Total Transcanal Endoscopic Ear Surgery for Cholesteatoma

Original Investigation

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Abstract

Objective: This study aimed to evaluate the outcomes of total transcanal endoscopic cholesteatoma surgery.

Methods: Twenty-seven cholesteatoma patients that had undergone transcanal endoscopic ear surgery (TEES) were included in the study. Age, sex, operation date of patients, operated side, need for ossiculoplasty, graft material, and surgical technique were recorded. All patients were evaluated through otoscopic, endoscopic, and audiological examinations and followed up for at least five months after surgery. All patients were staged using the European Academy of Otology and Neurotology/Japan Otological Society (EAONO/JOS) Staging System on Middle Ear Cholesteatoma.

Results: Mean age of the patients was 36.4 years (range, 4–67 years). According to the EAONO/JOS Staging System, 11 patients were stage 1, while 11 were stage 2, and five were stage 3. Two had lateral semicircular canal defect, one had facial canal dehiscence, and one had oval window defect. The average follow-up period was 19 months (range, 5–41 months), during which two patients experienced retraction pocket and hearing loss and one patient had perforation. One patient underwent revision surgery during follow-up and no recurrence or residual cholesteatoma was observed. The preoperative and postoperative air–bone gaps were 25.14±13.93 dB and 22.22±12.64 dB with no significant difference.

Conclusion: TEES is a minimally invasive and safe procedure with low complication and recurrence rates. As with all surgical procedures, experience is essential, and as experience increases, the capability to perform endoscopic otologic surgery on more complex cases may become possible.

Keywords: Cholesteatoma, endoscopic surgery, otologic surgical procedures, tympanoplasty, mastoidectomy

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Introduction

Cholesteatoma is defined as the growth of keratinizing squamous epithelium with the keratin debris and surrounding inflammatory reaction. Cholesteatoma is classified as congenital or acquired (1). Primary acquired cholesteatoma occurs when the retraction pocket originating from the tympanic membrane reaches the tympanic cavity and then advances toward the sinus tympani, facial recess, and attic (2). In advanced cases, cholesteatoma extends into the mastoid cavity. Surgical

treatment primarily aims to eradicate the disease and ensure a healthy middle ear cavity and to restore hearing if possible.

The post-auricular microscopic approach with the canal wall-down (CWD) mastoidectomy has been one of the most popular techniques for the treatment of cholesteatoma. Recently, however, minimally invasive approaches are becoming more popular. Tympanoplasties with or without cholesteatoma can be performed with endoscopes in a minimally invasive manner. Endoscopes have been used in otology since the 1960s, although initially for diagnosis (3). In the 1990s, their use spread to ear surgeries in addition to microscopes as an auxiliary tool. Recently, many otologic surgeries such as myringoplasty, tympanoplasty, stapedectomy, and cholesteatoma surgery are being performed with endoscopes alone. Endoscopes provide wider visualization, and with 0° and angled telescopes that can reach hidden regions such as the facial recess, the sinus tympani, the hypotympanum or the anterior attic (4). Endoscopic ear surgery (EES) does not require soft tissue incisions like postauricular or endaural incisions aside from harvesting graft. However, this method requires intense training due to its disadvantages such as one-hand surgery, need for good hemostasis, absence of depth perception due to two-dimensional view, and risk of thermal injury (5). In this study, we aimed to evaluate the outcomes of transcanal endoscopic cholesteatoma surgery in our clinic.

Methods

Only cholesteatoma patients who had undergone transcanal endoscopic ear surgery (TEES) were included in the study. Ethical approval was obtained from University of Health Sciences Turkey, İzmir Bozyaka Training and Research Hospital Clinical Research Ethics Committee (decision no: 2021/108, date: 23.06.2021). All patients were informed about the objective of the study and signed the written consent form. Using the data from patient records, we reviewed their complaints and the results of their otoscopic and audiological examinations done after surgery. All patients were followed up for at least five months after surgery. All operations were performed by the senior author with a rigid endoscope (3 mm, 0°, 30°, 15-cm lens) under general anesthesia. We recorded the age, sex, operation date, side, need for ossiculoplasty, graft material and surgical technique, and audiogram findings before and five months after surgery. Air-bone gap (ABG) closure and recovery levels based on each frequency (500, 1000, 2000, 4000, 8000 dB) were evaluated in the audiological results.

