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Original Research Article

Endoscopes as an alternative to microscopes for tympanoplasty: a comparative study

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ABSTRACT

Background: The objective of the study was to evaluate and compare the results of endoscope assisted tympanoplasty with microscope assisted tympanoplasty.
Methods: A prospective comparative study was conducted from January 2020 – September 2021 and included 60 patients of either sex in age group of 18-50 years having unilateral or bilateral inactive (mucosal) chronic otitis media with central perforation. Patients were randomly divided into 2 groups comprising of 30 patients each. Group-A (n=30) patients underwent endoscope assisted tympanoplasty while group-B (n=30) patients underwent microscope assisted tympanoplasty.
Results: The overall graft take up rate in group-A and group-B was 93.33% and 96.67% respectively. In group-A, graft take-up was 90.90% in grade-IV perforations and 88.89% in grade-V perforations and graft take-up was 100% in grade-II and grade-III perforation. While in group-B, graft take-up was 91.67% for grade-III perforations, and 100% uptake was seen in grade-I, grade-IV and grade-V perforation. In group-A, pre-operative average air bone (AB) gap was 30.95 dB and post operatively it was 14.44 dB with an average hearing gain of 16.55dB while in group-B, the average pre-operative AB gap was 32.81dB and post-operative AB gap was 13.71dB with an average hearing gain of 19.11dB. Mean average time taken in group-A was 79.83±8.78 minutes, while in group-B it was 101.13±11.07 minutes. The average pain assessment score was 4.9 in group-A as compared to a score of 5.4 in group-B.
Conclusions: The results of endoscope assisted and microscope assisted tympanoplasty are comparable. The operating microscope and endoscope should be employed as per the patient's requirement and surgeon's expertise.

Keywords: Endoscope, Microscope, Tympanoplasty, Mucosal

INTRODUCTION

Tympanoplasty is the surgical repair of the tympanic membrane performed to restore the integrity of the tympanic membrane and to improve hearing. A variety of graft materials have been used for repair of the tympanic membrane perforation with temporalis fascia being the most preferred graft material.[1] For decades, operating microscopes are being used for providing illumination and magnification in otologic surgery. Endoscopes have been introduced recently in the ear surgery and with the advantage of the angled endoscopes, surgeons are able to appreciate the micro-anatomy and hidden structures of the middle ear.[2,3] Most of the studies till date shows endoscope assisted and microscope assisted tympanoplasty type-I to be comparable in terms of graft take rate and hearing outcome, however there are conflicting views about success of both regarding intra operative pain, operative time and post-operative complications. The objective of the present study is to compare and evaluate the efficacy of microscope assisted and endoscope assisted tympanoplasty in respect to graft uptake, hearing gain,

evaluation of intra operative pain, operative time and post-operative complications.

METHODS

This prospective cohort study was conducted in the department of otorhinolaryngology of a tertiary care hospital of northern India from January 2020 to September 2021 after approval by institutional review board. Sixty patients in the age group between 18-50 years who had unilateral or bilateral chronic inactive (mucosal) otitis media were included in the present study with their written and informed consent. Patients selected had a dry ear over a period of at least 4 weeks without the use of topical or systemic antibiotics and a good cochlear reserve with an air-bone gap of ≥25 dB on pure tone audiometry. Patients with past ear surgery, cholesteatoma, marginal perforation, sensorineural hearing loss, tympanosclerosis, ossicular erosion, uncontrolled diabetes, marked deviated nasal septum and upper respiratory infection were excluded from the study. A detailed evaluation of each patient was done including history, general physical examination and complete ENT examination. Hearing status evaluation for type and degree of hearing loss was done by tuning fork tests with 512 Hz and pure tone audiometry at frequencies 250 Hz to 8000 Hz for air conduction and 250 Hz to 4000 Hz for bone conduction.

