



*Article info*

Received : 15.07.2023  
Accepted : 18.03.2024  
No. of Tables : 04  
No. of Figure : 04  
No. of References : 25

**Original Article**

# Ergonomic Transgression of the Corridor: A Sojourn of Microscopic to Endoscopic Middle Ear Surgery, the Learning Curve, Lessons Learned, and Reflections

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**Abstract:**

**Objective:** For the last 20 years, transcanal endoscopic ear surgery has emerged as a viable, ergonomic, and powerful alternative surgical modality of choice replacing the conventional microscopic approach in many ways. This study compares the functional and anatomical outcomes of endoscopic tympanoplasty with microscopic tympanoplasty using full-thickness tragal cartilage as a graft of choice.

**Methodology:** This observational, analytical, retrospective study was conducted in the department of Otolaryngology in a tertiary care hospital over two years. It included an analysis of medical records of 38 patients (above 10 years of age), who underwent conventional microscopic and transcanal endoscopic tympanoplasty (type I) for dry and small/medium size tympanic perforations. Morphological and functional outcomes were compared in both groups by noting the condition of graft and air-bone gap on follow-up.

**Result:** There were 19 patients each in both groups. The mean pre-and post-operative ABG in each group was comparable and the difference was statistically significant in each group ( $P < 0.05$ ). Comparing the mean ABG change between both groups, there was a statistically significant difference noted ( $P < 0.05$ ). The success rate was found to be 89.5% (17/19) in the endoscopic surgery group and 94.7% (18/19) in the microscopic surgery group. The difference in the anatomical success of both groups was not statistically significant.

**Conclusion:** There was no statistically significant difference between both groups regarding graft take-up rates but functionally hearing outcomes were better in the MES group which was statistically significant.

**Key words:** Transcanal endoscopic ear surgery; conventional microscopic ear surgery; tragal cartilage; tympanoplasty; myringoplasty

*Cite the Article:* Pandey AK, Haq AU, Gupta M. Ergonomic Transgression of the Corridor: A Sojourn of Microscopic to Endoscopic Middle Ear Surgery, the Learning Curve, Lessons Learned, and Reflections. *Bangladesh J Otorhinolaryngol* 2024; 30(1): 5-14

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**Introduction:**

Conventionally, middle ear reconstructive surgery has been performed over the years using an operating microscope via endaural, transcanal, or retro auricular approaches. During the past two decades, the introduction and evolution of EES have brought a renaissance in otologic surgery which continues to fascinate, mesmerize and captivate all otologic surgeons. The ever-expanding scope of EES has resulted in such widely diffused knowledge of middle ear anatomy, physiology, and surgical concepts among surgeons, trainees, and students that it intrigues them to the extent of bewilderment. The endoscope has changed the way we observe, understand, and treat chronic ear disease<sup>1</sup>.

The choice of an ideal/ universally acceptable optimal surgical technique, graft source, and instrumentation for tympanoplasty may be a debatable contention. The selection of a particular tympanoplasty technique often depends on the surgeon's skills, familiarity with a particular technique<sup>2</sup>, patient's choice, extension and achievable and expected surgical exposure of disease, and specifically, resources available or/and accessible to a population in a defined geographical area.

Initially, the endoscope was considered only an adjunct to the microscope. Over the years EES has gradually evolved as an independent surgical technique. EES has become more popular because of the smaller incisions and greater optical magnification. The endoscope technique has a few more advantages like less hospital stay and better cosmetic results as compared to the microscopic technique but it could take more operating time and is relatively technically difficult to master.

This study aims to compare the morphological and functional outcomes of endoscopic tympanoplasties (Type I) with microscopic tympanoplasties using full-thickness tragal cartilage as the graft of choice in dry and small/medium perforations in cases of chronic otitis media.

