OTOLOGY

Endoscopic stapedotomy: a comparison between 4 mm and 3 mm nasal endoscope

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Abstract

Background Although, both the microscopic and endoscopic stapes surgery have claimed a parallel audiological outcome, the comparison between two standard endoscopes (4 mm and 3 mm) in endoscopic stapedotomy is not well documented. We have compared the clinical utility and audiological outcomes of the 3 mm and 4 mm rigid nasal endoscopes in the primary endoscopic stapedotomy.

Materials and methods This is a retrospective study conducted in the Department of Otorhinolaryngology between June 2015 and May 2018. Total 46 patients of primary otosclerosis had undergone endoscopic stapedotomy where 3 mm and 4 mm nasal endoscopes have been used in 22 (group A) and 24 patients (group B) respectively. The preoperative, intraoperative and postoperative surgical findings including the hearing outcomes were compared between the two groups.

Results One patient (4.5%) in group A and 6 (25%) patients in group B required canaloplasty ($p = 0.00$, χ^2 test) and 7 (31.18%) patients in group A and 18 (75%) in group B had required curettage of the bony canal wall ($p = 0.04$, χ^2 test). There was no significant difference in the air–bone gap between the two groups ($p = 0.85$).

Conclusion Both 3 mm and 4 mm nasal endoscopes can be successfully used in the endoscopic stapedotomy providing a parallel visual field. Although, comparable results can be obtained in preserving the chorda tympani nerve, tympanic membrane, facial nerve, and postoperative giddiness including the audiological outcomes, the requirement of the canaloplasty and curettage of posterior bony canal can be significantly reduced in patients operated with 3 mm nasal endoscope, especially in patients with narrow/over angulated external auditory canal.

Keywords Endoscopic stapedotomy · Nasal endoscopes · Surgical outcome

Introduction

In contrast to the standard microscopic surgery, endoscopic stapedotomy provides an improved visualization of the middle ear structures resulting in minimal removal of the bone of the posterior canal wall, decreased chance of injury to chorda tympani nerve, and enhanced learning for the trainees [1–3]. It could have been possible due to the evolution of the rigid endoscopes and later by increasing the spectrum of the visual field to inspect the detailed anatomy of the middle ear structures, even by keeping the endoscope a distance apart in the external auditory canal [4, 5]. Similar to the routine

endoscopic sinus surgery, both 3-mm and 4-mm (0°/30°) rigid nasal endoscopes can be successfully used in otology, especially in the stapes surgery. It is claimed to have promising audiological outcomes as demonstrated in the past literature [6]. Although the obtained visual field with a 3-mm rigid nasal endoscope is relatively narrow in contrast to the 4-mm endoscope, the evolution of the newer endoscopes (3 mm) has significantly enhanced the spectrum of vision with a comparable working field. Hence the difference in the utility between the two endoscopes in relation to stapedotomy surgeries mainly depends upon the working space for the instrumentation which could be better for a narrow diameter endoscope (3 mm). Again, the use of a small-width nasal endoscope can be preferred in patients with a narrow/over-angulated external auditory canal to avoid canaloplasty as an adjunctive procedure. Although both the microscopic and endoscopic stapes surgeries have claimed parallel audiological outcomes [2, 7, 8], the comparative utility and

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audiological outcomes between the standard endoscopes (3 mm and 4 mm, Karl Storz rigid endoscope) in endoscopic stapedotomy are not well documented in the literature. In the present study, we have evaluated the usefulness of the 3-mm and 4-mm rigid nasal endoscopes and compared clinical and audiological outcomes in primary endoscopic stapedotomy.

Materials and methods

This is a retrospective study conducted in the Department of Otorhinolaryngology between June 2015 and May 2018, and all the patients who underwent endoscopic stapes surgery were included. A total of 51 patients were selected for the study who were later divided into two groups by quasi randomization and patients were alternatively distributed in the 3-mm endoscopic group (group A) and 4-mm endoscopic group (group B) containing 25 patients and 26 patients, respectively. Five patients did not come for follow-up in

