The Laryngoscope

Comparison Between Endoscopic and Microscopic Stapes Surgery

Hiromi Kojima, MD; Manabu Komori, MD; Satoshi Chikazawa, MD; Yuichiro Yaguchi, MD; Kazuhisa Yamamoto, MD; Kyoko Chujo, MD; Hiroshi Moriyama, MD

Objectives/Hypothesis: To investigate whether endoscopic stapes surgery is safer and less invasive than conventional stapes surgery using an operating microscope.

Study Design: Retrospective study.

Methods: The subjects were 15 patients (15 ears) who underwent endoscopic stapes surgery for otosclerosis or congenital stapedial fixation. Another 35 patients (41 ears) in whom microscopic stapes surgery was performed by the same surgeon were assigned to the control group. The procedures for endoscopic surgery were fundamentally the same as those for microscopic surgery, unless there was no anterior or posterior auricular skin incision. The two surgical techniques were compared with respect to the operating time, postoperative hearing, complications, postoperative pain, and the extent of drilling at the posterosuperior part of the external auditory canal.

Results: There were no differences of operating time or postoperative hearing between the endoscopic and microscopic groups. There was very little postoperative pain in the endoscopic group. Postoperative dizziness was mild in all patients who received endoscopic surgery. Drilling at the posterosuperior part of the external auditory canal was less extensive in the endoscopic group than in the microscopic group.

Conclusion: Endoscopic surgery is particularly suitable for stapedial disease. Endoscopic stapes surgery can even be done in patients with a curved and narrow external auditory canal. Endoscopic surgery is also suitable for education: The surgical anatomy can be understood easily and both the surgeon and assistants can observe the procedure on the same monitor. However, it should only be performed by experienced surgeons because one-handed manipulation is required and stereoscopic vision is not available.

Key Words: Endoscope, stapedectomy, otosclerosis, microscope.

Level of Evidence: 3b.

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INTRODUCTION

In Western countries stapes surgery is usually performed by the transcanal approach under an operating microscope. However, in Japanese patients it is often performed via a posterior or anterior auricular incision because of their narrow and curved external auditory canals. But this can lead to postoperative complications such as pain, auricular numbness, and cosmetic problems. Because both hands can be used during microscopic surgery, stapes surgery is the best option if it can be performed by the transcanal approach under a microscope. Unfortunately, employing the transcanal approach is difficult in most Japanese patients.

Recently the number of reports about endoscopic ear surgery has been increasing. This surgical technique is suitable for chronic otitis media, malformations of the auditory ossicles, traumatic damage to the ossicles, cholesteatomatous otitis media, otoslcerosis, and other diseases.[1–3] Among these indications, otosclerosis is considered to be a most suitable disease for endoscopic stapes surgery for the following reasons: Very good vision can be obtained with the endoscope because stapes surgery only requires viewing the area around the stapes; and the transmeatal approach is superior to the postauricular approach as a route for assessing the stapes. In the present study we compared the outcome of endoscopic stapes surgery with that of conventional surgery under the operating microscope to determine which method achieved better results.

MATERIALS AND METHODS

We studied 15 patients (7 males with 7 ears and 8 females with 8 ears) in whom endoscopic stapes surgery for otosclerosis or congenital stapedial fixation was performed during the 7-month period from December 2011 to June 2012. Otosclerosis and congenital stapedial fixation were diagnosed in 12 and three of these 15 patients, respectively. Surgery was done on the right and left ears in seven and eight patients, respectively. At the time of surgery the patients were aged from 14 to 64 years (mean: 40.1 years). The postoperative follow-up period ranged from 6 to 12 months (mean: 8.6 months). Initial and repeat surgery was performed in 13 and two ears, respectively. Table I shows a summary of these patients.

The control group comprised 35 patients (41 ears) (11 males with 13 ears and 24 females with 28 ears) who

From the Department of Otorhinolaryngology, The Jikei University School of Medicine, Tokyo, Japan.