The patients were divided randomly into two groups group-A and group-B. Patients in group-A (n=30) underwent endoscope assisted tympanoplasty while patients in group-B (n=30) underwent microscope assisted tympanoplasty. All patients were explained about the surgical procedure. All the patients were operated under local anaesthesia however, an option of general anaesthesia was given. Temporalis fascia graft of approximately 15×18 mm size was harvested above the hairline using a supra-auricular incision in both groups and incision was sutured with silk. The graft was spread on the slide and dried which was rinsed briefly with saline just before its placement to give it an optimal flexibility. In both group-A and B, all patients underwent underlay tympanoplasty type-I and were operated via trans-canal route. In endoscope assisted group, 0˚ 4 mm, 17 cm endoscope was used via transcanal approach. Other angled endoscopes were used if required for inspection of middle ear. In all cases a camera attachment and video monitor was used. The margins of the perforation were freshened with a sickle knife, a circular knife was then passed through the perforation and the under surface of perforation margins were de-epithelised. An incision was made in the external auditory canal (EAC) 5 mm lateral from the annulus from 10' clock to 2' clock (in anti-clock direction) and a tympano-meatal flap was elevated and middle ear entered. The handle of malleus was skeletonised. Temporalis fascia graft was trimmed and placed as underlay graft. The tympano-meatal flap was repositioned. Hearing was checked and EAC was packed with medicated gel foams. Similar surgical technique was followed in the microscope assisted tympanoplasty group.

All cases were regularly presented for follow up. Sutures were removed on 10th postoperative day and any evidence of infection was looked for. Patient was advised to keep ear dry. For follow up, patients were called on 4th, 8th and 12th week to look for any evidence of infection. At 12th week, final assessment regarding graft uptake & audiological improvement was done and pure tone audiometry repeated.

Ethical approval

This study was done in accordance with the ethical standards of the institutional and/or national research committee or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

Informed consent to participate and publish data

Informed and written consent was taken from the patients before enrolment in the study for their participation in the study and before the submission of the article and a written consent was also obtained for publishing their data in a journal article.

RESULTS

Age and sex distribution

In group-A, there were 13 male (43.33%) and 17 female (56.67%) with age ranging from 18 years to 50 years and maximum patients (50%) belonged to age group 26-35 years. Group-B comprised of 16 males (53.33%) and 14 females (46.67%) with patient's age range between 17 to 48 years and maximum patients (46.67%) in the age group of 15-25 years.

Presenting complaints

All cases in group-A and group-B had history of discharge while deafness was a presenting complaint in 23 cases in group-A and 24 cases in group-B.

Duration of ear discharge

In group-A, maximum patients 17 (56.7%) had ear discharge for 0-3 years, 10 (33.3%) cases had discharge for 4-6 years and only 03 (10%) had ear discharge for 7-9 years. In group-B, 12 (40%) cases were having ear discharges for 0-3 years, 17 (56.7%) cases had discharge for 4-6 years and only 01 (3.3%) case had discharge for 7-9 years. On applying Fisher exact test, value was 3.677 with degree of freedom value 2 and p value of 0.159 which is statistically non-significant.

Ear involvement

In group-A, 21 (70%) cases and in group-B, 20 (67.3%) cases were having unilateral involvement with

predominance of right ear involvement. Bilateral ear involvement was seen in 9 (30%) cases in group-A and 10 (33.33%) cases in group-B. On Fisher exact test, p value was 0.873 which is statistically non-significant (Table 1).

Table 1: Ear involved.

Ear involved	Total number of cases (%)	
	Group-A	Group-B
Unilateral		
Right	12 (40)	13 (43.33)
Left	9 (30)	7 (23.33)
Bilateral	9 (30)	10 (33.33)

Size of tympanic membrane perforation

Size of tympanic membrane perforation was graded from grade-I to grade-V.[4] In group-A, 9 (30%) cases had subtotal perforation (grade-V) whereas 11 (36.67%) cases had large central perforation (grade-IV). In group-B, 5 (16.67%) cases had subtotal perforation (grade-V), whereas 10 (33.33%) cases had (grade-IV) large central perforation (Table 2).

Table 2: Grades of tympanic membrane perforation in group-A and group-B.

S. no.	Grades	Tympanic membrane perforation	Group-A (%)	Group-B (%)
1	Grade-I	Pin-point perforation	00	00
2	Grade-II	Small: smaller than one quarter of tympanic membrane	05 (16.67)	03 (10)
3	Grade-III	Medium: up to half the size of tympanic membrane	05 (16.67)	12 (40)
4	Grade-IV	Large: up to three quarters the size of tympanic membrane	11 (36.67)	10 (33.33)
5	Grade-V	Sub-total: when only annulus remains	09 (30)	05 (16.67)

In group-A, 25 (83.3%) cases had normal appearing handle of malleus while 05 (16.7%) had a medially retracted handle of malleus while in group-B, 27(90%) cases had a normal appearing handle of malleus and 03 (10%) had a medially retracted handle of malleus. In group-A, 03 (10%) cases have mucoid discharge in middle ear and 01 (3.33%) cases have hyperplastic middle ear mucosa. While in group-B, 02 (6.67%) cases have mucoid discharge in middle ear and 01 (3.33%) cases have hyperplastic middle ear mucosa.