the postoperative period and they were excluded from the study. Hence, 46 patients were accounted for final analysis, of which 22 had undergone endoscopic stapes surgery using 3-mm (0°/30°) nasal endoscope (group A), and 24 patients were operated with a 4-mm (0°/30°) endoscope (group B) as demonstrated in the study design (Fig. 1). Patients were diagnosed, based upon the relevant clinical history, otoscopy, and pure tone audiogram (PTA) revealing conductive deafness ≥ 30 dB with normal bone conduction level at 0.5, 1, 2, and 4 kHz, with the absence of stapedial reflex. Patients with a history of chronic otitis media, an air–bone gap of less than 25 dB were excluded. The external auditory canal was labeled as narrow when all quadrants of the tympanic membrane were not visible directly under a microscope in the out-patient department. The preoperative variables such as the demographic profile of the patients, the status of the external auditory canal, and the pure tone audiogram were documented. Similarly, the intraoperative variables such as the use of the endoscopes, manipulation of the chorda
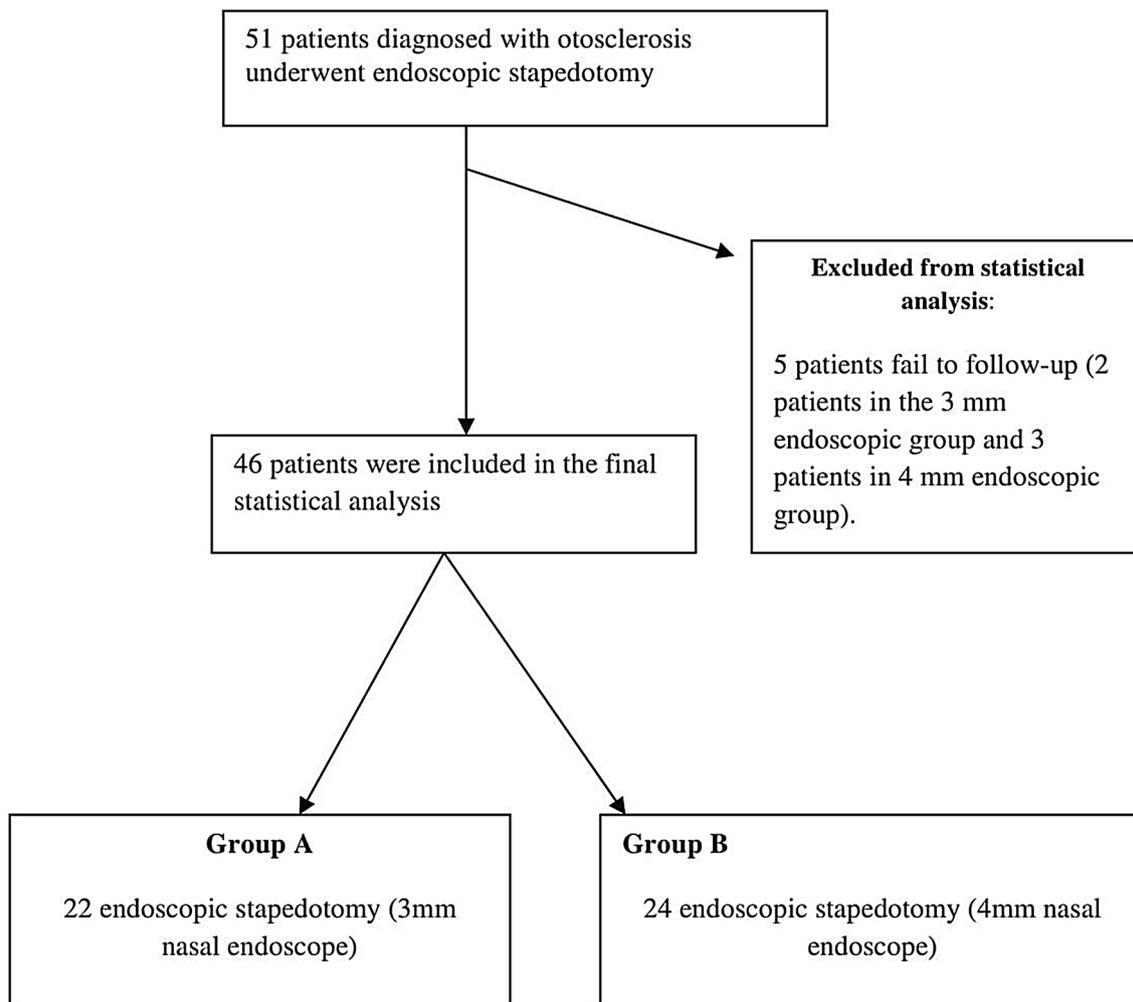

