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Primary endoscopic stapedotomy using 3 mm nasal endoscope: Audiologic and clinical outcomes

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ABSTRACT

Objective: To report the use of a 3 mm rigid nasal endoscope in primary endoscopic stapedotomy and clinical and audiological outcomes.

Materials and methods: Thirty patients diagnosed with primary otosclerosis underwent endoscopic stapedotomy that was performed using a 3 mm nasal endoscope (Karl Storz). At 6 months follow-up, the patients were evaluated for intraoperative findings, postoperative hearing outcomes and complications.

Results: Canaloplasty was performed in 2 (6.66%) patients, and no curettage of the canal wall was required in 12 (40%) patients. Transposition of the chorda tympani nerve was conducted in 11 (36.66%) patients. The average duration of surgery was 36 min (range 31—65 min). The air-bone gap (ABG) was 35 dB (range 24—50 dB) preoperatively and 14.63 dB (range 9—20 dB) postoperatively (p = 0.00). At 6 months follow-up, <20 dB ABG was achieved in 93.33% of the patients. No major intraoperative/post-operative complications were detected.

Conclusion: A 3 mm rigid nasal endoscope can be effectively used in stapedotomy to obtain adequate audiological outcomes. It can be considered as a better alternative to the standard microscope or 4 mm endoscope in preserving the posterior canal wall and chorda tympani nerve while minimizing operative time without causing significant complications.

1. Introduction

In recent times, endoscopic stapedotomy has garnered much attention as it provides enhanced visualization of the meso-tympanum. In addition, it ensures preservation of the posterior canal wall and chorda tympani nerve in the majority of cases (Hunter and Rivas, 2016; Kojima et al., 2014a; Iannella et al., 2017). Advanced rigid endoscopes can improve visualization in various otologic surgeries (Marchioni et al., 2009; Tarabichi, 2000). Conventional rigid endoscopes (4 mm, 180 mm length) have been successfully used in the past in different middle ear surgeries (Moneir et al., 2018). However, the new generation pediatric nasal endoscope (3 mm, 140 mm length) can also be effectively used in stapes surgeries (Pothier, 2013; Yung, 2001). The smaller diameter (3 mm) and high-definition camera of these new endoscopes significantly improve visualization and provide better resolution images of middle ear structures (Pothier, 2013; Yung, 2001). Moreover, its shorter length makes introduction of instruments easier and increases stability to the operating hand and decreases muscle strain and fatigue during the surgery (Cohen et al., 2016). A pilot study conducted by Bernardeschi et al. described the use of 3D endoscopes in various middle ear surgeries (Bernardeschi et al., 2018). Although a 3D endoscope can be useful in providing depth perception compared to standard 2D endoscopes, it is often difficult to introduce the 3D endoscope in a narrow external auditory canal due to its wider diameter. In this study, we shared our experience of using a 3 mm rigid nasal endoscope (140 mm, Karl Storz) in primary stapes surgery.

2. Material and methods

This study is a retrospective review of all patients who underwent primary endoscopic stapedotomy using a 3 mm nasal endoscope for otosclerosis in the Department of Otolaryngology

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between June 2016 and March 2019. The diagnosis was based on detailed clinical data including otoscopic features suggesting intact tympanic membrane, conductive deafness of more than 20 dB HL with a normal bone conduction threshold (at 0.5, 1, 2 and 4 kHz) and no stapedial reflex. Patients with mixed hearing loss were excluded. Demographic and clinical profiles, including the diameter of the auditory canal and pure tone audiogram were noted in the preoperative period. Patients were counseled regarding potential surgical outcomes and complications. A written informed consent was taken from each patient before the surgical procedure.

