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Comparative study of transcanal endoscopic versus conventional microscopic stapedotomy

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Abstract
Aim: to study the efficacy of endoscopic stapedotomy in comparison to traditional microscopic stapedotomy.
Methods: Fourty patients with otosclerosis were divided equally & operated upon using either microscopic or endoscopic stapedotomy from August 2019 to September 2021. Comparison depend on intraoperative parameters e.g. operative time, oval window exposure, chorda tympani nerve (CTN) injury and other intraoperarive complications. Postoperative parameters e.g. improvement of hearing, air bone gap (ABG), taste sensation & other postoperative complications also were used for comparison.
Results: There was less operative time in group A than in group B which was statistically significant. There is statisticaly significant decrease in post-operative ABG when compared with pre-operative ABG in both groups. There is no statistical significant difference between studied groups as regarding CTN injury. There was no statistically significant difference between studied groups as regarding intraoperative or post-operative complications.
Conclusion: postoperative hearing is better than preoperarive one in both groups. Postoperative complications such as CTN injury and taste disturbance were less in endoscopic than microscopic stapedotomy.

Keywords: endoscopic; microscopic; stapedotomy; chorda tympani nerve; taste, air bone gap

Introduction
Stapedotomy has been practiced as a surgical modality for the treatment of stapedial otosclerosis. The conventional tool for the surgery has been the operating microscope. The operating microscope renders the surgeon the advantage of use of both hands for instrumentation and hence greater stability which is of utmost importance in a surgery as delicate as stapes surgery. However, it has certain limitations. The field of view through an operating microscope is narrower as compared to an endoscope. This is because the focal length of the operating microscopes commonly used in otology is around 250 mm. This essentially has a number of implications. Certain working areas that do not lie directly in the line of our visual axis cannot be readily visualized by microscope. This means any tissue lying in front has to be repositioned or removed to ensure adequate visualization. This adds to the operative morbidity and longer operating times [1, 2]. Furthermore, this surgery may become technically difficult with hidden stapes and oval window or narrow external auditory canal. Removal of the scutum may be needed for better exposure of the stapes and oval window, and consequently there is a risk of damage to the chorda tympani nerve. Postoperative taste disorders are encountered in 20–60% of patients after stapes surgery [3, 4]. In addition, subluxation of the ossicular chain may result from removal of the posterior part of the bony canal [5, 6]. Endoscopes in middle ear surgery have made it possible to reach certain remote areas which were otherwise inaccessible via the straight axis vision of microscopes [1, 7]. The use of the endoscope would offer much benefits, such as good panoramic view and easy accessibility to the oval window niche, stapes and facial nerve. Also, with this technique, removal of the scutum and manipulation of the chorda tympani are less frequent. On the other hand, endoscopic ear surgery has some limitations, such as one hand operation and the needed learning and experience [8, 9]. Alterations in taste sensation are frequently reported by patients undergoing stapes surgery. This is directly related to the extent of manipulation of the chorda tympani nerve during surgery. This may range from minimal handling to even severing the nerve in difficult anatomical situations for the sake of access to the footplate area [10, 3].

Aim
We will study the efficacy of endoscopic stapedotomy in comparison to conventional microscopic stapedotomy.

Patients and Methods
This prospective randomized comparative study applied on 40 patients (40 ears) presented to ENT clinic at Al-Azhar university Hospital and diagnosed clinically and audiologically as stapedial otosclerosis. These patients

divided randomly into two groups, 20 patients (20 ears) operated using the traditional microscopic stapedotomy procedure and 20 patients (20 ears) underwent endoscopic stapedotomy procedure. Adult patients with progressive hearing loss, intact tympanic membrane, Conductive hearing loss & air bone gap (ABG) > 25 dB were included in the study. Pregnant females, patients with Ménière's disease & active otosclerosis were excluded. All patients were submitted to history taking, general examination & ENT examination e.g.otoscopy & tunning fork tests. Pure tone audiometry & ABG for every patient was measured at frequencies 500, 1000, 2000 & 4000 Hz. Tympanometry & acoustic reflex were also measured.