In 2018, EES was classified by Cohen et al. (6) as follows: EES Class 1, endoscopic inspection without dissection; EES Class 2, mixed use of the endoscope; and EES Class 3, total transcanal endoscopic surgery. In our study, all patients were treated with EES Class 3 (TEES). All video recordings of the surgeries were reviewed. The origin of cholesteatoma was identified as congenital, pars tensa, pars flaccida, or secondary to a tensa perforation. The European Academy of Otology and Neurotology/Japan Otological Society (EAONO/JOS) Staging System on Middle Ear Cholesteatoma was used to categorize the stages of cholesteatoma (7): Stage 1, cholesteatoma localized in the primary site [the site of cholesteatoma origin, i.e., the attic (A) for pars flaccida cholesteatoma; the tympanic cavity (T) for pars tensa cholesteatoma, congenital cholesteatoma, and cholesteatoma secondary to a tensa perforation]; stage 2, cholesteatoma involving two or more sites; stage 3, cholesteatoma with extracranial complications or pathologic conditions; and stage 4, cholesteatoma with intracranial complications (7).

During follow-up, all patients were monitored for postoperative complications, recurrence, and residual cholesteatoma. Diffusion-weighted magnetic resonance imaging (MRI) was used for monitoring recurrence in suspected cases after the otoscopic and endoscopic examinations.

Statistical Analysis

Data were analyzed using the SPSS software for Windows (v22.0; IBM Armonk, NY, USA). Individual and aggregate data were summarized using descriptive statistics including mean, standard deviations, and medians (minimum-maximum), as well as frequency distributions and percentages. Paired t-test was performed to compare the means. P values <0.05 were considered statistically significant.

Results

A total of 27 patients [14 females and 13 males with a mean age of 36.4 years (range, 4–67 years)] that had undergone TEES were included in the study (Table 1). Of them, 19 patients were operated on in the left ear and eight patients in the right ear. The origin of cholesteatoma was congenital cholesteatoma in two patients, secondary to a tensa perforation in three patients, pars flaccida cholesteatoma in 15 patients, and pars tensa cholesteatoma in seven patients (Figure 1). According to the EAONO/JOS Staging System on Middle Ear Cholesteatoma, 11 patients were in stage 1, 11 patients in stage 2, and five patients in stage 3 (Table 2).

Mean hospitalization was 2.4 days, ranging from one to seven days. Two patients had lateral semicircular canal fistula (LSCF) (Figure 2), one had facial canal dehiscence, one had oval window defect, and three had tympanosclerosis. In terms of perioperative complications, two patients had chorda tympani damage and one patient experienced bleeding due to a high jugular bulb. For tympanoplasty, perichondrium and cartilage graft were used in all patients. For ossicular reconstruction, type 1 tympanoplasty was performed in four patients, type 2 tympanoplasty in 15 patients, and type 3

tympanoplasty in eight patients. However, ossiculoplasty was not performed on four patients. Of all surgical operations, 23 were primary surgery and four were revision surgery. Ossicular reconstructions was performed using total ossicular reconstruction prosthesis (TORP) in six patients, incus in 13 patients, partial ossicular reconstruction prosthesis (PORP) in three patients, and bone cement in one patient (Figure 3).

Canal wall-up tympanoplasty (CWU) was performed in 26 patients, and CWD tympanoplasty in one patient. In CWU tympanoplasty, reconstruction was done with cartilage after atticotomy (Figure 4). Obliteration with cartilage and fascia was performed in only one patient who underwent CWD tympanoplasty. Average surgical time was 164 minutes (range, 116-minutes). The average follow-up period was 19 months (range, 5–41 months). In the follow-up period, retraction pocket and hearing loss were noted in two patients and a 2-mm size perforation in one patient. Diffusion-weighted MRI was used in two cases who were suspected of recurrence. However, there were no high-signal-intensity in diffusion-weighted MRI scans of these patients. Revision surgery was done in one patient who underwent TEES due to progressive conductive hearing loss two years after the first operation. There was only a dislocated TORP from the primary surgery and no recurrent cholesteatoma was identified during the surgery. Recidivism was not seen in any of the patients in the follow-up period.