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Send correspondence to Hiromi Kojima MD, Department of Otorhinolaryngology, Jikei University School of Medicine, 3–25-8 Nishishinbashi Minato-ku, 105–8461 Tokyo, Japan.
E-mail: kojimah@jikei.ac.jp

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TABLE I.
The Cases of Endoscopic Stapes Surgery.

Case No.	Age	Sex	The name of disease	Operating time (min)	The average Preoperative/Postoperative Air-Bone gab (dB)	Postoperative pain	The period of Postoperative dizziness (days)	Complication
1	14	F	congenital stapedial fixation	60	21.25/8.75	almost no pain	1	
2	37	F	otosclerosis	59	21.25/6.25	almost no pain	1	
3	29	F	otosclerosis	60	22.5/7.5	almost no pain	1	
4	64	M	otosclerosis	63	41.25/22.5	almost no pain	1	
5	45	F	otosclerosis	35	25.0/3.75	almost no pain	1	
6	33	M	congenital stapedial fixation	60	17.5/6.25	midpain requiring no alalgesics	2	
7	42	F	otosclerosis	46	22.5/3.75	midpain requiring no alalgesics	1	
8	50	F	otosclerosis	60	48.75/1.25	almost no pain	1	
9	35	M	otosclerosis	55	27.5/15.0	almost no pain	1	
10	47	M	otosclerosis	52	22.5/6.25	midpain requiring no alalgesics	1	
11	43	M	otosclerosis	51	30.0/7.5	almost no pain	1	
12	36	M	congenital stapedial fixation	53	31.25/8.75	almost no pain	1	Late facial paralysis (HB grade1)
13	38	F	otosclerosis	50	17.5/6.25	pain requiring no alalgesics	2	
14	29	M	otosclerosis	46	23.75/13.75	almost no pain	2	
15	60	F	otosclerosis	61	22.5/7.5	almost no pain	1	

underwent microscopic stapes surgery for otosclerosis or congenital stapedial fixation by the same surgeon during the 4 years and 9 months from March 2007 to November 2011. Otosclerosis and congenital stapedial fixation were diagnosed in 37 and 4 ears, respectively. At the time of surgery the patients were aged from 18 to 68 years (mean: 49.47 years), and the postoperative follow-up period ranged from 9 months to 10 years (mean: 27.2 months).

Instruments

For endoscopic surgery, a high definition monitor and a camera head manufactured by Karl Storz (Tuttlingen, Germany) were used together with a 4-mm or 2.7-mm, wide-range, 18-cm, rigid sino-nasal endoscope with 0 degrees of angulation.

Standard ear surgery instruments were used, as well as tailor-made slightly curved suction tubes, gouges, and round knives (45 degrees).

The monitor was positioned in front of the surgeon. An operating microscope was also set out before the operation so that the endoscopic procedure could be immediately switched to microscopic surgery if necessary. All surgery was performed as approved by our institutional Ethics Committee (23–198, 6659).

Surgical Procedure (Fig. 1)

In both groups all patients underwent stapes surgery under general anesthesia. The external auditory canal was infiltrated with 1% lignocaine containing 1/200,000 epinephrine. For microscopic surgery a skin incision was made at the anterior border of ear, and good vision was obtained by using a refractor. Otherwise there were no differences of the surgical procedures between the two groups. Briefly, a relatively large tympanomeatal flap was created in the posterosuperior part of the external auditory canal. Then, while preserving the chorda tympani, the bone wall in the posterosuperior part of the external auditory canal was drilled out until the pyramidal eminence and the horizontal part of the facial nerve came into view. After mobility of the stapes was confirmed, the distance from the footplate to the long limb of the incus was measured. Next, a small hole was made in the footplate of stapes using a 0.8-mm perforator, a 0.6-mm Schuknecht wire-piston prosthesis (Richards Co., Bartilett, TN) was inserted, and the wire was fixed to the long limb of the incus. Subsequently, the incudostapedial joint was removed using a pick, the stapedius tendon was severed, and the superstructure of the stapes was removed. Gelfoam was placed around the site of piston insertion in the footplate to prevent perilymphatic fistula formation, and the tympanic membrane was returned to its original position. Gelfoam was also used as packing for the external auditory canal. Finally, ointment-coated gauze was inserted lightly to prevent drying.