Microscopic Technique

Under hypotensive general anaethesia, using Leica M 320 HD microscope Transcanal horizontal incision performed by round knife 6-7 mm lateral to tympanic annulus from 7 -1 O'clock. Tympanomeatal flap (TMF) was elevated (Fig.1) & the annulus also was elevated using the round knife to inter the middle ear. Identification of the chorda tympani nerve under the tympanic membrane. The tympanomeatal flap was reflected anteriorly to demonstrate the ossicular chain. Curetting of posterosuperior meatal wall (Fig.3), may be needed, to avoid chorda tympani & ossicular injury, using an ear curette of House (Fig.2) to show the stapes footplate. Stapes fixation is ensured by testing ossicular mobility. Incudostapedial joint separation, cutting the stapedial tendon using angled needle or microcessor, fracture & then removal of stapes superstructure (head, neck, anterior & posterior crura). Stapes footplate fenestration was made using a 0.6 mm stapedial perforator or 0.5- 0.7 mm diamond burr. Teflon piston (Fig.4), was put in this Footplate orifice and the other end linked to the incus long process (Fig.5) with crimping. Ossicular mobility was tested after prosthesis application. Footplate fenestration was sealed using ear lobule piece of fat. Finally, repositionning of tympanomeatal flap and then gelfoam and antibiotic soaked gauze application in the external auditory canal.

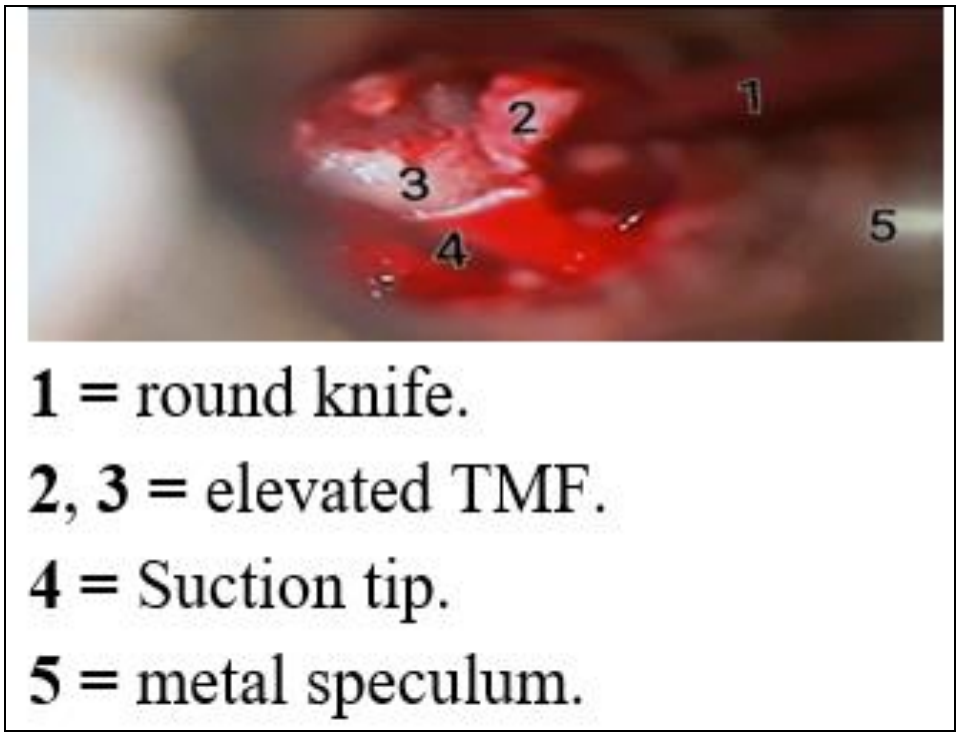


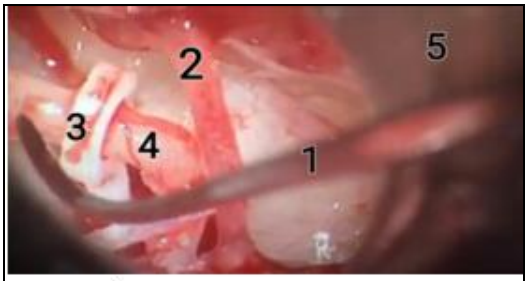
Fig 1: Microscopic TMF elevation by round knife.

