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REVIEW ARTICLE

Endoscopic stapes surgery outcomes and complication rates: a systematic review

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Abstract

Objective These days, the gold standard procedure for otosclerosis treatment is stapes surgery. The endoscopic approach of the procedure is gaining popularity as endoscopic ear surgery develops across the globe. The main objective of this study is to gather and compile well-documented and reliable data regarding surgical outcomes for the endoscopic approach to stapes surgery up to this date.

Materials and methods Publications in English were searched in the PUBMED/MEDLINE database and were systematically reviewed. A total of 16 articles were reviewed according to the inclusion criteria, obtaining a total of 573 patients managed surgically for otosclerosis, using an endoscopic approach. Data were systematically extracted and compared across variables.

Results Data were obtained as follows: mean age of 43 years; female proportion of 60%; 3 mm endoscope diameter of 51%, 4 mm of 39%; titanium piston-type prostheses of 52% and Teflon of 48%; length of the prosthesis (mode) was 4.5 mm; 0.6 mm diameter of the piston of 81% and 0.4 mm of 19%; mean surgical time was 55 min. Hearing results, mean preoperative air–bone gap (ABG) 31 dB; mean postoperative ABG 9 dB; ABG improvement of 22 dB; an ABG closure rate to 20 dB or less of 92% and an ABG closure rate to 10 dB or less of 77%. Complication rates: intraoperative tympanic membrane perforation of 5%; postoperative vertigo of 11%; postoperative dysgeusia of 10%; reported a postoperative neurosensorial hearing loss of 0.2%; reported gusher phenomenon of one case (0.2%).

Conclusion Endoscopic stapes surgery is completely achievable using 0º angle and 4-mm-diameter sinus surgery endoscope. Instrument availability should not be an obstacle to the development of this type of surgery in any otolaryngology department. Audiological outcomes are comparable to microscopic approaches.

Keywords Endoscopic stapedotomy · Endoscopic stapes surgery · Stapes surgery · Stapedotomy review · Endoscopic ear surgery

Introduction

Rosen introduced the original stapes procedure for the management of otosclerosis in 1953 [1]. Following then, other surgical methods have been described, including procedures such as lateral semicircular canal fenestration, stapedectomy, and stapedotomy. Traditionally, those surgical procedures have been achieved with the practice of an operating microscope [1].

When contrasted with traditional microscopic approaches for middle ear surgery, advocates of endoscopic ear surgery (EES) indicate distinct advantages: improved visualization and access, decreased postoperative pain, expanded teaching experience for surgical trainees, and reduced requirement for transecting the chorda tympani nerve [1–5].

Especially for stapes surgery, the wide angle of view provides for better visibility of the stapes and footplate, better identification of anatomic or pathologic variations, the capacity to visualize and confirm the prosthesis coupling. With these improvements, endoscopic stapes surgery presents comparable audiological results when correlated with the microscopic technique [1, 3]. While the rates of chorda

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tympani nerve transection and scutum removal are reduced [4, 6].

Despite the noted advantages, endoscopic surgery limits the surgeon to a single-handed surgical technique, as one hand is employed to hold the endoscope. In addition, theoretically, the endoscope does not grant binocular 3D and depth perception. However, this may be overcome by moving the endoscope to conceive a sense of spatial configuration amongst structures [7].

With the expanding availability of education courses committed to endoscopic ear surgery, surgical experiences have been shared globally allowing endoscopic approaches to be developed to the point where totally endoscopic stapes surgery has become a very broad choice, published even in children's ears [8]. The objective of this present study is to present surgical and audiological outcomes regarding endoscopic stapedotomy surgery at our institutions.

Materials and methods

Study selection

A search of the literature was performed in the PUBMED/MEDLINE database. Having as primary objective studies with patients who have undergone stapes surgery for otosclerosis with the endoscopic approach. Using this framework, three reviewers retrieved studies and critically evaluated those studies. Language restrictions were applied and only articles written in English were included. From a total of 133 articles evaluated, 16 studies continued to meet the defined criteria and were further analyzed. During the search procedure, the keywords selected for the study were "stapedotomy", "stapes surgery", "endoscopic stapedotomy", "endoscopic stapes surgery", "endoscopic otosclerosis", "endoscopic ear surgery". Keywords were either combined with each of the other keywords individually or in groups. Only studies in which surgical audiometric outcomes and/or complications rates as outcomes were included for further analysis. Also, references of the retrieved articles were searched.

