *U* test was used to analyze the data without normal distribution. Results were presented as mean [\pm SD (Standard deviation)], median (range) and percent. A *P* value, calculated with a 95% CI (confidence interval), less than 0.05 was considered to be statistically significant.

Results

A total of 67 patients with ATMP who underwent type-1 tympanoplasty via an ETT and CMT were enrolled to study. Of the patients in the ETT group, 14 (43.8%) were female and 18 (56.2%) were male, whereas 13 (40.6%) and 19 (59.4%) underwent operations in the right and left ears, respectively. The mean age [\pm SD (Standard deviation)] of

the patients in the ETT group was 36.6 ± 10.8 years (range 16–51 years). Of the patients in the CMT group, 15 (42.9%) were female and 20 (57.1%) were male, whereas 17 (48.5%) and 18 (51.4%) underwent operations in the right and left ears, respectively. The mean (\pm SD) age of the patients in the CMT group was 32.6 ± 7.8 years (range 21–44 years). There were 11 (34.3%) patients with ACWP in the ETT group, whereas the CMT includes 10 (28.6%) patients with ACWP. The average hospitalization period for the ETT and CMT group was 5.2 h and 26.7 h, in the order given ($p < 0.001$). The average follow-up period was 9.2 (range 6–30 months) and 8.1 (range 6–24 months) months for ETT and CMT group, respectively. A comparison of the clinical characteristics and surgical outcomes of patients is presented at Table 1.

The graft uptake rates in ETT and CMT group were 93.7% (30 out of 32 patients) and 91.4% (32 out of 35 patients), respectively ($p = 0.640$). Furthermore, there was no significant relationship between ACWP and graft success rates in either the endoscopic ($p = 0.685$) and microscopic ($p = 0.894$) group. Regarding the graft failure, graft reperforation was observed in one patient in both groups, while graft medialization was observed in 1 (3.1%) and 2 (5.7%) patients in the ETT and CMT groups, respectively.

The mean (\pm SD) duration of surgery in ETT and CMT groups were 37.2 ± 3.1 min and 52.9 ± 9.2 min, respectively.

Table 1 Comparison of the clinical characteristics and surgical outcomes of patients with ATMP

	ETT group (<i>n</i> = 32)	CMT group (<i>n</i> = 35)	<i>P</i> value
Age [mean ± SD (range)]	36.6 ± 10.8 (16–51)	32.6 ± 7.8 (21–44)	> 0.05
Gender			
Male	18 (56.2%)	20 (57.1%)	> 0.05
Female	14 (43.8%)	15 (42.9%)	> 0.05
Direction			
Right	13 (40.6%)	17 (48.5%)	
Left	18 (59.4%)	18 (51.4%)	
ACWP			
Yes	11 (34.3%)	10 (28.6%)	> 0.05
No	19 (65.7%)	25 (71.4%)	> 0.05
Anterior canalplasty requirement	0	8 (22.8%)	
Graft uptake rate	93.7%	91.4%	= 0.640
Duration of surgery (mean ± SD minutes)	37.2 ± 3.1	52.9 ± 9.2	< 0.001
Complications			
Reperforation	1 (3.1%)	1 (2.8%)	
Graft medialization	1 (3.1%)	2 (5.7%)	
Otitis externa	1 (3.1%)	6 (26.6%)	
Dysgeusia	2 (6.2%)	7 (20%)	
Hematoma	0	2 (5.7%)	
Wound infection	0	3 (8.5%)	
Numbness at auricula	0	2 (5.7%)	
Mild asymmetry at auricula	0	1 (2.8%)	
Average hospitalization period (hours)	5.2	26.7	< 0.001
Mean follow up period (months)	9.2	8.1	

A *P* value less than 0.05 was considered to be statistically significant

SD standard deviation, *ACWP* anterior canal wall protrusion, *ETT* endoscopic transcanal tympanoplasty, *CMT* conventional microscopic tympanoplasty

The average operative time was significantly shorter in the ETT group as compared to the CMT group ($p < 0.001$). When groups were separately compared to investigate the relationship between ACWP and operative times, there was no statistically significant difference observed between patients with ($n = 11$) and without ($n = 21$) ACWP (38.3 versus 36.3 min, in the order given ($p = 0.124$)) in the ETT group, whereas the mean operative time of patients with ACWP ($n = 10$) in the CMT group was significantly longer than patients without ACWP ($n = 25$) [62.3 versus 48.8 min, in the order given ($p < 0.001$)] (Fig. 2).