Fig 2: House ear microcurette for curettage of posterosuperior bony overhang.

1 = Tympanomeatal flap.
2 = Handle of malleus.
3 = incudostapedial join.
4 = Curette.
5 = Promontory.
6 = Metal speculum.
7 = Posterosuperior over hang
.**8** = Chorda tympani nerve.

Fig 3: Microscopic Curettage of posterosuperior meatal bony hump.

Fig 4: Teflon piston prosthesis.



1 = Rt. Angle needle.
2 = Chorda tympani nerve.
3 = Teflon piston in place.
4 = Long process of incus.
5 = Metal speculum.

Fig 5: Teflon piston in the footplate fenestrum & linked to the long process of incus (microscopic view).

Endoscopic Stapedotomy

The same surgical steps of the microscopic technique, the same instuments in adittion to vedio monitoring system, with 0°, 4 mm diameter and 17 cm long endoscope may be used when the EAC is wide enough. With narrow EAC, 3 mm diameter and 17 cm long endoscope can be used. TMF elevation (Fig.6), posterosuoerior Curettage of bony meatal wall & manipulation of CTN was done in some patients for better vision of of tympanic cavity& ossicles. Ossicular mobility is tested for insurance of Footpate fixation & stapedial tendon cutting by fine needle. Incudostapedial joint separation by straight needle & stapes superstructure fracturing & removal. A hole was made in the stapedial footplate (Fig.7) by stapedial perforator. Teflon piston prosthesis is placed in the Footplate hole and the other end linked to the Long process of incus with crimping (Fig.8). After sealing the footplate hole with fat, tympanomeatal flap was repositioned and antibiotic soaked pack was put in the External auditory meatus.

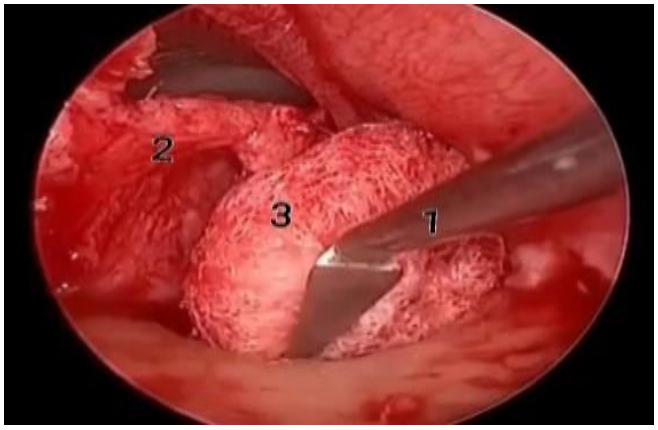


Fig 6: Endoscopic tympanomeatal flap (2) elevation by round knife (1) assisted by cotton piece (3).

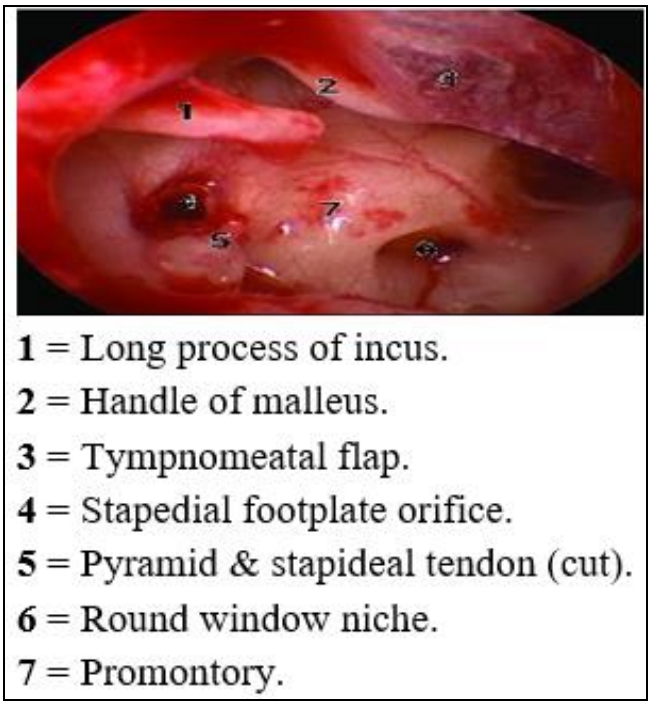


Fig 7: Endoscopic fenestration (4) in the stapedial Footplate.