Data extraction and outcome measurement

Tables with analytic data were made comparing age, sex, ear, operative endoscope, type of fenestration, type of prosthesis, length and width of the prosthesis, surgical time and curettage need proportion (Table 1). Audiometric data were also extracted, obtaining preoperative air-conduction (AC) thresholds, preoperative bone-conduction (BC) thresholds, preoperative air–bone gap (ABG), as well as postoperative AC thresholds, postoperative BC thresholds, postoperative air–bone ABG, ABG improvement. Also, the proportion of postoperative results of ABG reduced to less than 10 dB and to less than 20 dB (Table 2). Surgery was considered successful if the postoperative audiogram showed an ABG of 10 or fewer decibels (ABG < 10 dB) and improvement if the postoperative ABG was lesser than 20 dB. Complication rates were also extracted, measuring rates for tympanic membrane perforation during surgery, postoperative vertigo, postoperative dysgeusia, neurosensorial hearing loss (defined as a decrease of postoperative BC threshold greater than 15 dB), and Gusher phenomenon (Table 3).

Results were measured differently depending on the total number of patients gathered for each variable, discarding all patients in the studies where non-available data were found.

Results

Patient and procedure data (Table 4)

After summarizing the extracted data, results were obtained as follows: mean age of 43.1 years (range 6–87); the female proportion was 59.9%; the proportion of right operated ears were 53.1% and left ears 46.9%; the favoured diameter of endoscopes were the 3-mm endoscope with a 51% of utilization, followed by the 4-mm endoscope with 39% of utilization, and last the 2.7-mm endoscope with 10% of utilization; micro-drill was used for footplate fenestration in 95% of the cases and KTP laser was utilized in 5% of the cases, no CO_2 laser was reported in the series; only piston-type prostheses were reported, 52% were made of titanium and 48% of Teflon; the mode of the length of the prosthesis was 4.5 mm (range 4–6 mm); regarding the diameter of the piston, a 0.6 mm was utilized en 81% of the cases, and 19% utilized 0.4 mm; mean surgical time was 55.4 min (range 18–170 min).

Audiometric data (Table 5)

Hearing results were obtained as follows: mean preoperative AC threshold of 53.9 dB (SD 19.8); mean preoperative BC threshold of 23.8 dB (SD 14.7); mean preoperative ABG of 31.2 dB (SD 13.4); mean postoperative AC threshold of 28.7 dB (SD 18.3); mean postoperative BC threshold of 21.4 dB (SD 15.6); mean postoperative ABG of 8.8 dB (SD 12.5); an obtained ABG improvement of 22 dB (SD 16.6); an ABG closure rate to 20 dB or less of 92% and an ABG closure rate to 10 dB or less of 77%.