**Materials and methods:**

This observational, analytical, retrospective study was conducted in the department of otorhinolaryngology at a tertiary care center over two years from January 2017 to December 2018. This study was approved by the Institutional Ethical committee. The inclusion of the cases was visibly temporal. The TEES was first introduced in our institute in 2017. The current author forayed into the EES technique in January 2018 so the cases presented after January 2018 were subjected to the endoscopic approach. The cases that were operated on before January 2018 (in 2017) underwent traditional microscopic surgery. Before the surgical intervention, written informed consent was taken from all cases regarding the procedural details, potential complications, and the possibility of converting the EES approach to conventional MES. The data were retrieved and analyzed from the hospital's Medical records. A total of 38 cases were operated on in two years year and included in our study. A minimum follow-up period of 3 months post-operatively was necessary for all cases studied.

**Inclusion Criteria:**

1. Patients above the age of 10 years
2. Dry Perforation (for at least 3 months) of only small and medium-size
3. Cases with Conductive hearing loss (pure-tone average <40dB HL)

**Exclusion Criteria:**

1. Cases less than 3 months follow-up.
2. Active mucosal case
3. Ossicular pathology
4. Squamosal cases
5. Revision cases
6. Subtotal or total perforations.
7. Cases having external canal infection
8. Cases having mixed/sensorineural hearing loss

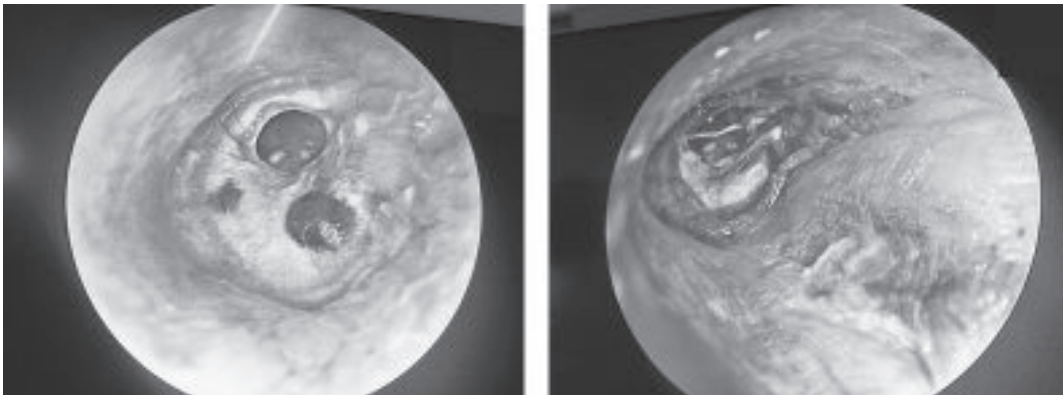
Findings of examination under microscope/otoscope /endoscope, pure tone audiometry, X-ray Temporal bone, intra-operative findings, reconstructive operative notes, and follow-up period details were noted of all patients, and results were analyzed. Regular postoperative follow-up was done 1<sup>st</sup>, 3<sup>rd</sup> and 6<sup>th</sup> months postoperatively. Morphological success was defined as dry tympanum with intact graft and absence of retraction, lateralization, or re-perforation at 3 months postoperatively.

Air conduction and bone conduction threshold average were measured at 500,1000,2000 Hz and the air-bone gaps (ABG) were calculated. Pre- and post-operative ABG (at 3<sup>rd</sup> month) were calculated for each group. Wilcoxon rank test was used to compare the functional

results before and after surgery in each group. Whereas the Mann Whitney test was used to compare the mean change in ABG between both groups. The Chi-square test was used to compare the morphological outcomes of both groups. Statistical significance was assigned at  $p < 0.05$ . Statistical analysis was done using a statistical package for the social sciences software (SPSS, version 21.0; SPSS Inc., USA).