Mean preoperative and postoperative ABG were 25.14±13.93 dB and 22.22±12.64 dB (Table 3). Mean preoperative and postoperative air-conduction thresholds, bone-conduction thresholds, and ABG were not significantly different (p=0.237, 0.189, and 0.417, respectively).

Table 1. Demographic characteristics and surgical results of the patients

Gender	
Female	14 (51.86%)
Male	13 (48.14%)
Age	36.4 years (4–67)
Follow-up period	19 months (5–41 months)
Hospitalization time	2.4 days (1–7 days)
ABG (dB)	
Preoperative ABG	25.14±13.93
Postoperative ABG	22.22±12.64
Perioperative complications	3 patients (11%)
Chorda tympani injury	2 patients
Intraoperative bleeding	1 patient
Postoperative complications	3 patients (11%)
Retraction pocket	2 patients
Perforation	1 patient
Recurrence of cholesteatoma	No
Residual cholesteatoma	No

ABG: Air-bone gap, dB: Decibel

Discussion

The use of surgical microscopes in ear surgery in the 1950s brought about significant developments in otology, thanks to their magnification and illumination features. Thereafter, the recent widespread use of endoscopes has led to similar developments in the field of EES. Endoscopes, which were initially used as auxiliary instruments in microscopic surgery, have replaced mainly microscopes, especially in transcanal surgeries. Although endoscopes have been used in ear surgery for more than 20 years, they have become increasingly popular with the development of those with narrower diameter, cold light sources, and high-resolution video recording systems (8, 9). The first procedure was endoscopic