2.1. Surgical steps

A single surgeon operated on all the patients under local anesthesia. Xylocaine (2%) with adrenaline was injected subcutaneously in the canal, covering all four quadrants. For the endoscopic stapes surgery, a 3 mm 0- and 30-degree angled nasal endoscope (140 mm in length, Karl Storz, Germany) was used. This endoscope was attached to a high-definition camera connected to a video monitor placed at the head end of the patient, facing the operating surgeon. The surgical procedure in each patient was video recorded. The instruments used were similar to those used in the standard microscopic stapes surgery. The use of a 3 mm nasal endoscope in stapedotomy was similar to endonasal surgeries, except that the surgeon operated in a sitting position. The endoscope was initially held with the left hand and later stabilized with a hand rest fixed to the operating chair. Most of the surgical steps in endoscopic stapedotomy were similar to microscopic surgery, except that one hand of the surgeon remained free for instruments.

A transcanal incision was made 6 mm lateral to the annulus, from 6 to 12 o'clock (Fig. 1). The tympanomeatal flap was elevated carefully until the middle ear cavity was reached. In selective cases with narrow/overhanging auditory canal, canaloplasty was performed. Whenever required, the posterior bony wall was curetted out for complete visualization of middle ear structures, i.e., for inspection of the horizontal segment of the fallopian canal and the base of the pyramidal process (Fig. 2). Ossicular fixation was confirmed by the absence of round window reflex in each case. The stapedial tendon was cut with the help of a curved micro scissor. Both the anterior and posterior crus were fractured, and the stapes suprastructure was removed using crocodile forceps. A fenestra was created over the posterior half of the footplate with a perforator (0.8 mm in diameter). A 0.6 mm diameter Teflon piston was inserted after measuring the vertical height from the undersurface of the incus to the footplate
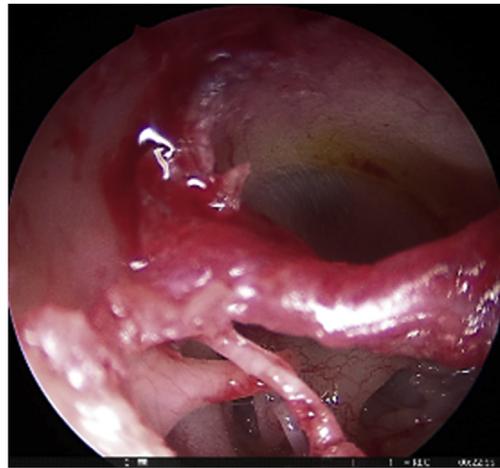

Fig. 2. Complete exposure of stapes suprastructure.

(Fig. 3). In all patients, adipose tissue (from ear lobule) was used to seal the footplate defect (Fig. 4). The movement of the prosthesis-ossicular assembly was confirmed and subjective hearing gain was evaluated on the table. The tympanomeatal flap was reposited and the canal filled with medicated Gelfoam. The lobular incision was stitched and covered with a small dressing. Intraoperative variables such as integrity of the chorda tympani nerve, preservation of bony canal and operative time were assessed. Hearing outcomes and complications in the postoperative period were documented.

2.2. Follow-up

Patients were discharged after 24 h of surgery and advised to attend the otology clinic at 1, 4, 12 and 24 weeks. At each follow-up visit, they were subjected to otoscopic and audiological examination to assess anatomical and hearing outcomes. At 6 months, both air and bone conduction thresholds were measured at 0.5, 1, 2 and 4 kHz and compared with those taken preoperatively. Similarly, the postoperative air-bone gap was also compared with that measured preoperatively.

2.3. Statistical analysis

The data were presented in number (%), mean (range), standard deviation (SD) and confidence interval (CI). Preoperative and