Parameters Investigated

The parameters investigated were the operating time, postoperative hearing, intraoperative and postoperative complications, postoperative pain, postoperative dizziness, and extent of drilling at the posterosuperior part of the external auditory canal.

Hearing was assessed at 2 to 7 months after surgery in the endoscopic group and at 6 months to 1 year after surgery in the microscopic group, and was classified according to the draft AAO-HNS hearing classification system.[4,5]

As intraoperative and postoperative complications, the incidence of floating footplate, facial paralysis, and chorda tympani injury were compared between the two groups.

In the endoscopic group each patient was questioned about the severity of postoperative pain at approximately 6 hours after surgery. The severity was recorded using three grades:

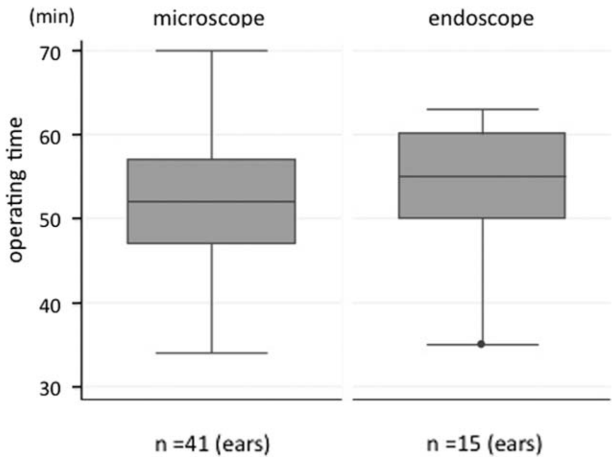

Fig. 1. Operation procedure of endoscopic stapedectomy:
a. A posterior tympanomeatal flap is elevated.
b. The scutum is removed.
c. A small hole is made in the center of the footplate.
d. The piston is inserted and the wire is tightened.
e. The superstructure of the stapes is fractured and removed.
f. A tympanomeatal flap is returned to the original position.

almost no pain, mild pain requiring no analgesics, and pain requiring analgesics. The severity of postoperative dizziness was compared as well as the duration of dizziness (number of days). Four patients underwent endoscopic surgery on one ear and microscopic surgery on the other. In these patients the severity of postoperative pain was compared between the two methods.

RESULTS

Surgical Procedure

Small fenestration stapedectomy could be performed in all patients from the endoscopic group and all patients from the control group.

Operating Time

When the operating time was compared between the microscopic group (41 ears) and the endoscopic group (15 ears), the mean operating time was 54.1 and 53.0 minutes, respectively, showing no significant difference between the two groups (t test) (Fig. 2).

Postoperative Hearing (Table II)

The postoperative air-bone gap was favorable in the endoscopic group, being $\leq$10 dB in 13 (86.7%) of the 15 ears. When 1 ear (6.7%) with an air-bone gap of 11–20 dB was included, the percentage of ears with a postoperative air bone gap $\leq$20 dB was 93.3%, showing no difference from the percentage in the microscopic group (97.5%). One patient had a postoperative air-bone gap of 21–30 dB. However, this patient's hearing had not improved despite two operations at other hospitals; endoscopic surgery was the third procedure. Accordingly, the postoperative outcome of hearing after endoscopic stapes surgery is considered to be very favorable, although this study had a short follow-up period.

Postoperative Complications

Late facial paralysis (House-Brackmann grade 1) occurred at 10 days after surgery in one of the 15 patients from the endoscopic group. This patient had congenital fixation of the stapes and the facial nerve was in contact with the ossicle (Fig. 1). The facial nerve was not injured during surgery, and the paralysis resolved by 1 month postoperatively.