Hearing loss

Pure tone audiometry at frequencies 250 Hz to 8000 Hz for air conduction and 250 Hz to 4000 Hz for bone conduction were done in all cases. The average of 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz was taken for calculation of average hearing loss. As per WHO classification of hearing loss, 10 (33%) cases of group-A had 26-30 dB hearing loss and 20 (66.7%) had moderate hearing loss (41-60 dB) while in group-B, 15 (50%) cases had hearing of 26-40 dB and similar percentage had hearing loss of 41-60 dB (Table 3).[5] On applying Chi square test, value was 1.71 with degree of freedom value 1. The p value was 0.190 which is statistically insignificant.

Table 3: Hearing loss in group-A and group-B.

Grade of impairment	Hearing loss range (dB)	Total number of patients (%)	
		Group-A	Group-B
Slight	26-40	10 (33.33)	15 (50)
Moderate	41-60	20 (66.67)	15 (50)
Severe	61-80	-	-
Profound	≥81	-	-

Graft take up rate

In group-A, graft take-up was 90.90% in grade-IV perforations and 88.89% in grade-V perforations. Graft take-up was 100% in grade-II and grade-III perforation. Overall in group-A, the graft takes up was seen in 28 cases with graft take up a rate of 93.33% with graft rejection in two cases. While in group-B, graft take-up was 91.67% for grade-III perforations, and 100% uptake was seen in grade-I, grade-IV and grade-V perforation with overall graft take up in 29 cases with a graft take up rate of 96.67% and graft rejection in one case (Table 4).

Table 4: Relation between graft take-up rate and size of perforation.

Grade of perforation	Total number of cases with graft take-up			
	Group-A (%)		Group-B (%)	
	Total cases	Graft take-up	Total cases	Graft take-up
Grade I	-	-	-	-
Grade II	05	5/5 (100)	03	3/3 (100)
Grade III	05	5/5 (100)	12	11/12 (91.67)
Grade IV	11	10/11 (90.90)	10	10/10 (100)
Grade V	09	8/9 (88.89)	05	5/5 (100)
Over All graft take up rate (all cases)	30	28/30 (93.33)	30	29/30 (96.67)

Hearing improvement

Hearing levels were assessed at 3 months. The average pre-operative hearing levels in group-A, was 44.51 dB with an AB gap of 30.95 dB and post operatively hearing levels was 26.87 dB with an AB gap of 14.44 dB resulting in an average hearing gain of 16.55 dB. While in group-B, the average pre-operative hearing gain was 43.46 dB with an AB gap of 32.81 dB and average post-operative hearing level was 24.37 dB with an AB gap of 13.71 dB resulting in hearing gain of 19.11 dB. In group-A, 0-5 dB gain was seen in 02 (6.66%) cases, 6-10 dB gain was seen 06 (20%) cases, 11-15 dB gain in 08 (26.67%), 16-20 dB in 07 (23.33%) and >20 dB gain was seen in 07 (23.33%) cases. In group-B, 0-5 dB gain was seen in 01 (3.33%), 6-10 in 02 (6.67%), 11-15 dB in 10 (33.33%) 16-20 dB in 07 (23.33%) and >20 dB gain in 10 (33.33%) cases. However, on comparing hearing improvement of group-A with group-B with p value was 0.377 which is statistically insignificant (Table 5).

Table 5: Hearing gain in group-A and group-B.

Hearing improvement (dB)	Number of cases (group-A) (%)	Number of cases (group-B) (%)
0-5	02 (6.66)	01 (3.33)
6-10	06 (20.00)	02 (6.67)
11-15	08 (26.67)	10 (33.33)
16-20	07 (23.33)	07 (23.33)
>20	07 (23.33)	10 (33.33)

Average time taken for surgery

Mean average time taken in group-A (endoscope assisted myringoplasty) was 79.83±8.78 minutes while in group-B (microscope assisted myringoplasty) it was 101.13±11.07 minutes. The average time duration in endoscope assisted myringoplasty was approximately 21 minutes less compared to the microscope assisted myringoplasty, which is significant (p value <0.001).