In the CMT group, anterior canalplasty was required in 8 (22.8%) out of 10 patients with ACWP to visualize and to refresh the anterior margin of the perforation. However, none of the patients with ACWP ($n = 11$) in the ETT group required canalplasty. In 6 (26.6%) of 8 patients who underwent anterior canalplasty in the CMT group, otitis externa developed postoperatively, while otitis externa observed in 1 (3.1%) patient in the ETT group.

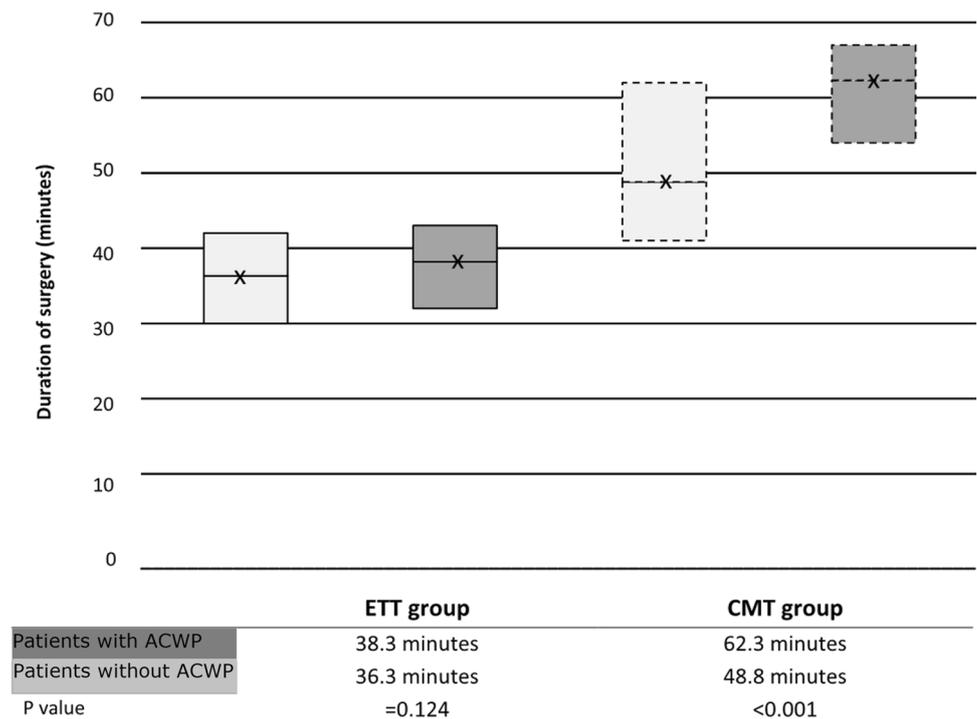
Despite the preservation of the chorda tympani nerve in all cases, transient dysgeusia was observed in 2 (6.2%) patients in ETT group and 7 (20%) patients in CMT group.

Postoperative complications were observed in the CMT group as follows: 2 (5.7%) patients had a hematoma, wound infection in 3 (8.5%) patients, numbness at auricula in 2 (5.7%) patients, and mild asymmetry at auricula in 1 (2.8%) patients. No major complications, such as sensorineural hearing loss or facial paralysis, were observed in either group.

Discussion

In the final quarter of the twentieth century, endoscopes were first used, as primary or auxiliary devices, for an ear examination and surgery thus the era of endoscopy in otology begun [2, 6, 10]. The use of endoscopes in ear surgery is associated with significant advantages such as the visualization of concealed areas without canalplasty and minimal invasiveness of the surgery with lower complications [4, 11]. Nevertheless, the lack of a stereoscopic view, one-handed surgery, and the longer learning curve remain the main limitations of endoscopic ear surgery [12–14]. The repair of ATMPs is challenging due to the poor graft stabilization,

Fig. 2 Comparison of groups regarding the relationship between ACWP (anterior canal wall protrusion) and duration of surgery



insufficient vascularization, and difficulties in visualization of the relationship between the anterior margin of the perforation and graft due to the ACWP [15–17]. Using the chondroperichondrium which is durable to infections and resorption and is resistant to the negative pressure generated by sniffing, as a graft material to repair ATMPs significantly lowers re-perforation and medialization risk [1]. Therefore, in the present study, the chondroperichondrial composite graft was used to repair ATMPs. To our knowledge, this is the first study comparing the outcomes between ETT and CMT in repairing ATMPs with a chondroperichondrial composite graft using the over-underlay technique.