Table 1 Patient and procedure data

Paper	*N*	Age (range)	Female (%)	Right side (%)	Endoscope	Fenestration	Prosthesis	Length (mm)	Width (mm)	Surgical time in min (range)	Curettage
Bianconi [9]	150	48 (6–78)	56	60	3 mm	Drill 0.6 mm	Piston type titanium	4–6	0.6	34 (18–76)	84
Gulsen [10]	38	33 (19–51)	47	53	2.7 mm	Drill	Piston type teflon	4–5	–	45 (32–65)	26
Pradhan [11]	22	35 (22–48)	91	68	3 mm	Drill 0.8 mm	Piston type teflon	–	0.6	35 (29–65)	7
Pradhan [11]	24	30 (19–45)	91	71	4 mm	Drill 0.8 mm	Piston type teflon	–	0.6	46 (38–70)	18
Moneir [12]	14	34 (22–56)	–	–	4 mm	–	Piston type teflon	4.5	0.6	39 (–)	–
Bhardwaj [13]	20	33 (18–48)	40	–	4 mm	Drill 0.8 mm	Piston type teflon	–	0.6	76 (50–102)	0
Nassiri [2]	81	48 (19–74)	65	44	–	Drill/laser	–	–	–	86 (43–151)	60
Kuo [14]	17	50 (30–65)	71	41	3 mm	KTP laser	Piston type titanium	4–4.75	0.6	107 (40–160)	–
Ardiç [15]	37	42 (–)	68	–	4 mm	Drill	Piston type teflon	–	0.4	–	–
Sproat [6]	34	47 (–)	41	44	–	Drill 0.7 mm	Piston type titanium	–	–	–	–
Iannella [16]	20	44 (31–61)	60	55	–	Drill 0.6 mm	Piston type titanium	–	0.4	45 (30–65)	17
Surmelioglu [17]	22	39 (20–59)	46	46	4 mm	–	Piston type teflon	–	–	66 (51–78)	–
Hunter [3]	51	48 (26–87)	61	47	–	–	–	–	–	79 (35–170)	36
Naik [18]	20	33 (31–40)	35	–	4 mm	–	Piston type teflon	4.75–5.25	0.6	31 (20–48)	17
Mirigov [19]	8	–	75	38	3 mm	Drill 0.5 mm	Piston type titanium	4.5–4.75	0.4	–	0
Nogueira [20]	15	37 (–)	87	–	4 mm	NAD	Piston type teflon	4.5	0.6	–	–
***N* per variable**	**573**	**565**	**559**	**467**	**387**	**353**	**441**	**262**	**347**	**479**	**434**
Mean(%)		**43.1 (6–87)**	**59.9**	**53.1**						**55.4 (18–170)**	**61.1%**

Table 2 Audiometric data

Paper	*N*	AC preop	SD	BC preop	SD	ABG preop	SD	AC postop	SD	BC postop	SD	ABG postop	SD	ABG improvement	SD	ABG < 20 dB	ABG < 10 dB
Bianconi [9]	150	55	24	26	20	29	21	32	24	23	22	8	21	20	22	139	118
Gulsen [10]	38	39	6	10	2	28	7	18	3	11	3	9	3	23	7	33	32
Pradhan [11]	22	-	–	–	–	37	7	–	–	–	–	14	7	23	11	18	12
Pradhan [11]	24	–	–	–	–	36	8	–	–	–	–	15	7	22	12	20	13
Moneir [12]	14	–	–	–	–	33	–	–	–	–	–	10	–	23	–	13	10
Bhardwaj [13]	20	–	–	–	–	37	5	–	–	–	–	11	9	26	–	18	–
Nassiri [2]	81	55	–	24	–	31	–	24	–	20	–	6	–	25	–	81	68
Kuo [14]	17	60	–	31	–	29	–	30	–	23	–	7	–	22	–	–	–
Ardiç [15]	37	–	–	23	8	31	8	–	–	21	9	9	8	22	–	34	29
Sproat [6]	34	56	17	28	13	29	9	28	10	22	9	7	4	21	10	34	27
Iannella [16]	20	–	–	–	–	–	–	–	–	–	–	–	–	–	–	19	17
Surmelioglu [17]	22	–	–	–	–	37	7	–	–	–	–	9	7	21	–	–	–
Hunter [3]	51	56	–	23	–	33	–	35	–	26	–	11	–	21	–	45	–
Naik [18]	20	–	–	–	–	–	–	–	–	–	–	–	–	–	–	17	11
Mirigov [19]	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6
Nogueira [20]	15	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
***N* per variable**		**371**	**222**	**408**	**259**	**510**	**347**	**371**	**222**	**408**	**259**	**510**	**347**	**510**	**268**	**471/511**	**343/448**
Mean		**53.9**	**19.8**	**23.8**	**14.7**	**31.2**	**13.4**	**28.7**	**18.3**	**21.4**	**15.6**	**8.8**	**12.5**	**22**	**16.6**	**92.2**	**76.6**