Surgical techniques of endoscopic tympanoplasty in our setup

All endoscopic surgeries were done under general hypotensive anesthesia by the same surgeon. Before surgery, all cases were informed regarding the possibility of conversion to a retro auricular approach, wherever it was deemed necessary. Rigid endoscopes (Karl Storz) of 4 mm in diameter, 0°, 30°, and 18 cm in length and high definition monitor and camera were used. The ear canal was cleaned with normal saline at room temperature and inspected thoroughly. First, the perforation and status of the middle ear mucosa were examined. Perforation edges were freshened using alligator forceps and a sharp needle. Tympanosclerotic patches, if present, in the tympanic membrane were removed (Figure 1-2).



**Fig.-1 & 2:** Visualisation of perforation endoscopically. Freshening of margins and presence of a tympanosclerotic plaque.

Tragal cartilage with perichondrium graft was harvested. In the external ear canal, a circumferential incision was made 6 mm lateral to the annulus from 6 o'clock to 12 o'clock and a tympanomeatal flap was elevated reaching the annulus, thus providing access to the middle ear (figure no 3(a,b,c).

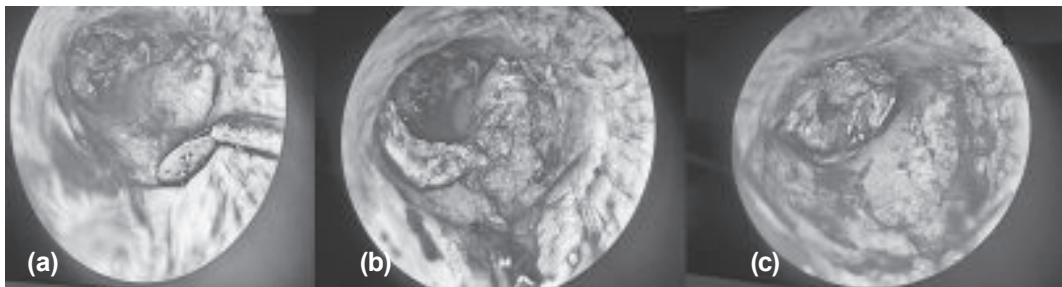
Tragal cartilage with perichondrium graft was harvested. In the external ear canal, a circumferential incision was made 6 mm lateral to the annulus from 6 o'clock to 12 o'clock and a tympanomeatal flap was elevated reaching the annulus, thus providing access to the middle ear (figure no 3(a,b,c).

Continuity and movements of the ossicles and mucosal condition of the middle ear were checked. The malleus was separated from the tympanic membrane remnant using a

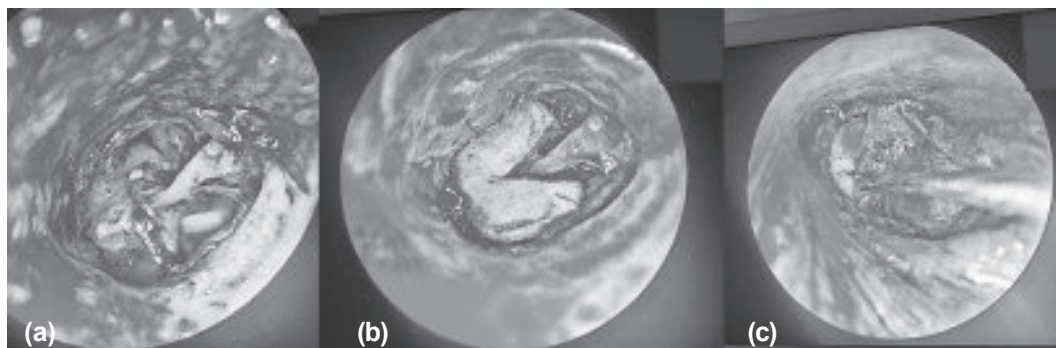
pick. The prepared graft was placed lateral to the malleus and medial (over-underlay) to the membrane remnant supported over a gel foam bed in the middle ear (Figure no 4a,b,c). On completion of the above steps, gel foam pieces were also placed in the outer ear canal.

Surgical techniques of microscopic tympanoplasty in our setup

All the surgical steps were similar to endoscopic tympanoplasty except that we used a postauricular approach using Wilde's incision and microscope (Zeiss). Canalplasty was done in cases of anterior canal bulge obscuring visualization and freshening of the anterior margin of perforation and thereafter graft placement.