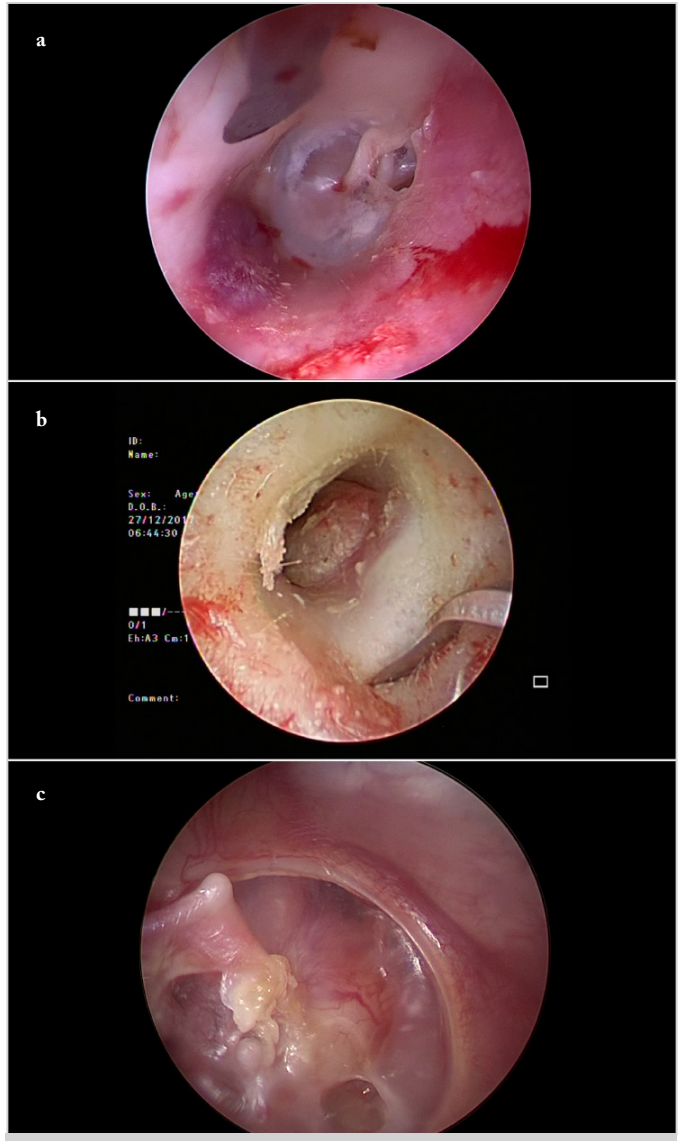

Figure 1. Different types of cholesteatoma: a) Attic cholesteatoma in the left ear, b) Congenital cholesteatoma in the left ear, c) Pars tensa cholesteatoma in the right ear

myringoplasty followed by limited attic cholesteatoma removal, ossicular chain reconstruction, and now all can be performed with TEES (10, 11).

Despite the success of the treatment techniques for cholesteatoma, there is no consensus on the optimal surgical technique that simultaneously eradicates the disease with a low recurrence rate and preserves the middle ear anatomy and physiology. Though good results can be obtained with a postauricular approach and microscopic surgery and recurrences originating from the mastoid cavity are low, recurrences occur due to the inability to sufficiently clear the cholesteatoma, especially from hard-to-reach areas such as sinus tympani and facial recess (12). CWD mastoidectomy is performed by lowering the posterior wall of the external auditory canal to reach these areas and results in handicaps such as the inability to create a self-cleaning cavity and the need for the patient to avoid contact with water (13). As an alternative, CWU mastoidectomy combined with posterior tympanotomy allows access to these areas while preserving the posterior wall, but this procedure requires postauricular incision and sometimes sacrificing the healthy bone (9, 13). On the other hand, the recurrence rate of the disease, which is approximately 5–7% in CWD, can increase to 20–25% when CWU is preferred (14, 15). Another disadvantage of the CWU techniques is the frequent need for second-

Table 2. Type of surgical technique and classification of cholesteatoma

Classification (EAONO/JOS Staging System on Middle Ear Cholesteatoma)	Number of patients n=27 (100%)
Stage 1	11 (41%)
Stage 2	11 (41%)
Stage 3	5 (18%)
Stage 4	None
Origin of cholesteatoma	
Congenital cholesteatoma	2 (7%)
Cholesteatoma secondary to a tensa perforation	3 (11%)
Pars flaccida cholesteatoma	15 (56%)
Pars tensa cholesteatoma	7 (26%)
Type of tympanoplasty	
Canal wall-up	26 (96%)
Canal wall-down	1 (4%)
Ossicular reconstruction	
No	4 (15%)
Incus interposition	13 (48%)
PORP	3 (11%)
TORP	6 (22%)
Bone cement	1 (4%)

TORP: Total ossicular reconstruction prosthesis, PORP: Partial ossicular reconstruction prosthesis, EAONO/JOS: European Academy of Otology and Neurotology/Japan Otological Society