Fig. 1 Study design

tympani nerve, the curettage of the bony canal wall for the exposure, and the duration of surgery were noted. The postoperative hearing outcomes and giddiness were documented. Written informed consent was obtained from each patient prior to the surgical procedure. All the surgeries were performed by a single operating surgeon. All the surgeries were performed under local anaesthesia (xylocaine 2% with 1:100,000 adrenaline) through transcanal approach and the local anaesthesia was infiltrated into the 4 quadrants in the canal with a 26-gauge needle. A circumferential incision was made approximately 6 mm lateral to the tympanic annulus from 6 o' clock to 12 o' clock position. The tympanomeatal flap was elevated and the mesotympanum was inspected for the ossicular continuity. Canaloplasty was performed in patients with narrow and over-angulated external auditory canal. In the selected cases, the posterosuperior canal wall of the external auditory canal was curetted out for adequate exposure of the stapes suprastructure, i.e., visualization of the tympanic segment of the facial nerve and the base of the pyramid. The stapedial tendon was cut and the incudostapedial joint was dislocated. Small fenestra was made over the stapes footplate with the help of a perforator (0.8 mm diameter). A Teflon piston (0.6 mm diameter) was inserted through

the fenestra after measuring the vertical length from the undersurface of the long process of incus to the stapes footplate. The stapes suprastructure was fractured and removed with forceps. As a routine practice, a small piece of lobular fat was used for sealing the stapedotomy window after positioning the piston in each patient. The tympanomeatal flap was reposited back and the intraoperative hearing outcome was subjectively assessed.

The external auditory canal was packed with gelfoam. Figure 2 reveals the sequential stages of the endoscopic stapedotomy. The intraoperative surgical findings, complications, and duration of surgeries were noted. The preoperative audiogram was compared with the postoperative audiogram.

Follow-up

Patients were discharged after 24 h of surgery and follow-up visits were advised at the end of 1, 4, 12, and 24 weeks of surgery. At each follow-up visit, clinical examinations, including the otoscopy and PTA, were performed in each patient. PTA done at the end of 6 months of surgery was compared with the preoperative audiogram and both air
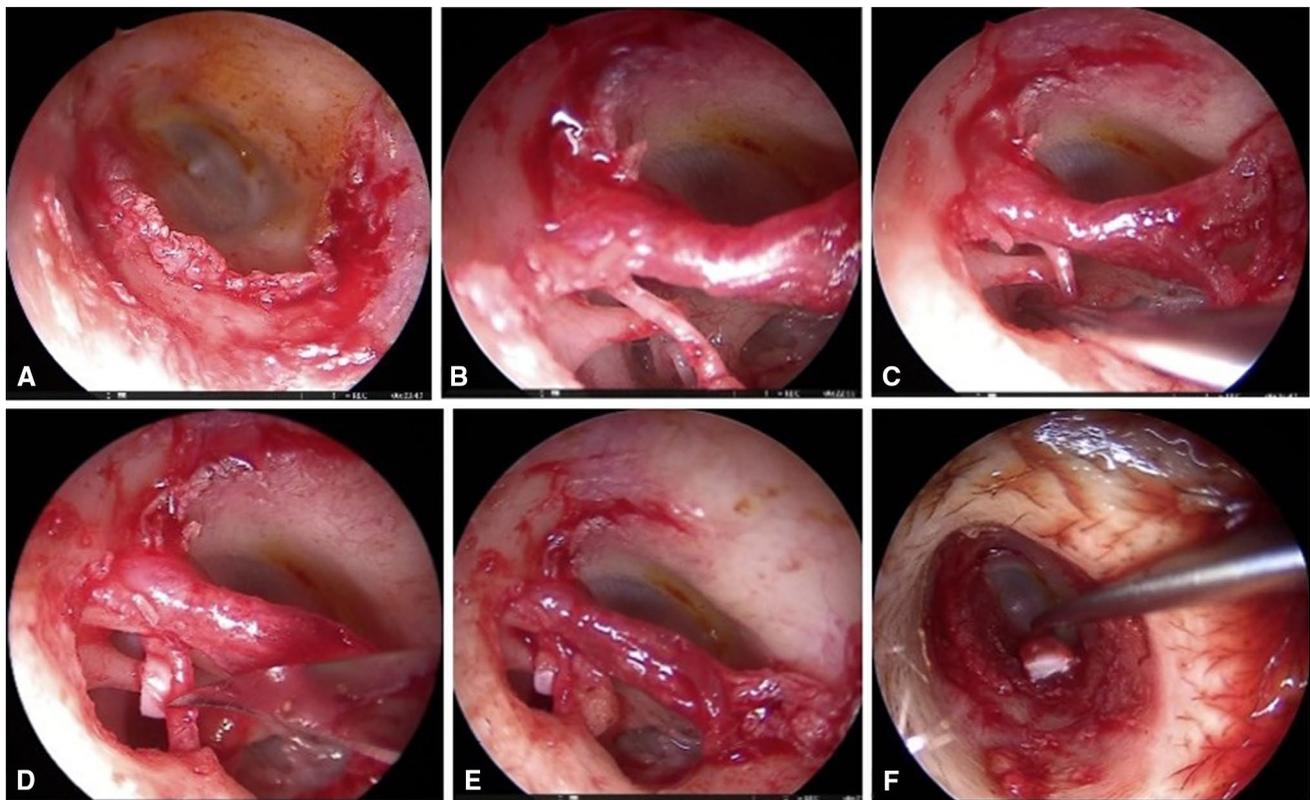