Table 3 Complication data

Paper	N	TM perforation	Vertigo	Dysgeusia	NSHL	Gusher
Bianconi [9]	150	6	9	1	1	1
Gulsen [10]	38	1	7	7	0	–
Pradhan [11]	22	2	3	3	0	–
Pradhan [11]	24	1	5	4	0	–
Moneir [12]	14	1	1	1	0	–
Bhardwaj [13]	20	0	3	0	0	–
Nassiri [2]	81	7	14	24	0	–
Kuo [14]	17	–	–	–	–	–
Ardiç [15]	37	–	–	–	–	–
Sproat [6]	34	1	0	2	0	–
Iannella [16]	20	0	4	4	0	–
Surmelioglu [17]	22	1	3	1	0	–
Hunter [3]	51	4	2	5	0	–
Naik [18]	20	0	4	0	0	–
Mirigov [19]	8	0	1	0	0	–
Nogueira [20]	15	0	1	1	0	–
N	**573**	**24**	**57**	**53**	**1**	**1**
***N* per variable**		**519**	**519**	**519**	**519**	**573**
%		**4.6**	**11.0**	**10.2**	**0.2**	**0.2**

TM tympanic membrane, *NSHL* neurosensorial hearing loss

Table 4 Patient and procedure results

Variable	Data (range)
Mean age	43 years (6–87)
Female	60%
Right side	53%
Endoscopes	
4 mm	39%
3 mm	51%
2.7 mm	10%
Fenestration	
Microdrill	95%
KTP laser	5%
Prosthesis	
Piston type teflon	48%
Piston type titanium	52%
Length (mode)	4.5 mm (4–6)
Width	
0.6 mm	81%
0.4 mm	19%
Mean surgical time	55 min (18–170)
Attical curettage necessary	61%

Table 5 Audiometric outcomes

Audiogram variable	Preop (mean ± sd)	Postop (mean ± sd)	*p* value
AC (dB)	53.9 ± 19.8	28.7 ± 18.3	< 0.05
BC (dB)	23.8 ± 14.7	21.4 ± 15.6	< 0.05
ABG (dB)	31.2 ± 13.4	8.8 ± 12.5	< 0.05
Surgical outcomes			
ABG improvement (dB)	22.0 ± 16.6		
ABG closure rate			
Postop ABG ≤ 10 dB	77%		
Postop ABG ≤ 20 dB	92%		

AC air conduction, *BC* bone conduction, *ABG* air–bone gap

Table 6 Complication rates

Complications	Data (%)
TM perforation	4.6
Vertigo	11
Dysgeusia	10.2
NSHL	0.2
Gusher	0.2

Complication data (Table 6)

Complication rates were obtained as follows: intraoperative tympanic membrane perforation of 4.6%; postoperative vertigo of 11%; postoperative dysgeusia of 10.2%; reported a postoperative neurosensorial hearing loss of 0.2%; reported Gusher phenomenon of one case (0.2%).

Discussion

Stapes surgery is a widespread technique, as it is the gold standard surgical treatment for otosclerosis. Originally, the procedure was performed using an operative microscope. But as endoscopic ear surgery is becoming more popular between otologists, each year more studies are emerging amongst literature searches, increasing the amount of data that could be collected about the endoscopic approach of this procedure (Fig. 1).

It is important to acknowledge that otologists who want to continue their development with EES (after completion and management of type 1 tympanoplasties), stapedotomy surgery could be the next step to achieve. No extra equipment is needed, as surgery is completely achievable with a 0º angle 4-mm-diameter endoscope (the same used for endoscopic sinus surgery). The surgical procedure is unchanged as in microscopic surgery and intraoperative bleeding is completely manageable.

The first results were published in 1999 by Tarabichi [21], observing an ABG reduction to < 10 dB postop of 85%. During the 2000s, almost no results were published, as EES was left behind due to hard criticism by the otologist's community, and very few studies were published about EES. New studies started to reemerge in the 2010–2020 decade. In 2011, Nogueira [20] published an ABG reduction to < 25 dB of 93%, Daeshi and Jahandideh [22] published a similar study showing an ABG reduction to < 20 dB of 94% and < 10 dB of 58%. Another study was published by Hunter et al. [7] which showed an ABG reduction to < 20 dB of 90%. Monier et al. [12] discussed one of the first studies comparing endoscopic vs microscopic stapedotomy approaches, reporting a postop ABG < 10 dB in about 71% of their endoscopic cases and 57% of their microscopic cases, while ABG < 20 dB was reported in about 94% of their endoscopic cases and 89% of their microscopic cases.