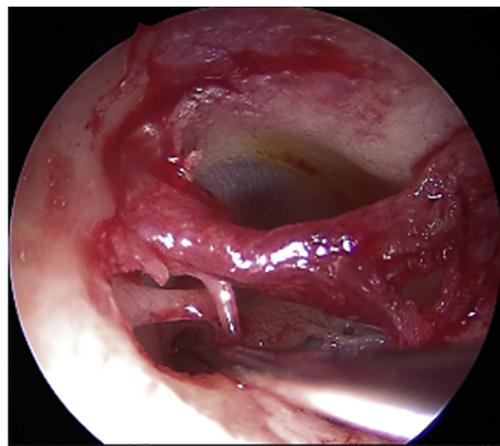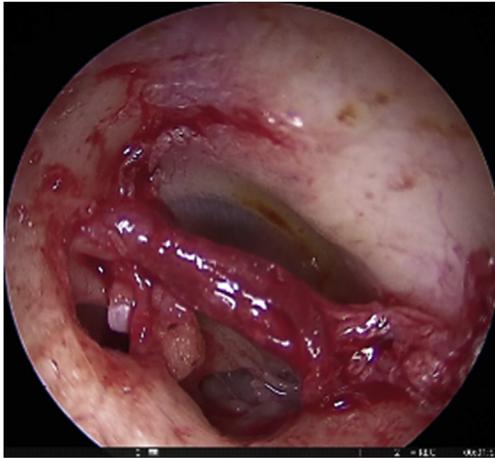**Fig. 1.** Transcanal incision from 6 to 12 o'clock (right ear).

Fig. 3. Fenestra made over the stapes footplate with a 0.8 mm perforator.

Fig. 4. Teflon piston (0.6 mm diameter, 4.25 mm length) inserted through the stapedial fenestra, anchored over the long process of the incus, and a piece of lobular fat graft sealing the stapedial fenestra after the insertion of the piston.

postoperative parameters were compared using the paired t-test. Statistical analysis was conducted with the help of the SPSS v 20.0 software.

3. Results

Thirty surgeries performed in 30 patients with bilateral otosclerosis using a 3 mm rigid nasal endoscope (0°/30°, 140 mm length) were included. The mean age of the study population was 34 years (range 19–48 years). Twenty-nine patients were female and one patient was male. The mean follow-up period was 7 months (range 5–16 months). Stapedotomy was performed on right side in 24 cases and on left side in the remaining 6 cases. Patient data, including intraoperative parameters, are presented in Table 1. Canaloplasty was performed in 2 patients (6.66%) due to posterior bony overhang. In 12 cases (40%), the bony canal was completely preserved without curettage for adequate exposure of stapes suprastructure. Minimal bone curettage was required in 18 patients (60%). The chorda tympani nerve was transpositioned in 11 patients (36.66%) as it obscured direct visualization of the surgical field. The nerve was resected in 1 patient (3.33%) because of iatrogenic injury during surgery. Dehiscent fallopian canal was found in 2 cases (6.66%) at the level of the second genu. None of our cases exhibited facial nerve overhanging, floating footplate, aberrant stapedial artery or perilymph gusher. The average duration of the surgery was 36 min (range 31–65 min).

The mean preoperative bone conduction (BC) threshold was 14.73 dB HL (range 8–16 dB HL), compared to 49.93 dB HL (range 38–62 dB HL) preoperatively. Preoperative ABG was 35 dB (range

Table 1
Demographic and clinical data of the study population (n = 30) (mean age = 34 years, range 19–48 years).

Demographic/Clinical Variable	Number of Cases (%)
Female	29 (93.50%)
Right ear	24 (77.41%)
Canaloplasty	2 (6.45%)
Bone curettage	12 (40%)
Transposition of chorda tympani nerve	11 (36.66%)
Chorda tympani nerve injury	1 (3.33%)
Postoperative giddiness	2 (6.66%)
Tympanic membrane injury	2 (9%)
Tympanic membrane perforation	0 (0%)

24–50 dB), compared to 14.63 dB (range 9–20 dB) postoperatively. Postoperative air-bone closure (ABC) and air-bone gap (ABG) were found to be 20.43 dB (range 4–44 dB) and 14.83 dB (range 6–30 dB), respectively (Table 2, p = 0.00). ABG was <10 dB in 70% and <20 dB in 93.33% of the patients at 6 months follow-up (Table 3). Postoperative giddiness was detected in only 2 patients (6.66%) that persisted longer than 6 h after surgery, and none of the patients presented with sensorineural hearing loss at 6 months follow-up.