Fig. 2 Surgical steps of endoscopic stapedotomy. **a** Transcanal incision (right ear) from 6 o'clock to 12 o'clock position; **b** complete exposure of the stapes suprastructure; **c** small fenestra was made on the footplate with 0.8-mm perforator; **d** Teflon piston (0.6 mm diameter) was inserted through the window, anchored over the long process of incus; **e** lobular fat was used to seal around the prosthesis; **f** tympanomeatal flap was reposited back and external auditory canal was filled with medicated gelfoam

conduction and bone conduction thresholds were measured at the frequencies of 500, 1000, 2000, and 4000 Hz. The mean postoperative air–bone gap (ABG) was calculated in each patient and later it was compared with the preoperative ABG within a single group and in between the groups.

Statistical analysis

Preoperative and postoperative data were compared using the unpaired t test. Categorical variables between groups were analyzed using the Chi-squared test or Fisher's exact test. Results were presented as n (%), mean (range), standard deviation (SD), standard error difference (SED), and confidence interval (CI). Statistical analysis was performed using the statistical package SPSS v 20.0.

Results

Of the 46 patients, 22 had undergone endoscopic stapes surgery using a 3-mm nasal endoscope (group A) and 24 patients were operated with a 4-mm endoscope (group B). The mean age of the patients in group A was 35 years (22–48) and patients in group B was 30 years (19–45). Almost all the patients (99%) were females in both groups. The average period of follow-up for the group A patients was 8 months (5–17 months) and for group B, it was 5 months (3–11 months). The mean age of the study population was 34 years (22–48). The demographic data and intraoperative findings of the patients have been described in Table 1. Karl Storz 3-mm (0°/30°, 14 mm length) and 4-mm (0°/30°, 18 mm length) rigid nasal endoscopes were used for the stapes surgery in group A and group B, respectively. Seven patients in group A and nine patients in group B had either a narrow or over-angulated external

auditory canal. One patient in group A and six patients in group B required canaloplasty as an adjunctive surgical procedure for the primary endoscopic surgery. Of the 22 patients in group A, complete exposure of the stapes and the oval window was achieved in 11 patients with the use of 3-mm endoscope and curettage of the bony canal was not required. Rest 11 patients required minimal removal of bone for complete exposure of the stapes. Six patients in group B, did not require curettage and minimal curettage was done in 18 patients. Translocation of the chorda tympani nerve was required in 12 patients in group A and iatrogenic transaction of the chorda tympani nerve was done in three patients due to overstretching during the exposure of stapes. Similarly, in group B, 16 patients required manipulation of the chorda tympani nerve and later was sacrificed in 4 patients. The average duration of the surgery in group A was 35 min (29–65) and in group B, it was approximately 46 min (38–70). The preoperative ABG in group A was 37 dB (26–48 dB) and in patients of group B, it was 36 dB (24–50 dB). Postoperative ABG in patients of group A and group B were found to be 14 dB (8–26 dB) and 15 dB (8–26 dB), respectively. Similarly, the postoperative AB closure (ABC) in group A and group B was 23 dB (2–38 dB) and 21 dB (4–40 dB), respectively (Table 2). The difference in the preoperative and postoperative ABG was found to be 23 dB in group A and 22 dB in group B. Although there was a significant difference between the preoperative and postoperative ABG in each group ($p < 0.05$), there was no significant difference noticed when the difference of ABG was compared between the two groups ($p = 0.85$) as demonstrated in Fig. 3. Again, 54.54% of the patients of group A and 54.16% of patients of group B had < 10 dB of AB gap in the postoperative period. Similarly, 81.81% of the patients in group A and 83.32% of patients in group B had < 20 dB