In the endoscopic group none of the patients developed postoperative dysgeusia due to chorda tympani injury.

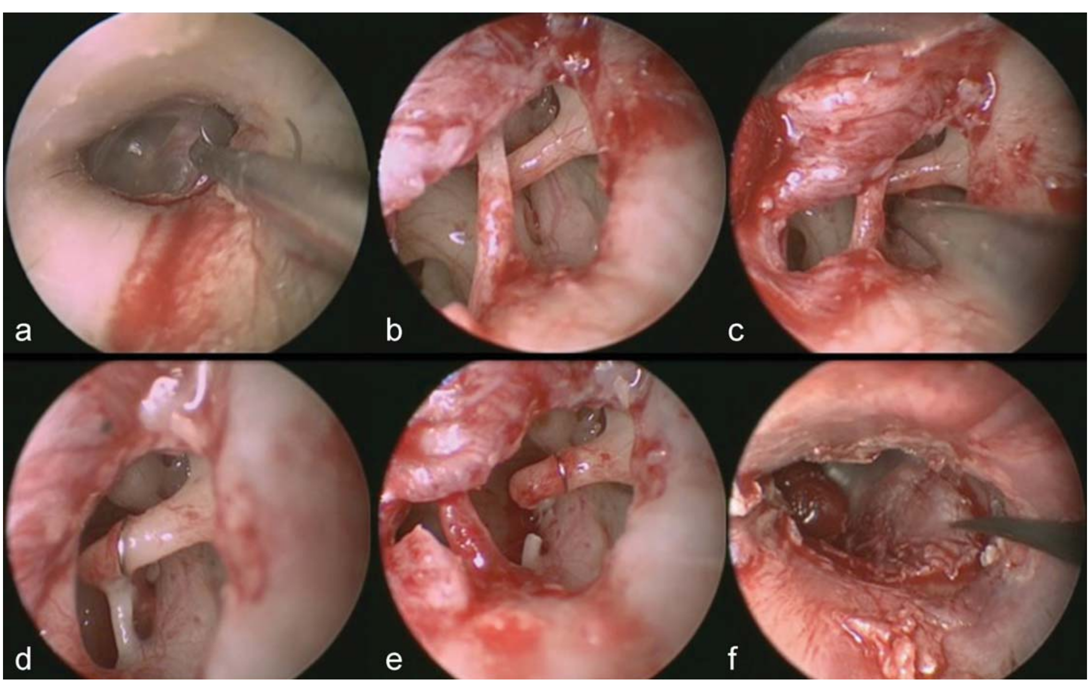

Fig. 2. Comparison of operating time between endoscopic and microscopic stapedectomy.

TABLE II.
Hearing Result.

Average postoperative Air bonegap (dB)	Small fenestra stapedectomy	
	Microscope	Endoscope
– 10	32 (78.0%)	13 (86.7%)
11 – 20	8 (19.5%)	1 (6.7%)
21 – 30	1 (2.4%)	1 (6.7%)
31 –	0	0
	n = 41 ears	n = 15 ears

In the microscopic group the chorda tympani was not severed in any of the patients. However, transient abnormal taste sensation that was presumably due to intraoperative chorda tympani traction occurred in four of the 35 patients.

Postoperative Pain

When asked about the severity of postoperative pain, it was respectively rated as "almost no pain" or as "mild pain requiring no analgesics" in 14 and one of the 15 patients from the endoscopic group. Thus, there was little postoperative pain in the endoscopic group (Table I). Four patients underwent bilateral surgery, with a microscopic procedure for one ear and endoscopic surgery for the other. All of them answered that they had suffered from irritating pain for 2 to 3 days after microscopic surgery, which was performed via an incision at the anterior border of the ear but had no pain after endoscopic surgery.