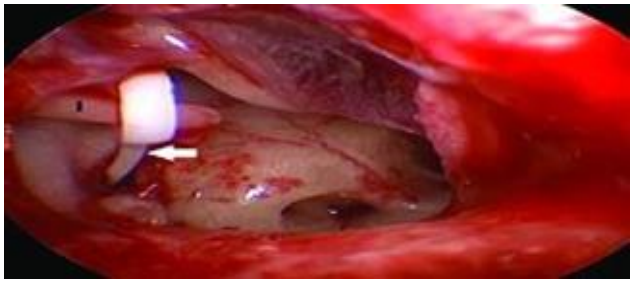


Fig 8: Endoscopic view of teflon piston prosthesis in FP orifice.

Postoperative PTA was performed for all patients either microscopic (Group A) or endoscopic (Group B) at 4 months and an ABG was measured at frequencies 500, 1000, 2000 & 4000 Hz. *Comparison of the two groups as regard the following parameters*:

Preoperative: clinically, PTA, AR.

Operative: time of each procedure in minutes, Accessibility and visibility of the field of surgery & intraoperative complications

Postoperative: hearing, tinnitus, vertigo, subjective taste disturbance, pain and other complications. PTA, AR.
Data were analyzed using Statistical Program for Social Science (SPSS) version 20 (USA). P-value < 0.05 was considered significant.

Results
This study comprises 40 patients divided into two groups; group A of 20 patients who had performed microscopic stapedotomy and group B of 20 patients who had performed endoscopic stapedotomy. The patients' age in both groups ranged from 18 to 50 years old [14 males (35 %) and 26 females (65 %)]. The most common clinical presentation of both groups was hearing loss affecting all patients. Stapedotomy was performed on the right ear of 7 patients (35%) of group A and 12 patients (60 %) of group B. It was performed on the left ear of 13 patients (65 %) of group A and 8 patients (40 %) of group B. There was no statistical significant difference (Table 1).

Table 1: Comparison of side of surgery in studied groups.

		Group A (20)		Group B (20)		P-value
Side of surgery	Right stapedotomy	7	35%	12	60%	0.342
	Left stapedotomy	13	65%	8	40%	

There was statistically significant decreased operative time in group A when compared with operative time in group B (Table 2).

Table 2: Comparison of operative time in studied groups.

		Group A (N = 20)	Group B (N = 20)	P-value
Operative time (min)	Mean ±SD	70 ± 11.2	85 ± 8.8	0.001
	Median	70.5	85.5	

The mean preoperative air- bone gap(ABG) at frequencies 500, 1000, 2000 & 4000 Hz for all patients of both groups was measured. It ranged from 30 - 58dB. The mean ABG in group A was 40 ± 7.5 with median ABG of 39.5 while the mean ABG in group B was 38 ± 7.6. There is no statistical significant difference(P-value>0.005) (Table 3).

Table 3: Comparison of pre-operative ABG in studied groups.

Pre-operative		Group A (N = 20)		Group B (N = 20)		P-value
ABG	Mean ±SD	40 ± 7.5		38 ± 7.6		0.604
	Median	39.5		37.5		
ABG	30 - 40 dB	11	55%	13	65%	0.778
	41- 50 dB	7	35%	5	25%	
	51 - 60 dB	2	10%	2	10%	

The mean postoperative ABG at frequencies 500, 1000, 2000 & 4000 Hz. for all patients of both groups was measured, at 4 months Postoperatively. It ranged from 3 to 45 dB.
The mean postoperative ABG in group A was 7.75 ± 11.5 while in group B it was 10. 5 ± 10.2. There is no statistical significant difference between studied groups (Table 4).