4. Discussion

Endoscopic stapedotomy has become a popular surgery in the past decade as it provides improved visualization of middle ear structures. This has led to enhanced structural identification in the narrow middle ear space, resulting in preservation of vital anatomical structures such as the bony canal wall and chorda tympani nerve. A 3 mm rigid nasal endoscope, although designed for pediatric sinus surgery (Neel et al., 2017), can be effectively used in stapes surgery as demonstrated in the present study. Similar to a 4 mm nasal endoscope (180 mm length), the 3 mm (140 mm length) rigid endoscope can be successfully used in various middle ear surgeries with promising results (Pothier, 2013; Yung, 2001). Although it is a slim endoscope, the visual field can be significantly enhanced due to the presence of high-definition cameras (Pothier, 2013; Yung, 2001). In addition, the short shaft length (140 mm) of a 3 mm endoscope allows easy instruments introduction with increased stability in the hand and reduced muscle strain and fatigue (Cohen et al., 2016). In the present study, canaloplasty was required for complete view of the tympanic membrane in only 2 patients (6.66%), and no endaural incision was needed for exposure. This is probably because of the better adjustment of the narrow diameter endoscope both in the external and middle ear. Of the 30 patients, bone curettage was avoided in 12 patients (40%), and only minimal bone removal was required in 18 patients (60%). These results are better compared to the study conducted by Gulsen et al., in which 68.4% of the patients required curettage of the outer bony wall during endoscopic stapedotomy (Gulsen1 and Karatas2, 2019). As demonstrated by Iannella et al., the posterior canal wall was drilled in 85% of the cases in endoscopic stapedotomy and in all cases in microscopic stapedotomy (Iannella and Magliulo, 2016). Bony canal preservation in our study may have been possible due to the wide-angle visual field provided by the endoscope (NogueiraJúnior et al., 2011). Due to its slenderness and the absence of bony protection in the middle ear, the chorda tympani nerve is quite vulnerable to trauma by even minimal surgical maneuvers. In stapes surgery, the chorda tympani nerve is often overstretched during curettage of the posterior canal wall. In the present study, the chorda tympani nerve was transposed in 11 patients (36.66%) and resected in 1 patient (3.33%) because of overstretching during surgery. As described by Das et al., 81.25% of the patients who underwent endoscopic stapes surgery required transposition of the chorda tympani nerve (Das et al., 2019). The better preservation of the nerve in the present study may be due to the wide-angle view of the endoscope, requiring minimal displacement of the chorda tympani nerve. As seen in the study, the nerve was preserved in all but one case, where it was sacrificed due to iatrogenic injury during surgery. As taste sensation is supplied by the chorda tympani nerve, some degree of taste dysfunction is always expected in all middle ear surgeries. At the first follow-up in this study, 5 patients (16.66%) reported various degrees of taste dysfunction, and at 24 weeks, the number decreased to 2 (6.66%). Preservation of taste sensation in our study was significantly better than that reported in the literature, where 65.62% of patients had various degrees of taste dysfunction postoperatively (Das et al., 2019). This encouraging

Table 2
Audiological outcomes.

	Preoperative Mean ± SD (range)	Postoperative Mean ± SD (range)	Mean Change in dB (p value)
Bone conduction threshold (dB HL)	14.73 ± 5.1 (8–16)	14.63 ± 4.2 (9–20)	0.10 (p = 0.84)
Air conduction threshold (dB HL)	49.93 ± 6.8 (38-62	28.66 ± 9.8 (10–49)	21.33 (p = 0.000)
Air-bone gap (dB)	35.0 ± 8.1 (24–50)	14.83 ± 7.2 (6–30)	20.17 (p = 0.000)

dB = decibel; HL = hearing level.

Table 3
Postoperative air-bone gap.

Air-Bone Gap (dB)	Number (%)
0–10	15 (50%)
11–20	09 (30%)
21–30	04 (20%)
>30	0 (0%)

dB = decibel.

result may be partially related to the transient nature of the taste disorder, which usually recovers within six months of surgery (Yung et al., 2008; Guder et al., 2012; Berling Holm et al., 2017), as demonstrated in the present study.