**Fig.-3:** a- Circumferential Incision with a knife. b & c ). Elevation of tympanomeatal flap.



**Fig.-4:** a ) inspection of middle ear after elevation of flap. b ) Placement of cartilage graft. c ) placement of TM flap over cartilage graft.

**Results:**

A total of 38 cases, operated in two years, were included in this study after considering inclusion and exclusion criteria. Among 38 cases 19 cases underwent microscopic surgeries (MES) and 19 cases underwent endoscopic surgeries (EES). In the EES group (Table-I), the mean ABG pre-operatively was found to be  $21.04 \pm 9.98$  dB, and postoperatively it was found to be  $14.36 \pm 4.73$  dB. This shows a significant difference in ABG changes suggesting endoscopic tympanoplasties have a good outcome of hearing ( $p=0.001$ ).

On the other hand, 19 cases underwent microscopic tympanoplasty. The mean ABG pre-operatively was found to be  $26.69$  dB  $\pm$

$10.52$  and postoperatively it was found to be  $11.67 \pm 6.88$  dB (Table-II). This shows a significant difference in ABG suggesting microscopic tympanoplasties have a good surgical outcome of hearing ( $p=0.001$ ).

Comparing the functional outcomes between these two groups, the mean change in ABG was calculated for each group and compared. It was found to be significant (Table-III).

Describing the morphological outcomes, we observed an 89.5% (17/19) success rate in graft uptake in the EES group. Whereas 94.7% (18/19) success rate was noticed in the microscopic group. Statistically, there was no significant difference in morphological success rates between these two groups (Table-IV).

**Table-I :** Comparison of pre and post-operative air-bone gap in the Endoscopic tympanoplasty group

Group 1	Pre-op		Post-op		Z	p-value
	Mean	SD	Mean	SD		
Endoscopic	21.04	9.98	14.36	4.73	-3.209	0.001

\*ABG-Air-bone gap, SD: Standard deviation.

**Table-II:** Comparison of pre and postoperative air-bone gap in microscopic tympanoplasty group.

Group 2	Pre-op		Post-op		Z	p-value
	Mean	SD	Mean	SD		
Microscopic	26.69	10.52	11.67	6.88	-3.704	0.001

\* ABG-Air-bone gap, SD: Standard deviation.

**Table-III :** Comparison of mean ABG change between both groups.

	EES		MES		t	p-value
	Mean	SD	Mean	SD		
Mean change in ABG	6.68	7.04	15.03	11.19	-2.753	0.009

**Table-IV : Comparison of Success and failure in the endoscopic and microscopic surgery groups.**

Group	Endoscopic		Microscopic		Total value	Chi-square value	p-value
	Success	Failure	Success	Failure			
Success	17	89.5%	18	94.7%	35	0.362	0.547
failure	2	10.5%	1	5.3%	3		
Total	19	100.0%	19	100.0%	38		

Regarding the failures, two reperforation cases occurred in EES whereas one reperforation occurred in the MES group. One perforation that was noticed in EES occurred in the anterior part where the cartilage graft was slipped medially. In another EES failure, cartilage was displaced posteriorly leading to perforation in the posterior part. Perforation in the MES group's failed case was noticed in the membrane part adjacent to the cartilage graft in the inferior part.