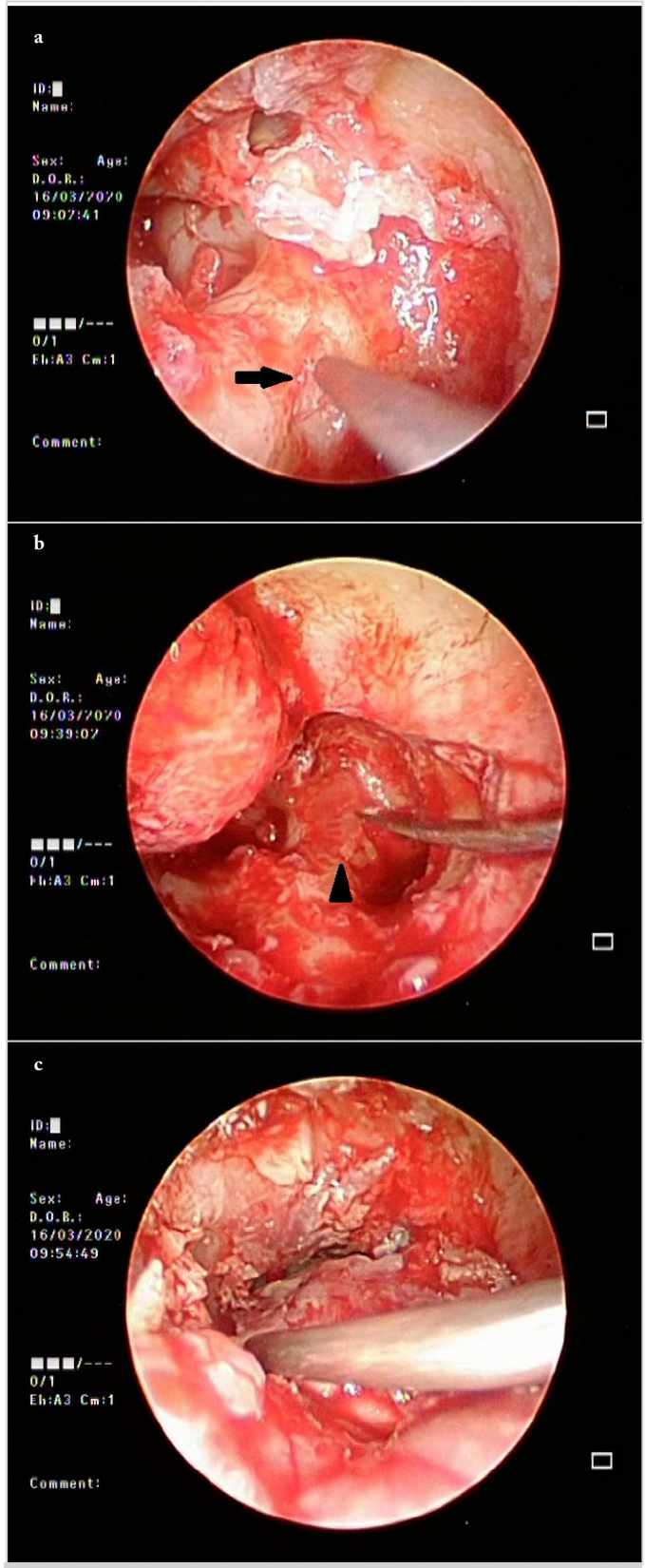

Figure 2. Lateral semicircular canal bone defect (LSCF): a) LSCF in the left ear, black arrow indicates bony defect, b) The fistula is covered by autologous fat and tragal perichondrium, black arrowhead indicates the defect covered by the tragal perichondrium, c) Final view of the atticotomy defect and tympanic membrane after the reconstruction

look surgery in terms of close follow-up of the recurrence. Another alternative is transcanal atticotomy, and it requires a certain amount of exposure, which can be difficult to provide in cases where the external auditory canal is narrow and the rate of recurrence of cholesteatoma may increase (14).

In their review published in 2020, Verma and Dabholkar (16) included 1685 patients who underwent exclusively endoscopic surgery or endoscopic surgery in combination with a microscope and found that in 267 (15.82%) patients who underwent microscopic surgery, residual cholesteatoma was detected most commonly in hidden areas such as the sinus tympani, the facial recess, and the anterior epitympanic regions when the endoscope was used for inspection after microscopic surgery. In endoscopic surgery, these areas can be seen quite well from a wider angle, even in patients with a narrow external auditory canal. When Ghadersohi et al. (17) compared EES 1, EES 2, and EES 3 in 68 pediatric patients who were operated on because of cholesteatoma, they found the lowest recurrence and residual rate in the TEES group (EES 3) with a recurrence rate of 4.5% and residual disease of 0%. One of the main advantages of using a microscope over endoscopes is that it allows the use of both hands. However, Dixon and James (18) compared the postauricular approach with TEES in pediatric cholesteatomas and found the rate of residual disease to be 6.3% in the TEES group and 10.9% in the postauricular approach, concluding that, microscopically, the two-handed approach did not provide any additional advantage over the endoscopic approach in clearing cholesteatomas in the middle ear and/or attic. Similarly, Li et al. (9), in their meta-analysis comparing microscopic ear surgery and EES, revealed that residual disease and recurrence were statistically significantly less in EES and that graft success, operation time, and auditory performance were not significantly different between the groups. In the presented study, no recurrence or residual disease was detected in any of the cases. However, while retraction pocket and hearing loss occurred in two patients, perforation occurred in one patient, and no residual cholesteatoma was detected in one patient who underwent revision surgery.