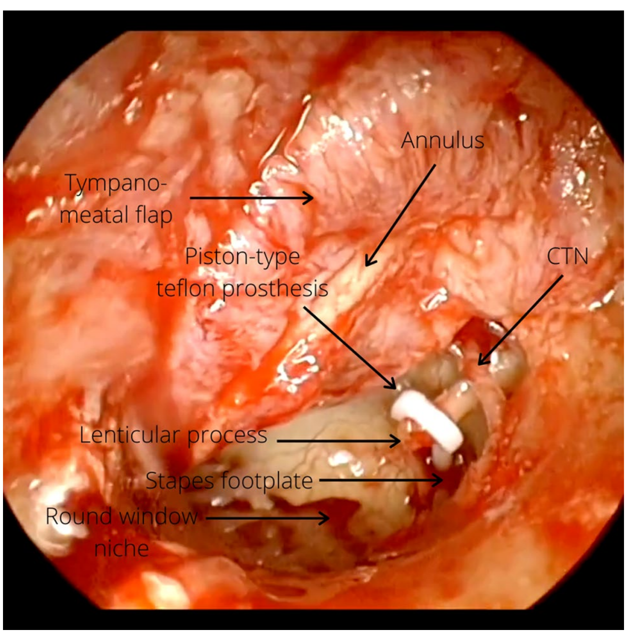

Fig. 1 Endoscopic view of a placed piston-type Teflon prosthesis. *CTN* chorda tympani nerve

As EES started to become more prevalent amongst surgeons, more studies started to emerge in the last few years. This implies more data to collect in relation to EES in general as well as for stapedotomies. As was foreseeable, one of the first systematic reviews and meta-analyses about this matter was published. In 2018, with seven studies meeting the inclusion criteria, Nikolaos et al. [23] showed that in their odds ratio (OR) analysis, no significant differences were found between endoscopic and microscopic approaches regarding hearing restoration. Obtaining an overall postoperative ABG < 10 dB of 72% in the endoscopy group and 68% in the microscopy group. In relation to complications, dysgeusia and scutum drilling took place statistically significantly less often in the endoscopy group.

It is well known that data in surgical matters are not easy to collect as surgeons have the tendency of having different surgical protocols depending on countries, health centres, or even different protocols within the same department. Also, it is not easy to approve randomized controlled trials between surgical techniques, as normally a placebo surgery would be unethical. So, normally the highest level of evidence in surgical matters lies within systematic reviews and meta-analysis of cohort studies (level 2A).

Surgeons should always have in mind the learning curve needed for EES, which is normally longer than for microscopic surgery. The experience with the use of microscopes and solid knowledge of middle ear anatomy should encourage the development of such procedures in any otolaryngology department. However, initially, longer operative time and a learning curve are the principal grounds that may discourage most ear-surgeons from initiating endoscopic stapes surgery [16].

This systematic review reveals data that could encourage ear surgeons to integrate microscopic surgical abilities with the visual enhancement that endoscopes provide to start exploring the endoscopic ear surgery field.

Conclusion

Endoscopic stapes surgery is completely achievable using 0º angle and 4-mm-diameter sinus surgery endoscope. Instrumentation should not be an impediment to the development of this type of surgery in any otolaryngology department. Audiological outcomes are comparable to microscopic approaches. Perks of this technique are that it allows better visualization of middle ear structures, increasing surgical precision. As evidence shows, it allows lesser manipulation of the chorda tympani nerve and decreases the need for curettage of the bony wall. A longer learning curve and longer operative times, in the beginning, are the principal grounds that discourage ear surgeons from initiating with endoscopic stapes surgery.

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Compliance with ethical standards

Conflict of interest The authors report no conflicts of interest.

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