#### Discussion:

This retrospective analytical study comprised 38 cases of CSOM having dry small/medium perforation which had been temporally distributed and hence operated under EES and MES groups. Morphologically 89.5% (17/19) success rate in graft uptake was noticed in the EES group and a 94.7% (18/19) success rate was seen in the MES group and the difference was not statistically significant. Functionally, the comparison of mean ABG change between both groups was statistically significant. In one study, a success rate of 95.8% (23/24) was achieved in the microscopic tympanoplasty group whereas a 92.3% (36/39) success rate was observed in the endoscopic tympanoplasty group and the difference between these two groups was not statistically significant<sup>3</sup>. In another study, it was concluded that the endoscopic technique is more advantageous than the microscopic technique in the context of the duration of surgery, cost of the

instrument, and better magnification. Hearing gain between these techniques was not statistically significant ( $P=0.36$ ) and graft take-up rates were the same in both techniques<sup>4</sup>. Also in another study<sup>5</sup>, no significant difference was noted between the microscopic and endoscopic tympanoplasty groups regarding morphological and functional outcomes. However, the consumption of medical resources in the endoscopic group was lower than the microscopic group in the context of average operating time ( $p<0.0001$ ) and the average duration of anesthesia ( $p<0.0001$ ).

The MES, being the gold standard and traditional technique is a more comfortable two-handed approach. Three-dimensional visualization along with better magnification also plays a role in its wide acceptance as the main modality for middle ear reconstructive surgery. The average success rate of microscopic assisted myringoplasty lies between 90-95%<sup>6</sup>. However, the vision of a microscope may be limited when using a trans-canal approach, particularly in hidden areas. Although the postauricular approach provides excellent exposure to the anterior part of TM, in cases of anterior canal wall bulge or tortuous canals, visualization is often obscured which necessitates canalplasty for disease clearance and proper graft placement.

MES incorporating the postauricular incision requires soft tissue dissection and sometimes

bone drilling for wide exposure. Also a large post-auricular incision results in greater postoperative pain and ear numbness<sup>7</sup>. MES is difficult in the transcanal approach and it has been described that a decrease of brightness proportional to the magnification is associated with MES<sup>8</sup>. In a study, a successful graft uptake rate of 96.7% was seen in a microscopic group whereas a 100% graft take rate was observed in endoscopic in-lay butterfly cartilage tympanoplasty. No difference in a mean decrease in the air-bone gap between these 2 groups or extent of postoperative discomfort was noticed. However, a significant difference was observed in terms of identification of external and middle ear anatomical features by trainees and understanding of surgical steps<sup>9</sup>.

Currently, endoscopes are becoming widespread in otological surgeries. Indications are increasing and include middle ear tumors, ossiculoplasty, tympanoplasty, cochlear implantation<sup>10</sup>), and even excision of vestibular schwannoma<sup>11</sup>. EES is a better tool for teaching and training facilities involving observation and demonstration of surgical steps which also shares a common field of view<sup>12</sup>. Kozin et al categorically depicted that an obvious benefit existed for observational EES<sup>10</sup>. For training purposes, everybody can observe the surgical steps regarding pathophysiological and anatomical aspects on the screen/monitor through the surgeon's eyes<sup>11</sup>.

During MES it requires a constant readjustment of the microscope and repositioning of the patient's head for adequate exposure. On the contrary, EES only requires a frequent change in the angling of the wrist / hand which holds the endoscopic instrumentation. EES preserves the integrity of the cartilaginous canal. EES is also associated with the diminished need for mastoidectomy<sup>13</sup>. The beauty and science

of it lie in the fact that it "brings the surgeon's eye to the tip of the scope"<sup>14</sup>. This Improved resolution, high magnification, and panoramic view provided by the endoscope, during EES, helps "to look around the nooks and corners of the middle ear cavity like sinus tympani, retrotympanum, epitympanum and tensor fold region"<sup>11,13,15</sup>.

The learning curve is one crucial factor affecting surgical outcomes with the use of endoscopes, as experienced in sinonasal and skull base surgeries<sup>16</sup>. The learning curve in TES may be quite challenging initially requiring patience and perseverance. Being a single hand surgery learning curve period may be longer. Dogan and Bayraktar observed that it takes 60 operations to become proficient in endoscopic tympanoplasty, accompanied by a gradual decrease in operative time with considerable morphological and functional outcomes<sup>17</sup>. Predictably, this intermediate period defines the nuances of a learning curve.