Table 4: Comparison between studied groups as regarding post-operative ABG.

Post-operative		Group A (20)		Group B (20)		P-value
ABG	Mean ±SD	7.75 ± 11.5		10. 5 ± 10.2		0.429
	Median	4		6.5		
ABG	0 - 10 dB.	17	85%	15	75%	0.719
	11- 30 dB.	2	10%	3	15%	
	31 - 50 dB.	1	10%	2	5%	

The mean pre- and post-operative ABGs for both groups were compared. The mean preoperative ABG was 40 ± 7.5dB for group A and 38 ± 7.6dB for group B. It is considered significant (P- value < 0.005) (Table 5).

Table 5: Comparison of ABG (pre & post) in studied groups.

		Group A (20)	Group B (20)
Pre-operative	Mean ±SD	40 ± 7.5	38 ± 7.6
	Median	39.5	37.5
Post-operative	Mean ±SD	7.75 ± 11.5	10. 5 ± 10.2
	Median	4	6.5
Stat. test	p-value	< 0.005	< 0.005

Bony work on posterosuperior bony meatal wall, for good demonstration of the stapes footplate region, was done in 15patients (75 %) of group A and 4 patients (20%) of group B and was not performed in 5 patients (25%) of group A and 16 patients (80%) of group II. It shows high statistical significant difference (Table 6).

Table 6: Comparison between studied groups as regarding bony curettage.

		Group A (20)		Group B(20)		P-value
Bony work	done	15	75%	4	20%	0.0004
	Not done	5	25%	16	80%	

Chorda tympani was manipulated, for better visualization of the stapes footplate & oval window region, in 17 patients (85 %) of group A & 5 patients (25%) of group B. It was not manipulated in 3 patients (15%) of group A & 15 patients (75 %) of group B. It was statistically significant difference (Table 7).

Table 7: Comparison between studied groups as regarding CTN manipulation.

		Group A (N20)		Group B(20)		P-value
CTN manipulation	Manipulated	17	85%	5	25%	0.0001
	Not manipulated	3	15%	15	75%	

CTN Injury occurred only in 4 patients (20 %) of group A & 2 patient (10%) of group B. This study shows no statistical significant difference as regarding CTN injury in studied groups (Table 8).

Table 8: Comparison between studied groups as regarding CTN injury.

		Group A(20)		Group B (20)		P-value
CTN injury	Injured CTN	4	20%	2	10%	0.076
	Intact CTN	16	80%	18	90%	

The majority of patients in both groups have no intraoperative or postoperative complications. Fibrous adhesions around stapes FP, present in 3 patients (15%) of group A & 2 patients (10%) of group B, was released using straight needle. Intraoperative tympanic membrane (TM) perforation occurred in 1 patient (5%) of each group. It was reconstructed by temporalis facia graft in 1 patient & fat graft in the other patient. Postoperatively, Tympanic membrane (TM) perforation was found in one patient (5%) of group A & the patient was improving & planned for myringoplsty later on. Two patients (10%) of group A & 3 patients (15%) of group B suffered from dizziness up to 2 days post-operatively which was managed conservatively until improvement & discharge. Tinnitus was present in one patient (5%) of group B and improved within 3 months with reassurance & conservative treatment. Subjective taste disturbance (dysguesia) was found only in 2 patients (10%) of group B & improved within 6 months postoperatively. It shows no statistical significant difference between studied groups as regarding intra-operative or post-operative complications (Tables 9 & 10).

Table 9: Intra-operative complications in studied groups.

Intra-operative challenges	Group A (20)		Group B (20)		P-value
No	16	80%	17	85%	0.723
FP adhesions	3	15%	2	10%	0.632
TM perforation	1	5%	1	5%	1.0

Table 10: Post-operative complications in studied groups.