Postoperative Dizziness

Postoperative dizziness was mild in all patients who received endoscopic surgery. The duration of dizziness after endoscopic surgery was 1 day (the day of surgery) in 12 patients and 2 days (until the next day) in three patients. It was not 3 days or more in any patient. Yet the duration of dizziness after microscopic surgery was 1 day in 25 patients, 2 days in seven patients, and 3 days or more in three patients.

Drilling of the Posterosuperior Part of the External Auditory Canal (Fig. 3)

Comparison between the microscopic and endoscopic techniques showed the following: When the extent of drilling was adequate for endoscopic surgery, including visualization of the facial nerve (Fig. 3a), only the

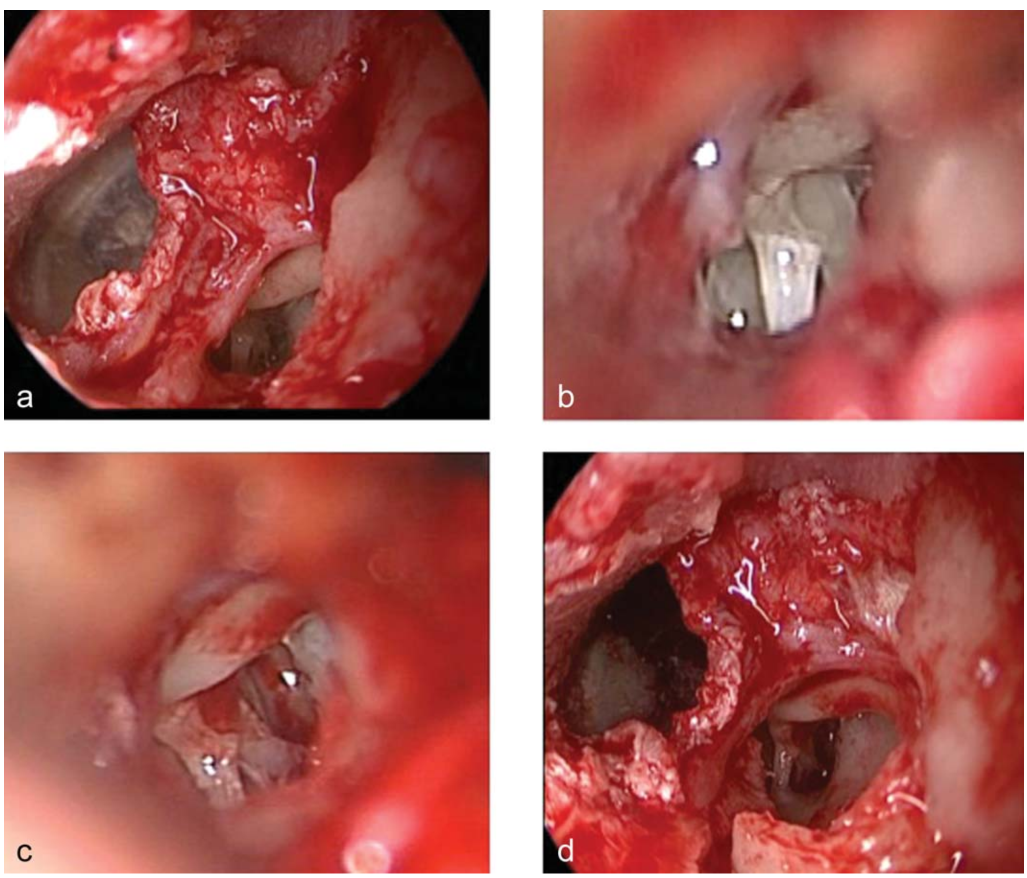

Fig. 3. Comparison of a microscopic view and an endoscope view:
a. The extent of drilling by which sufficient vision was obtained at endoscopy.
b. Vision is inadequate under the operating microscope, so microscopic surgery cannot be performed.
c. Drilling is extended so that surgery can be performed under the microscope.
d. The extent of drilling is greater than for endoscopic surgery.

area around the incudostapedial joint could be seen clearly with the microscope. Thus, microscopic surgery could not be performed because of inadequate vision (Fig. 3b). Yet when drilling was extended so that microscopic surgery could be performed (Fig. 3c), the amount of bone removed was larger than that necessary for endoscopic surgery. Thus the extent of drilling required for endoscopic surgery was smaller than that for microscopic surgery.