Concerns regarding the mechanical and thermal injury to the external and middle ear during EES have also been described<sup>18,19</sup>. Nevertheless, the risk of thermal injury can be circumvented by using a Storz cold light Fountain Halogen 150 W light source which has a color temperature of approximately 3400K and can illuminate adequately the small middle ear cavity<sup>19,20</sup>. It is also advisable that keep in mind the manufacturer's recommendation, to keep the light intensity below 50%<sup>21</sup>. In our study, we adopted a technique of regular saline wash of the surgical field to manage the potential thermal effects and it also helps to remove bleeding from the surgical area thus, clearing the surgical field and vision.

In our study, we kept a wet piece of gel foam in the protympanum area to minimize fogging or mist formation affecting the endoscope tip. EES has certain limitations particularly in a stenotic canal, occurring in craniofacial

anomalies and Down/Goldenhar syndrome<sup>22</sup>, exostoses, and coagulopathies<sup>5</sup>. Concerns regarding the ototoxicity of antifog solutions<sup>23</sup> have also been described in the literature.

The crucial steps that determine the successful outcomes of every endoscopic tympanoplasty suggested are; adequate hemostasis, graft harvest, preparing the TM and middle ear approach, assessment of ossicular integrity and ventilation pathway, and grafting<sup>1</sup>. During EES, it is prudent and decisive to achieve adequate hemostasis. Tragal cartilage was used in our series as the graft of choice. In a meta-analysis incorporating 21 studies including 1323 operated tympanoplasty ears, canalplasty rates were significantly lower in endoscopic cases (0% vs 18%,  $P < .0001$ )<sup>24</sup>. In our study canalplasty was required in two cases of the MES group whereas no canalplasty was required in the EES group.

In our series, we noticed no significant complications in either group. In the MES group, two cases complained of post-aural numbness, and one case developed post-surgery otorrhoea which was managed successfully by conservative treatment. In the EES group, one case developed post-operative ear discharge which was treated conservatively resulting in viable neomembrane. In one series, no ear protrusion was noticed in the EES group, whereas 4 cases (13.3%) in MES had misaligned pinna, one EES case had postauricular numbness, 9 cases in MES (30%) had post auricular numbness. Post-surgical myringitis was noticed in 4 (11.8%) cases of the EES group, while 4 cases (13.3%) in the MES group had the same complaint. Epithelial cysts were seen in 3 cases (8.8%) of the EES group while in 5 cases (16.7%) of the MES group had the same complaint. There was no incidence of retraction. One case of anterior blunting and 2 cases of lateralization in the

MES group, whereas none of the above complications were observed in the EES group. In our series no complications such as blunting, lateralization of neomembrane, ossicular injury, post-operative worsening of hearing (sensorineural loss), wound gaping, hematoma, keloid formation, facial nerve injury, misaligned pinna, and injury to chorda tympani noticed in either group<sup>24</sup>.

Basic working principles are the same for both techniques nevertheless comparison between these two techniques may be difficult. Comparing the outcomes between both techniques should not be only governed by the type of surgical techniques, pathology, patient's demographic details, or risk factors but by the clear-cut criteria for success<sup>1</sup>. A stricter definition of a successful outcome must incorporate not only the anatomical, and functional criteria but also the aspect of prevention of complications and correspondingly the guidelines have also been suggested regarding this<sup>25</sup>.

According to us, our study lacked randomization and blinding as well. Being retrospective in nature, small sample size, and relatively shorter follow-up period were other constraints in this study. This study was carried out in a single institution and the experience of a single surgeon might be a potential confounder. In our opinion, the strength of this study is the depiction of the viability of EES with comparable morphological and audiological outcomes with fewer complications even in our learning phase.

#### **Conclusion:**

There was no significant difference between endoscopic myringoplasty and microscopic surgery in this study as similar morphological success rates whereas a significant difference was found concerning functional outcomes. We sum up, therefore, our surgical



observations and experiences by the conclusion that the choice of technique for ear surgeries should be made considering the anticipated post-operative recovery, cost, patient profile, and surgeon's comfort.

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