Post-operative complications	GroupA (20)		Group B (20)		P-value
No	17	85%	14	75%	0.256
Dizziness	2	10%	3	15%	0.632
Tinnitus	0	0%	1	5%	0.311

Subjective dysguesia	0	0%	2	10%	0.146
TM perforation	1	0%	0	0%	0.311

Discussion

This study was applied on 40 otosclerosis Patients presented to ENT clinic at Al-Azhar university hospital,Assuit by conductive hearing loss and were operated upon via either microscopic (group A = 20 patients) or endoscopic (group B = 20 patients) stapedotomy, from August 2019 to september 2021. The mean preoperative ABG for group A was 40 ± 7.5 & 38 ± 7.6 for group B. The mean postoperative ABG was 7.75 ± 11.5 group A & 10. 5 ± 10.2 for group B. Surmelioglu *et al*., reported that the postoperative ABG was 9.3 dB in the endoscopic group and 13.5 dB in the microscopic group, and there was no statistically significant difference between the two groups [11]**.** In contrast to this study, the mean postoperative ABG in our study was 7.75 ± 10.2 in the endoscopic group B and 10.1 ± 11.5 in the microscopic group A, which was statistically significant. Naik and Nemade, had not reported any postoperarive complications as taste failure, facial nerve paralysis and tympanic membrane perforation [12]. In contrast to this study, our study reported 2 patients with taste disturbance in group B and one case of postoperative tympanic membrane perforation in group A. In this study, Postopearetive ABG was decreased in both groups A&B when compared with pre-operative ABG which was significant statistically. In our study, there was an increase in the operative time for endoscopic stpedotomy with a mean 87 ± 8.8minutes as compared to microscopic stpedotomy with a mean 75 ± 11.2 minutes which was statistically significant. In Q Yang *et al* study, a mean operative time of endoscopic stapes surgery was (74.1±26.0) minutes While that of microscopic approach was (66.5±15.9) minutes & Statistical difference was evident. The average operative time of endoscopic surgery became shorter as the cases increased [13]. Bhardwaj *et al* study on 40 (20/20) patients showed that mean operative time was 50.25 and 76.05 minutes in the microscopic and endoscopic groups respectively [14]**.** These results were consistent with our study. Endoscopic stapedotomy has the advantages of good visualization, less bony work in posterosuperior deep meatal wall and easy accessibility to the stapes, oval window niche and facial nerve [15] which is in agreement with our study in which bony work was performed in 15 patients (75 %) of group A and 4 patients (20 %) of group B which was significant statistically.

Surmelioglu *et al*., reported that the incidence of CTN iniury was more in the microscopic group than the endoscopic group which is in agreement with our study but, impaired taste sensation was noticed in 33% in the microscopic group and in 4.5% of the endoscopic group which is in contrast to our study as only 2 patients (10 %) of the endoscopic group developed impaired taste sensation and no patients (0%) of the microscopic group developed impaired taste sensation but, this was a subjective complaint [15].

As regarding postoperative complications, Kojima *et al* study reported that one patient of the endoscopic group developed late facial nerve paralysis in contrast to our study as none of patients in either group developed facial nerve paralysis. In agreement with Kojima study, none of patients in the endoscopic group & 2 patients of the microscopic group developed postoperative impaired taste sensation which improved within 6 months postoperatively. In Kojima *et al* study, four patients of microscopic group developed taste abnormalities [16].

Conclusion

Microscopic stapedotomy is the traditional method for surgical treatment of otosclerosis. Curettage of posterosuperior meatal wall, increased possibility of CTN injury and taste affection which is more common with microscopic technique. Endoscopic stapedotomy has become very common with easy accessibility to the stapes. Curettage of posterosuperior bony meatal wall, CTN manipulation & injury are less common with the endoscopic technique. Postoperative complications such as CTN injury and taste disturbance were more in endoscopic than microscopic stapedotomy. Endoscopic stapes surgery has some limitations such as one-handed surgery, loss of binocular vision, difficult haemostasis with repeated suctioning of the operative field that leads to more operative time. Endoscopic stapedotmy is more difficult technique than microscopic surgery specially with beginners due to absent stereoscopic view and difficult one handed surgery.

Recommendations

- The use of 3mm diameter angled endoscope for good exposure of oval window region.
- The well trained and experienced surgeons should perform stapedotomy either endoscopic or microscopic.
- It is necessary to extend work to include more patients in order to get more crucial results,

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