DISCUSSION

Ear surgery is usually performed with both hands under an operating microscope. However, endoscopes have been used for observation and treatment of conditions in the tympanic sinus and periossicular areas because these areas may be hard to visualize completely under the microscope.[6–9] Particularly for the treatment of cholesteatoma, we have actively employed an endoscope combined with a microscope to minimize drilling, thereby preserving both hearing and the facial nerve.[10] However, this is "endoscopy-assisted surgery" in which the operating microscope plays the leading role. Thanks to various innovations in endoscopes and instruments, reports have been published in recent years about pure "endoscopic ear surgery" in which all procedures are performed with an endoscope.[1–3,11]

Yet, few reports from Western countries have been published concerning stapes surgery that is entirely performed by endoscopy, presumably because stapes surgery is usually done by the endaural approach and there is less need for endoscopic procedures.[12]

Endoscopic stapes surgery has the following advantages: 1) A good view of the operating field can be obtained easily by endoscopy in Japanese patients for whom microscopic surgery via the endaural approach is difficult because they often have a narrow and curved external auditory canal. Microscopic stapes surgery is performed at some institutions, but its advantages are limited because the otoscope has to be held with the left hand; thus, surgical manipulation can only be done with one hand. In addition, during endoscopy very fine structures can be observed if the endoscope is brought close enough, while overall relations can be accurately assessed if it is pulled back slightly. 2) Endoscopic surgery is better for education. Since the monitor can be viewed by both the surgeon and assistants, the surgical anatomy and procedure can be understood more easily. 3) It is noteworthy that there was no auricular numbness and little pain after endoscopic surgery. This emphasizes the usefulness of endoscopic surgery that is performed via an endaural incision, as was also suggested by the impressions of patients who underwent surgery by different methods on each ear. 4) Drilling at the posterosuperior part of the external auditory canal can be minimized by performing endoscopic surgery. This may also be related to better postoperative wound healing. Nogueira[12] minimized the extent of drilling by using a 30-degree endoscope and completed surgery without drilling in some cases. We performed minimal drilling to allow treatment with a 0-degree endoscope. We also planned for endoscopic surgery be immediately switched to microscopic surgery if unexpected adverse events occurred.

Endoscopic stapes surgery also has some disadvantages: 1) Manipulation with one hand is problematic. However, bleeding is limited and aspiration should be minimized after fenestration during stapes surgery, so there is little need to use an aspiration tube held by the left hand and surgery can be completed with the right hand alone. 2) Stereoscopic vision cannot be obtained because the monitor is two-dimensional. Stereoscopic vision is generally considered to be necessary for perceiving subtle differences of depth when cutting the stapedial limb or tightening the wire. However, by performing this procedure several times, a surgeon can become accustomed to the manipulations required and the lack of stereoscopic vision eventually becomes unimportant. 3) Appropriate measures should be taken to prepare for unexpected complications during endoscopic surgery. The most common problem may be a floating footplate. However, its incidence is probably not different between microscopic and endoscopic surgery because there are no procedural differences between the two techniques. To avoid a floating footplate fenestration is performed first at our institution and then the superstructure of the stapes is removed after inserting the wire piston. Therefore, even if floating footplate occurs, it will probably only be partial (limited to the anterior or posterior half of the footplate). If a floating footplate occurs despite such preventive measures, it is necessary to perform total stapedectomy. This can be done endoscopically, but it may be performed more safely and securely under the operating microscope. Although we have never encountered a floating footplate that required total stapedectomy, keeping such a risk in mind, we are always ready to immediately switch to the operating microscope and are also ready to close the oval window by using gelatin sponge soaked in physiological saline. If continuation of endoscopic surgery is considered difficult because of complications, we should switch to the operating microscope without hesitation to ensure safety.