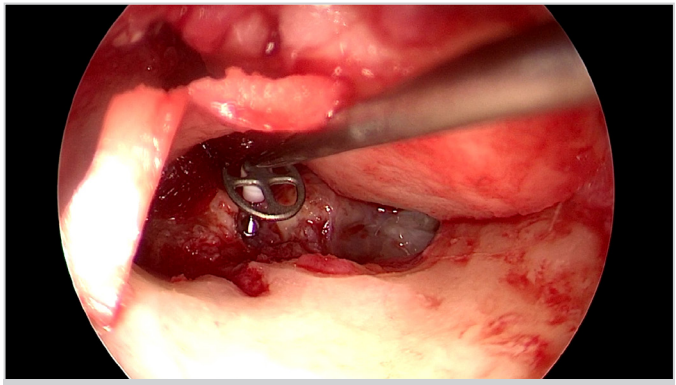

Figure 3. Ossiculoplasty with titanium prosthesis in the right ear

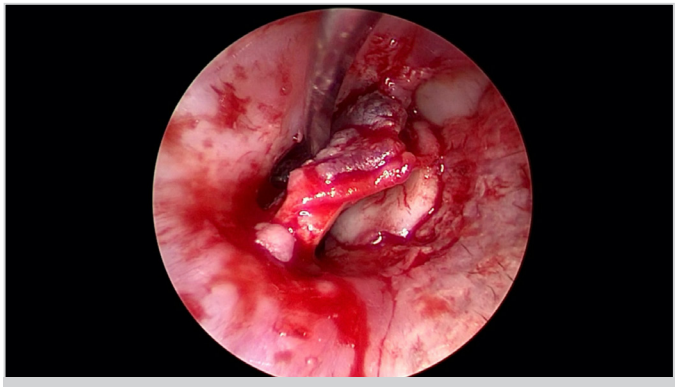

Figure 4. Repair of atticotomy defect with cartilage in the left ear

One disadvantage of microscopic surgery is the access to only the downstream corridor of ventilation through mastoidectomy. Thanks to the vision it provides, endoscopic surgery allows surgeons to reach the upstream parts of the ventilation system, such as the protympanum, anterior mesotympanum, eustachian tube isthmus, and tympanic isthmus (19). A postauricular incision and an excessive mastoidectomy is not needed for TEES. Therefore, TEES is a good option especially in patients with small and sclerotic mastoid cavities.

Although TEES is generally not recommended for cholesteatomas extending beyond the lateral semicircular canal, our experience shows that cholesteatoma can be reliably excised by TEES even in patients in stage 3 patients (18, 20). However, a postauricular approach and mastoidectomy may be required in cases with a large mastoid since it would be difficult to follow the cholesteatoma sac. Two patients in our study had LSCF and were operated on with TEES. In one patient, after the removal of the bone with curettes and burrs in the attic part of the external auditory canal, the LSCF was managed to be visualized by angled endoscopy and handled with curved instruments. Subsequently, the cholesteatoma was removed from the fistula and the endosteum was

Table 3. Preoperative and postoperative comparison of pure-tone audiometry results

	Preoperative (n=27) (mean ± SD)	Postoperative (n=27) (mean ± SD)	p-value
Air-conduction PTA	50.48±24.22	46.29±26.45	0.237
Bone-conduction PTA	25.34±18.53	24.09±17.23	0.189
Air-bone gap	25.14±13.93	22.22±12.64	0.417

PTA: Pure-tone audiometry, SD: Standard deviation

intact. The bony defect of 2-mm diameter on the lateral semicircular canal was covered with autologous fat and tragal perichondrium. Villari et al. (21) showed a similar approach with TEES in their study regarding LSCFs on the ampullar arm apart from the graft material. Only one of our patients was operated on with transcanal endoscopic canal-wall-down procedure. We concluded that endoscopic surgery could be performed in complicated cases, but more studies are needed to determine the utility of TEES in complicated cases.