Table 1 Demographic data and patients characteristics of the study population ($n = 46$)

	Endoscopic (3 mm) ($n = 22$)	Endoscopic (4 mm) ($n = 24$)	P value, χ^2 test
Number of procedures	22	24	
Age (years)	35 (range 22–48)	30 (range 19–45)	
Female (%)	20 (91%)	21 (91%)	
Ear, right (%)	15 (68%)	19 (71%)	
Narrow auditory canal	07 (31.81%)	09 (37.5%)	
Canaloplasty	01 (4.5%)	06 (25%)	0.00
Bone removal	7 (31.81%)	18 (75%)	0.04
Chorda tympani nerve injury	03 (13.63%)	04 (16.66%)	0.80
Postoperative giddiness	03 (13.63%)	05 (20.83%)	0.45
Tympanic membrane injury	02 (9%)	01 (4%)	0.17
Tympanic membrane perforation	00 (0%)	00 (%)	
Follow-up (months)	08 (range 5–17)	05 (range 3–11)	
Operative time (min)	35 (range 29–65)	46 (range 38–70)	

Table 2 Pre and postoperative hearing results for 3 mm and 4 mm endoscopic groups

	Characteristics 3 mm ($n=22$)	Endoscopes 4 mm ($n=24$)	P, 95% CI, SED
Postoperative ABC	23.22 ± 10.54 dB	21.87 ± 12.00 dB	$p=0.68$, CI (− 5.3 to 8.0),SED = 3.3
Postoperative ABG	14.05 ± 6.64 dB	14.54 ± 7.16 dB	$p=0.80$, CI (− 4.6 to 3.6), SED = 2.0
Pre-post ABG	23.22 ± 10.54	22.22 ± 11.40 dB	$p=0.85$, CI (− 5.9 to 7.1), SED = 3.2
Preoperative ABG	37.27 ± 6.9 dB	36.42 ± 8.4 dB	$p=0.71$, (CI − 3.7 to 5.4), SED = 2.3

CI confidence interval, *dB* decibel, *ABG* air bone gap, *ABC* air bone gap closure, *SED* standard error difference