In recent years operations on the cranial base such as endoscopic transnasal pituitary surgery have been performed either one-handed or four-handed. Because there are two relatively wide nasal cavities, a one-handed operation can be avoided if an endoscope is inserted through one cavity and forceps through the other. It has been reported that a two-handed procedure can be performed by fixing the endoscope for spinal or cranial base transsphenoidal neurosurgery.[13] When ear surgery is performed it is possible to insert one endoscope and two forceps at the same time, but this means that the working space becomes inadequate because of the narrow external auditory canal. At present it is not practical to fix the endoscope and perform two-handed surgery. It is too dangerous because secondary injury will occur if the patient or operating table moves. We have also tried the Olympus EndoArm endoscope (Olympus, Japan) and our impressions of this instrument were as follows: Handling of the instrument was quite satisfactory, but image quality was inferior to that of images obtained with the HD monitor. Also, the movement of forceps was limited in the narrow external auditory canal, and the angle and distance of the endoscope could not be changed easily. For these reasons, we hesitate to use the Olympus endoscope. However, if the image quality is improved and forceps with better handling are developed in the future, this endoscope could become a useful tool.

Comparison of the operating time showed no difference between endoscopic surgery and conventional surgery under the operating microscope via an anterior auricular skin incision. Considering that endoscopic surgery was only introduced 6 months before the present study, the operating time will become shorter with improvement of the surgical technique in the future.

Postoperative hearing was satisfactory in both groups, showing no difference between the two surgical methods.

In the endoscopic surgery group, postoperative dizziness did not persist for 3 days or more in any of the patients and was mild in all patients. This was presumably because the procedure for the fenestration of the stapedial footplate was gentler.

In the present series, postoperative facial paralysis occurred in one patient from the endoscopic group and its cause was unknown. However, the patient had congenital stapedial fixation and the facial nerve was in contact with the stapes, while the space for inserting a drill to perform fenestration was very small. The facial nerve was not damaged, but it was probably compressed during fenestration or piston insertion, resulting in the occurrence of postoperative edema. However, this problem is not peculiar to endoscopic surgery and the outcome would probably have been the same if conventional surgery had been performed. In such patients it may be more appropriate to remove the suprastapedial structure first and then fenestrate the footplate. At 1 month postoperatively the patient's facial paralysis was almost completely resolved, and a diagnosis of late facial paralysis was made. No other complications occurred. The chorda tympani was preserved in all patients, and there were no cases of dysgeusia. With endoscopic surgery there are no blind spots, even if there is an overhanging posterior wall of the external auditory canal, and the chorda tympani can easily be identified. Therefore, endoscopic stapes surgery may be superior for surgical intervention on the chorda tympani. In the present study endoscopic surgery was found to be safe based on the incidence of complications, although we investigated a limited number of patients. However, stapes surgery is difficult and complications can lead to serious sensorineural hearing impairment. With endoscopic stapes surgery, handling of an endoscope is required, so the operation is done with one hand. Therefore, it should not be performed by surgeons without adequate experience of both ear surgery and endoscopic surgery at other sites, such as endoscopic intranasal surgery.

CONCLUSION

Endoscopic surgery is particularly suitable for stapedial disease. Endoscopic stapes surgery can be performed despite a curved and narrow external auditory canal and is minimally invasive, being characterized by little drilling and almost no postoperative pain. Endoscopic surgery is also suitable for education; the surgical anatomy can be easily understood and both the surgeon and assistants can observe procedures on the same monitor. It should only be performed by experienced surgeons because the operation has to be done one-handed and because stereoscopic vision is unavailable.

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