Intra-operative pain assessment

The average pain assessment score according to the visual analog scale (VAS) was 4.9 in group-A as compared to a score of 5.4 in microscope assisted myringoplasty group-B.[6]

Follow-up examination and results

In both group-A and group-B, all patients presented for regular follow up. On 10th day suture and pack removal was done. The suture site and external ear were examined and no discharge or pus was noticed. At 4th week in group-A, ear discharge was noted in 03 patients that resolved by change of antibiotic in 02 cases. Residual perforation was noted in 04 cases which healed in 02 cases by application of trichloroacetic acid cautery and at three month follow up, only 02 patients had graft rejection. In group-B, discharge was noted in 04 patients on 4th week which resolved by change of antibiotic and at the 12th week follow up, only 01 patient had graft rejection (Table 6).

Table 6: Over-all follow up results group-A and group-B at 12th week.

Parameters	Group-A	Group-B
Cases operated	30	30
Cases followed up	30	30
Graft rejected	02	01
Graft lateralization	00	00

DISCUSSION

Goal of myringoplasty is closure of perforation with improvement in hearing levels. For the success of tympanoplasty an adequate area of contact between the graft and the tympanic membrane remnant is essential. Factors that can affect the optimal graft placement include external auditory canal geometry, location of perforation, bleeding during surgery, operating field illumination and magnification. Microscopes have been used traditionally for decades for providing illumination and magnification in otologic surgery. Recently endoscopes are also increasingly used as an alternative in otologic surgery. We report the results of the prospective comparative study between endoscope assisted tympanoplasty type-I and microscope assisted tympanoplasty type-I in cases with inactive (mucosal) chronic otitis media with central perforation in respect to graft take up rate, hearing outcomes, duration of surgery and patient's pain assessment.

The age of patients in both group-A and group-B ranged from 18-50 years. In group-A, there were 13 males (43.33%) and 17 females (56.67%) and group-B, comprised of 16 males (53.33%) and 14 females (46.67%); however these differences were statistically insignificant. Duration of discharge varied from 0-6 years in 27 (90%) cases in group-A, and in 29 (96.7%) cases group-B, while 3 cases (10%) in group-A and only 01 case (3.3%) in group-B had discharge for more than 7 years. Discharge was non-foul smelling and usually varied from mucoid to mucopurulent. However, no correlation was observed between duration of ear discharge and success of tympanoplasty in our study. The probable factor being that in the present study only ears dry for more than four weeks were included.[7-10] Bilateral ear involvement was present in 9 (30%) cases in group-A compared to 10 cases (33.33%) in group-B. However, there was no correlation in the present study between bilateral ear involvement and success outcome of tympanoplasty. The relation between graft take up rate and the size of perforation revealed that in group-A, a 100% graft uptake was seen in grade-II and grade-III perforation with the graft take up rate falling to 90.90% in grade-IV and to 88.89% in grade-V (subtotal) perforation. While in group-B, cases with grade-II perforation, grade-IV and grade-V perforation, graft

uptake was 100%, but in grade-III perforation graft uptake was 91.67%. The overall graft take-up rate in group-A was 93.33% as compared to 96.67% in group-B. Maran et al reported graft uptake of 89.91% in endoscope assisted myringoplasty and a success rate of 96.6% in microscope assisted myringoplasty.[11] Harugop et al reported a success rate of 96.2% in endoscopic assisted myringoplasty as compared to 86% in microscope assisted myringoplasty.[12] Hsu et al reported a success rate of 96.2% in endoscope assisted myringoplasty while a graft take-up rate of 92% was reported in microscope assisted myringoplasty group.[13] Jyothi et al in a comparative study of endoscope versus microscope assisted myringoplasty reported a success of 91.67% in endoscope group and a graft take up rate of 93.3% in microscope assisted group.[3] The results are suggestive that the graft take-up rate of tympanoplasty type-I in both endoscope assisted and microscope assisted myringoplasty are comparable, however microscope assisted tympanoplasty type-I is better for large and subtotal perforations.[11]