Fig. 3 Box plot shows the difference in the preoperative and postoperative ABG with different endoscopes used. ABG air–bone gap
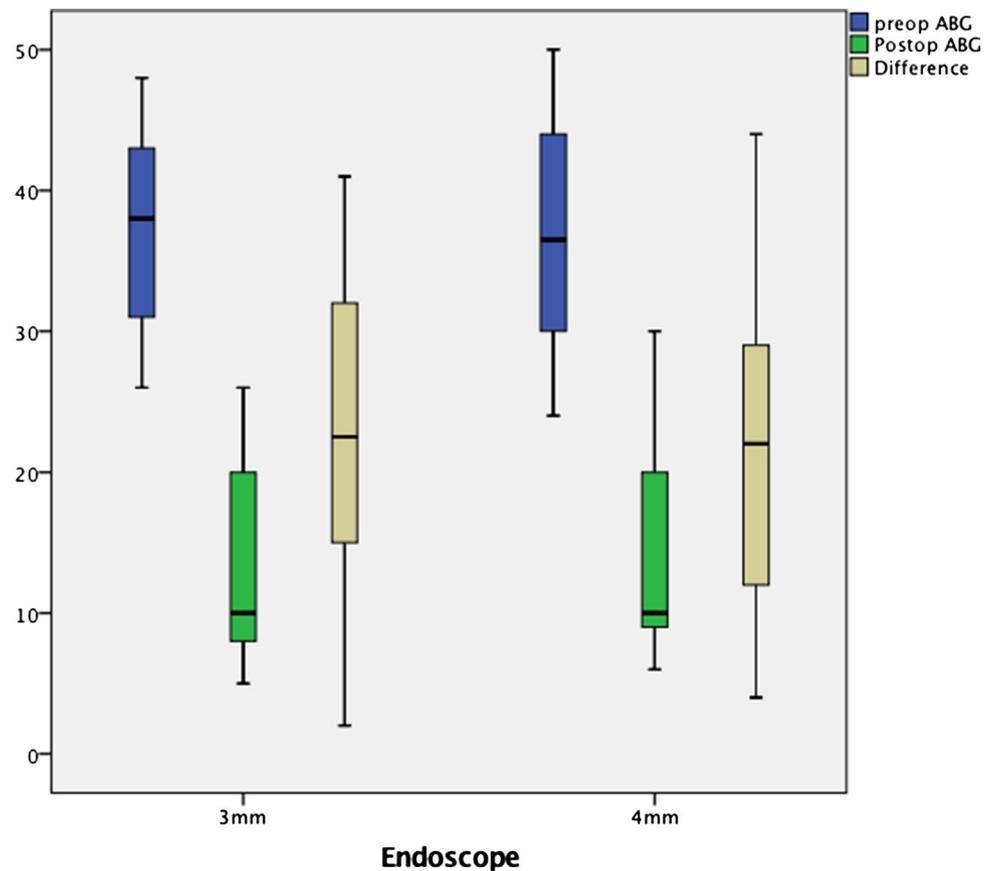

Table 3 Air–bone gap reported in bins of 10 decibels

ABG (dB HL)	Group A ($n=22$); number of patients (percentage, %)	Group B ($n=24$); number of patients (percentage, %)	P value χ^2 test
0–10 dB	12 (54.54%)	13 (54.16%)	0.76
11–20 dB	06 (27.27%)	07 (29.16%)	0.96
21–30	04 (18.18%)	04 (16.16%)	0.65
> 30 dB	00 (0%)	00 (0%)	1.00

dB HL Decibel hearing loss, *ABG* Air bone gap

of AB gap in the postoperative period (Table 3). Similar results have been shown in the literature by Naik et al. showing an AB gap better than 20 dB in 85% of cases in patients undergoing stapes surgery [9]. Giddiness in the immediate postoperative period was detected in three (13.63%) patients in group A and five (20.83%) in group B who required anti-vertiginous medication.

Discussion

In contrast to the standard microscopic surgery, endoscopic stapedotomy has gained its popularity in the past decades because of its better visual field in a narrow anatomical space, especially in the middle ear. Similar to the endonasal surgery [10], both 3-mm and 4-mm rigid nasal endoscopes can suitably be used in the stapes surgery as demonstrated in the present study. Although a parallel visual field can be obtained by both the endoscopes irrespective of their diameter, instrumentation is relatively easy with a smaller diameter and a shorter endoscope (3 mm). Again with the presence of a narrow external auditory canal, the utility of a 3-mm nasal endoscope is significantly enhanced for better visualization of the tympanic membrane with a lesser requirement of the canaloplasty.

As evident in the present study, of the seven patients in group A with a narrow canal, one had undergone canaloplasty, and of the nine patients in group B, six patients required canaloplasty for the complete visualization of the tympanic membrane. The significant difference ($p = 0.02$) could be due to the better negotiation of the narrow-diameter endoscope even in a narrow/over-angulated external auditory canal. Similarly, bone curettage was completely avoided in 11 (50%) patients in group A and 6 (25%) patients in group B, which could be due to the wide-angle endoscopic view obtained with both the endoscopes, and the difference was found to be statistically significant ($p = 0.04$) as supported by Kojima et al. [11]. Again, the encouraging results with the 3-mm endoscope could be due to the wide visual field and provision of better working space in contrast to the 4-mm endoscope. Similar results have also been reported by Nogueira Junior et al. demonstrating minimal requirement of curettage in endoscopic stapedotomy [12]. The chord tympani nerve is quite vulnerable for injury in stapes surgery, and it is more prone for the stretch injury during elevation of the flap and curettage of the posterior canal wall as it often comes in the direct field of vision, especially in the microscopic stapes surgery. In contrast, injury of the chorda tympani nerve can be avoided to a great extent in endoscopic stapes surgery because of the wide-angle surgical view of the newer endoscopes and easy negotiation of micro-instruments, enabling minimal manipulation of the nerve. In the present study, a total of 28 patients (12 patients in group A and 16 patients in group B) required some degree of translocation of the chorda tympani nerve, and 7 patients (3 patients in group A and 4 patients in group B) required iatrogenic resection of the nerve due to overstretching. We did not find any significant difference in the nerve injury rates between the two groups of patients ($p = 0.80$).