In terms of auditory performance, we found that our patients' average ABG had decreased from 24 dB to 21 dB, which could be due to the lower pre-operative ABG of our patients compared to those reported in other studies that showed slightly higher values. Glikson et al. (14) compared EES and CWU tympano-mastoidectomy and found that air conduction pure-tone average had increased from 37.2 preoperatively to 39.6 postoperatively in the EES group. Similarly, it had increased from 41.5 to 42.2 in the microscopic group, and the difference was not significant. In contrast, Hunter et al. (22) achieved improvement in all groups in a similar study, but they found no difference between microscopic, endoscopic, and combined approach groups, although there was more improvement in the endoscopic patient group. In the present study, the incus was used most frequently in ossicular reconstruction with a rate of 48%. On the contrary, Hunter et al. (22) used PORP in three of their patients who underwent ossicular chain reconstruction in the TEES group.

We used the closed technique in all our patients that were operated on with TEES and repaired the defect in those who underwent atticotomy with tragal cartilage. No complications were reported in these patients, and the normal external auditory canal anatomy was seen intact in the postoperative follow-up period. Thus, we can say that TEES has the advantage of avoiding additional morbidity from a postauricular incision. Postoperative pain is less in patients who undergo EES compared to that of those who undergo classical microscopic surgery (23, 24). This could be due to the absence of the need for a postauricular incision or the drilling of the mastoid bone. Magliulo and Iannella (24) compared EES and microscopic surgery in attic cholesteatomas in 80 patients and found that graft success, postoperative ABG, and taste sensation were not significantly different between the groups, while the mean recovery time and postoperative pain were less in the EES group. Moreover, mean recovery time was 36.3 days in the EES group and 69.9 days in the microscopic surgery group. The mean follow-up period in studies on TEES range from 4.96 to 31.2 months (9, 17, 22, 25). Our average follow-up period was 19 months, ranging from 5 to 41 months, similar to other studies.

Our study has some limitations. The first is its retrospective nature and the absence of a control group. More accurate results can be obtained in a prospective study conducted in comparison to a control group undergoing microscopic cholesteatoma surgery. The second limitation is the low number of patients and the subsequent relatively short average follow-up period, albeit our follow-up periods are not short compared to those in the literature. Longer follow-up periods would enable more accurate results.

Conclusion

Although the superiority of TEES over the classical approaches in terms of recidivism rates has not been proven, the results obtained so far seem promising. While facilitating access to hidden areas such as sinus tympani, facial recess, and anterior epitympanic space, TEES also allows the preservation of normal middle ear physiology and stands out as a good alternative for microscopic surgery in suitable cases. Experience is essential in all surgical procedures, and as experience increases, endoscopic surgery may be performed on more complex cases. Further studies with longer follow-up periods and with large number of patients operated on with TEES are needed.

Ethics Committee Approval: This study was approved by University of Health Sciences Turkey, İzmir Bozyaka Training and Research Hospital Clinical Research Ethics Committee with decision number 2021/108 dated 23.06.2021.

Informed Consent: All patients were informed about the objective of the study and signed written consent forms.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: A.D., G.A.Y., Concept: A.D., M.E.Z., A.A., Design: A.D., M.E.Z., Data Collection and/or Processing: G.A.Y., O.D., A.A., Analysis and/or Interpretation: G.A.Y., O.D., Literature Search: A.D., M.E.Z., A.A., Writing: A.D., G.A.Y., M.E.Z.

Conflict of Interest: The authors have no conflicts of interest to declare.

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Main Points

- Transcanal endoscopic ear surgery (TEES) stands out as a good alternative to microscopic surgery in suitable cases and facilitates access to hidden areas such as the sinus tympani and the facial recess.
- We found TEES to be a safe and highly reliable approach for treating cholesteatoma with low complication and recidivism rates.
- Endoscopic ear surgery may be performed on more complicated cases as experience increases.

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