The mean operative time was calculated from the start of the incision to packing of the external auditory canal. Most authors have reported less operative time for endoscope assisted tympanoplasty as compared to microscope assisted tympanoplasty. Pal et al reported a mean operative time of 83.8±22.7 minutes for microscopic approach versus 63.2±13.6 minutes for the endoscopic group.[14] Dogan et al reported an average operative time of 62.00±12.48 minutes in endoscopic group versus 69.93±12.56 minutes in microscopic group.[15] Patel et al reported an average operative time of 75 minutes in endoscopic group as compared to 90 minutes in microscopic assisted group.[16] Lakpathi et al reported an average operative time of 96.32 minutes in endoscopic assisted tympanoplasty group as compared to 136.09 minutes in microscope assisted tympanoplasty group.[2] One difference between our study and reports of previous study was the route (approach) to the middle ear. In the present study, all the patients in both group-A and group-B were operated via transcanal route, thus avoiding a post aural incision and to achieve a better comparison between endoscope assisted and microscope assisted tympanoplasty. In-spite of the transcanal route in both groups, the average operative time of endoscope assisted tympanoplasty (79.83±8.78 minutes) was significantly less than the microscopic assisted group (101.13±11.07 minutes) with a p value of 0.001 which was statistically significant. Pain assessment was done on visual analog scale (VAS).[6] In group-A, nine cases had a pain score of 04, fifteen cases had a pain score of 05 and six cases had a pain score of 06. While in group-B, six cases had a pain score of 04, six cases had a pain score of 05 and eighteen cases had a pain score of 06. In our study, the average pain level on visual analog scale in group-A was 4.9 while in group-B, it was 5.4 on a 10-point scale. Choi et al on an NRS-II scale reported a level of 0.8±1 in endoscopic myringoplasty group and a level of 1.5±1.3 in microscopic myringoplasty group.[17] Our results are similar to other studies with lower pain threshold level in endoscope assisted tympanoplasty as compared to microscope assisted tympanoplasty. Microscope assisted tympanoplasty resulted in comparative better post-operative hearing results. In group-A, the average pre-operative and post-operative AB gap was 30.95 dB and 14.44 dB respectively with an average post-operative gain of 16.55±6.85 dB. Majority of patients, 15 (50%) had a gain in the range of 11-20 dB, 08 patients (26.67%) had a gain of more than 20 dB while 07 (23.33%) patients had a gain in range of 6-10 dB. While in group-B, the average pre-operative and post-operative AB gap was 32.81 dB and 13.71 dB respectively with an average post-operative gain of 19.11±8.27 dB. Majority of patients, 17 (56.67%) had a gain in the range of 11-20 dB, 01 case had a hearing gain in range of 0-5 dB, 02 cases had a hearing gain in the range of 6-10 dB and 10 (33.33%) cases had a hearing gain of more than 20 dB. Similar results were reported by other authors. Jyothi et al in endoscope assisted tympanoplasty reported a mean average gain of 16.16±4.68 dB while in microscope assisted myringoplasty group, the author reported an average hearing gain of 19.54±3.45 dB, the results of which are comparable to the results in our study.[3] Maran et al reported a post-operative hearing gain of 12 dB in endoscope assisted tympanoplasty as compared to the hearing gain of 13.5 dB in microscope assisted group.[11] Hsu et al reported an average hearing gain of 10.27±6.4 dB in endoscope assisted tympanoplasty and an average hearing gain of 12.43±7.46 dB in microscopic assisted group.[13] Lade et al reported the hearing gain of 10.4 dB in endoscope assisted tympanoplasty compared to a gain of 15.5 dB in microscope assisted tympanoplasty.[18] In previous studies, better post-operative cosmetic results were reported in endoscope assisted tympanoplasty. Lakpathi et al reported a post aural visible scar in 70% of patients in microscope assisted tympanoplasty group as compared to zero scar rates in endoscope assisted tympanoplasty.[2] Since in our study, all the ears in group-A and group-B were operated through the transcanal route which maintains the canal integrity, none of the patients had complaints of a post aural visible scar.