Henawi et al. evaluated the outcomes of endoscopic transcanal push-through (modification of underlay technique) and CMT for ATMPs using chondroperichondrial composite graft, and found that the graft uptake rate was 92.9% and 85.7%, in the order given [11]. Celik et al. reported that the graft success rate was 87.5% for ATMPs treated with ETT [18]. The present study revealed that graft uptake rates were comparable with studies those reported in the literature and there was no significant difference between ETT and CMT regarding graft uptake rates ($p=0.640$), and furthermore, ACWP does not significantly affect the graft success rate in patients with ATMPs treated with either the endoscopic and microscopic approach.

The longer the operative time, the longer the duration of exposure to anaesthetic agents, thus operative time is an important parameter that affects the surgical approach decision of otorhinolaryngologists. Most studies have shown that

the endoscopic technique yields a shorter operative duration as compared to the microscopic approach [19–21]. We suggest that excellent and panoramic visualization of the perforation edges without anterior canalplasty, particularly at the anterior margin of the perforation, may contribute to shorter operative times in the endoscopic group. Additional time-consuming procedures such as anterior canalplasty and bone curettage may often be required in order to achieve appropriate exposure with the microscopic approaches. Furthermore, the necessity of frequent position changing while operating with the microscope is another time-consuming factor. Tseng et al. advocated that partial visualization of the perforation margin due to ACWP significantly prolonged the duration of surgery in patients with ATMPs underwent endoscopic myringoplasty [15]. However, in this study, ACWP found not to be significantly prolonging the duration of surgery in the ETT group since anterior canalplasty taking additional time is not required in patients with ACWP. On the other hand, this study revealed that ACWP significantly prolongs the duration of surgery in the CMT group. It is obvious that the endoscopic approach yields a shorter duration of surgery for repairing ATMPs in patients with ACWP in particular (Fig. 2).

The ETT technique is minimally invasive and ensures an almost pain-free postoperative period [21]. Besides, in a study comparing endoscopic and microscopic approach for ATMPs, authors reported mean estimated blood loss in the endoscopic group was significantly less than the microscopic group [11]. In CMT group, the anterior canalplasty

procedure and retroauricular approach are the factors that may contribute to a higher level of pain postoperatively. Postoperative pain reduces the quality of life and may result in increased analgesics use and may lead to prolonged hospitalization. In this study, the reasons for significantly prolonged hospitalization in microscopic tympanoplasty group compared to endoscopic tympanoplasty group includes an intravenous analgesic requirement of patients for pain reported at the early postoperative period and a control examination necessity at postoperative day one for possible retroauricular hematoma formation. Thus, ETT offers a higher level of patient comfort during the postoperative period and lowers medical expenditures. Moreover, delayed anterior tympanomeatal flap healing in patients who required anterior canalplasty may be responsible for that is why otitis externa was observed more frequently in CMT group. The stretching of the chorda tympani nerve due to excessive manipulation may lead to transient or permanent dysgeusia. Despite the preservation of the integrity of the chorda tympani nerve in all cases, a transient taste disturbance was observed in both groups. The dysgeusia that was seen more frequently in CMT group spontaneously improved without any medical treatment within 3 months in all the patients. As seen in the present study, numbness and minor asymmetry at auricle are the bothersome complications that may occur in the retroauricular approach. Consequently, it is obvious that the CMT is associated with increased morbidity postoperatively as compared to the ETT in patients with ATMPs (Table 1).

In an experimental study, researchers speculated that an increase in heat due to the endoscope light in the middle ear may lead to sensorineural hearing loss [22]. The use of LED light sources with lower heat dissipation, as compared to halogen and xenon light sources, may avoid the increase in the temperature in the middle ear; however, due to the lack of sufficient studies on this topic, sensorineural hearing loss due to thermal damage should be carefully considered when working with the endoscopes. Nevertheless, in the present study, we did not observe sensorineural hearing loss in any of the patients in ETT group.

Conclusion

In summary, ETT which is offering comparable graft success rates in ATMPs yields shorter operative times, fewer complication rates, and more minimally invasive surgery relative to the CMT. In particular patients with ACWP, for the repair of perforations localized in the anterior quadrant of the tympanic membrane, ETT is a reliable, valid and reasonable technique and could be considered as a primary treatment option.

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Compliance with ethical standards

Conflict of interest The authors of present study declare that they have no conflict of interest.

Informed consent Informed consent was obtained from all individual participants included in the study.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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