Looking into the past literature [13, 14], similar results have been established, demonstrating a lower incidence of nerve injury in endoscopic stapedotomy as compared to the standard microscopic surgery which could be due to the improved visualization of the middle ear structures resulting in the better preservation of chorda tympani nerve. However, disturbance in the taste sensation had not been documented in any of the patients in the postoperative period till 6 months of follow-up, which could be due to the under-reporting of taste dysfunction in the postoperative period as described in the literature [15]. Again, the taste dysfunction is claimed to be transient and complete resolution might be possible at the end of 1 year [16, 17].

The audiological outcome is the most important parameter to assess the success of stapes surgery. Although a significant difference was noted between the preoperative and postoperative ABG in each group ($p < 0.05$), there was no significant difference noticed when the difference of ABG was compared between the two groups ($p = 0.85$) as demonstrated in the present study. Again, 54.54% of the patients of group A and 54.16% of patients of group B had < 10 dB of AB gap in the postoperative period. Similarly, 81.81% of the patients in group A and 83.32% of patients in group B had < 20 dB of AB gap in the postoperative period without any significant difference ($p = > 0.05$), which has been supported by Naik et al. showing an AB gap better than 20 dB in 85% of cases in patients undergoing stapes surgery [9]. The devastating complication in stapes surgery is the sensorineural hearing loss (SNHL) and it has been documented in around 0.5% of the cases in the literature [18]. Fortunately, none of the patients in the present study had SNHL in the postoperative period, which could be due to the small sample size. There is always a challenge to avoid the learning curve in endoscopic stapes surgery for the optimal results which is peaking around 60–70 cases operated under the microscope [19]. In contrast to the present study, the author had expertise both with endoscopic sinonasal surgery and endoscopic ear surgery, and hence the learning curve was not accounted for the study. Some degree of giddiness is often encountered during the postoperative period of patients undergoing stapes surgery. In contrast, in the present study, of the 46 patients, only 8 (19.04%) patients complain of giddiness in the immediate postoperative period and no significant difference was noted when compared between the two groups ($p = 0.45$). The satisfactory control of vertigo could have been due to better sealing of the stapedotomy window with fat plugging. None of the patients in both groups had a perforation of the tympanic membrane or facial nerve injury. Kojima et al. reported that stapes surgery can be performed with an endoscope despite the presence of a curved and narrow external auditory canal and is minimally invasive because less drilling is required, there is less pain, and there are fewer chorda tympani injuries [2]. The major disadvantages in the endoscopic stapedotomy are the lack of stereoscopic vision and having to work with a single

hand, making it little difficult for the beginners because of the learning curve [14]. Although otoendoscopes have been recommended routinely in the stapes surgery by different authors, in the present study, nasal endoscopes (3 mm and 4 mm) were used without much difficulty, probably due to the familiar use of the same in the endoscopic sinus surgery. In addition, our study had a short follow-up time; longer follow-up period of over a year may be required to obtain a better understanding of long-term results [20].

Conclusion

Both 3-mm and 4-mm nasal endoscopes can be successfully used in the endoscopic stapedotomy enabling a parallel visual field. Although comparable results can be obtained in preserving the chorda tympani nerve, tympanic membrane, facial nerve, and postoperative giddiness, including the audiological outcomes, the requirement of the canaloplasty and removal of the bony canal can be significantly reduced in patients operated with 3-mm nasal endoscope, especially in patients with narrow/over-angulated external auditory canal. The study contains a small population size with relatively small follow-up period and hence a larger sample size with a longer follow-up period may be required for the better understanding of the results.

Compliance with ethical standards

Conflict of interest There are no conflicts of interest among the authors.

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

Informed consent Written informed consent has been taken from each patient prior to the surgery and same has been informed to the institute reviewer board. No part of the body has been demonstrated in the case report without the permission of the concerned patient.

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