Endoscopes are useful in comparative narrow canal, however in some cases surgeon need to convert endoscope assisted technique to microscope assisted technique due to difficulty in raising tympanomeatal flap and bleeding. Dogan et al in their study reported 03 cases of endoscope assisted tympanoplasty needed to convert to microscopic surgery due to technical difficulties during flap elevation.[15] In our study, none of the patients required conversion from endoscope assisted tympanoplasty to microscope assisted tympanoplasty.

Microscopes provide a binocular vision with added advantage of adjustable illumination and magnification. They enable surgeon to see the enlarge and three dimensional images of the microstructures in the surgical field that increases the efficacy of ear surgery. Further with the use of a microscope, surgeon can use both hands during the ear surgery that is helpful in handling the instruments properly, reducing the trauma and to control bleeding

which is essential for accurate graft placement. Unlike endoscopes which need to be inserted in the external auditory canal, overcrowding of the instruments during ear surgery is minimised and also microscopes do not require frequent defogging during surgery. Microscopes due to its adjustable heads up display, improves the ergonomics and provides comfort to the surgeon.[2,3,11] The limitation of microscopes is that it provides magnification in a straight line. Curved external auditory canal and canal with a bony bulge will limit the complete visualization of the surgical field which may require additional procedure like canaloplasty during surgery.[2,11,12]

Endoscope allows view of the whole tympanic membrane in a single field without the need of manipulating patient's head. The middle ear structures and microanatomy can be easily visualised through the perforation using endoscopes. The endoscopic approach to ear surgery can prove handy in curved EAC. This can prove helpful in visualising the surgical field and hence avoiding a need of post aural approach and canaloplasty. Moreover, endoscopes are comparatively cheaper and easily portable. Endoscopes can be used with the camera and video monitors to provide larger image.[2,12] However, endoscopes have their own limitations. Surgeon uses one hand for holding the endoscope usually with the camera unit which if used for a longer period of time can lead to arm fatigue. Moreover, only one hand is free for performing the surgery.[2,3,12] The magnification of the endoscope is fixed unlike that of microscope which can be increased or decreased.[19] Further, endoscope provide a monocular vision which can lead to loss of depth perception.[2] There is fogging of the lens requiring frequent removal of the endoscope from the operative field. Moreover, in case of bleeding it becomes difficult to operate using single operating hand where microscope is of proven advantage.[2,15,20] These problems were highlighted in study by Dagon et al, where authors reported that due to bleeding at surgical site and single handed approach in endoscope assisted tympanoplasty needed to convert to microscope assisted.[15]

Savlon® is often used for cleaning and defogging during surgery. There is a risk of exposure of middle ear mucosa to savlon. There are still no studies to prove the safety of savlon exposure to middle ear.[12] Since the endoscope is inserted into the ear canal during surgery, the possibility of thermal injury to middle ear structures cannot be ruled out. Moreover, there is a risk of injury by endoscopes itself in case of accidental movement of the head by the patient.[20]

The overall graft take-up rate in endoscope assisted tympanoplasty (group- A) was 93.33% as compared to 96.67% in microscope assisted tympanoplasty (group-B). The average hearing gain in endoscope assisted tympanoplasty (group-A) was 16.55 dB as compared to 19.11 dB in microscope assisted tympanoplasty (group-B). Hence, the results of both endoscopes assisted and microscope assisted tympanoplasty are comparable with endoscope assisted tympanoplasty having an advantage of less operative time and better post-operative cosmetic results and on other hand microscope assisted tympanoplasty provides marginally better graft take-up and post-operative hearing results for large central and subtotal perforations.[3,11]

Both microscope and endoscope have their role in middle ear surgery. Each has their own advantages and disadvantages given the variation in anatomy and extent of disease, both microscope and endoscope can be complimentary to each other as visualising modalities. However, this study has some limitations. In both endoscope assisted and microscope assisted tympanoplasty, a long learning curve and healthcare cost needs further assistance and investigation. Moreover, some patients despite proper guidance for post-operative care, fails to comply and comes with discharging ear.

CONCLUSION

The results of endoscope assisted tympanoplasty and microscope assisted tympanoplasty are comparable. Both the techniques have its own advantages and disadvantages, hence both techniques can be employed based on certain factors like variation in external auditory canal and size of perforation. Since the surgical outcome depends on patient's factor and surgeon's skill, operating microscope and endoscope should be employed as per the patient's requirement and surgeon's expertise.

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