Preoperative and postoperative bone conduction thresholds were similar in our study (p = 0.84). Significant improvement in both AC thresholds and ABG was observed at 24 weeks (p = 0.00), with ABG <10 dB in 70% and <20 dB in 93.33% of the patients. A study conducted by Naik and Nemade (2016) demonstrated complete ABC in 55% and up to 20 dB in 30% of patients following endoscopic stapedotomy. Similar results have been obtained by Hunter et al., who conducted a multicentric analysis of 65 cases of otosclerosis and demonstrated <20 dB ABG in 90% of cases following endoscopic stapedotomy (Hunter et al., 2016). Parallel audiologic results have also been claimed by Kojima et al. (2014b) and Bianconi et al. (2019). Sensorineural hearing loss is a rare complication in stapes surgery (observed in 0.5% of cases (Vincent et al., 2006)), and none of our patients had postoperative sensorineural loss, although this may also be related to the small sample size and a short follow-up period.

Most of our patients reported some degree of giddiness in the postoperative period, possibly due to loss of perilymph during fenestration. Only 2 patients (6.66%) had subjective giddiness for over 6 h after surgery and needed vestibular sedatives in the immediate postoperative period. The better vertigo control may be attributed to the use of adipose tissue seal that prevented excessive loss of perilymph during surgery and in the early postoperative period. No other complications were detected except for tympanic membrane injury, which occurred in 2 patients during surgery and was repaired with temporalis fascia grafting. Successful results of endoscopic stapes surgery have also been documented by Kojima et al. In their study, they described the effectiveness of endoscopic stapedotomy in a narrow and angulated auditory canal with reduced postoperative pain and injury to the chorda tympani nerve (Kojima et al., 2014a). As described by Fernandez et al., the endoscopic approach for stapes surgery is considered an option in cases with complicated oval window anatomy by producing adequate visualization of middle ear structures (Fernandez et al., 2019).

The average duration of the surgery in our study was 36 min, which is in contrast to the 54.1 min in standard duration of microscopic and 53.0 min in other endoscopic stapes surgeries, respectively (Kojima et al., 2014a). As described by Iannella and Magliulo, the average surgery time is 45 min for endoscopic and 36.5 min for microscopic stapedotomy, respectively (Iannella and Magliulo, 2016). Although there is always a learning curve in endoscopic stapedotomy for an optimal result (Yung et al., 2006), it

was not accounted in the present study because the author is an expert in both endoscopic and microscopic ear surgeries. In addition, the learning curve is mostly limited to the first 10 cases of endoscopic ear surgery (Iannella and Magliulo, 2016). Lack of depth perception is an important limitation of endoscopic stapedotomy compared to the microscopic ear surgery. Moreover, working with a single hand is always a challenge in endoscopic ear surgery, especially for beginners (Nogueria Junior et al., 2011). Despite the mentioned limitations, endoscopic stapedotomy has gained its popularity as demonstrated in the present study, where a 3 mm rigid nasal endoscope was successfully used without any difficulty. Although our postoperative outcomes were satisfactory, a larger sample size with longer follow-up period may be needed for a better understanding of the results.

5. Conclusion

The 3 mm rigid nasal endoscope (140 mm, Karl Storz) can be successfully used in endoscopic stapes surgery as an alternative to the conventional microscope/endoscope, for improved wide-angle view of the surgical field. Although similar audiological and clinical outcomes have been obtained compared to the standard microscopic/endoscopic ear surgery, the use of the 3 mm rigid nasal endoscope can be encouraged in stapes surgery as it does not cause any significant complications. However, a large sample size with a long-term follow-up and prospective randomized controlled study may be required for a better understanding of the results.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.joto.2020.05.003.

References

Berling Holm, K., Knutsson, J., Stromback, K., et al., 2017. Taste disturbance after stapes surgery: an evaluation of frequency, severity, duration, and quality-of-life. Acta Otolaryngol. 137, 39—43.

Bernardeschi, D., Lahlou, G., De Seta, D., Russo, F.Y., Mosnier, I., Sterkers, O., 2018. 3D endoscopic ear surgery: a clinical pilot study. Eur. Arch. Oto-Rhino-Laryngol. 275 (2), 379—384.

Bianconi, L.1, Gazzini, L.2, Laura, E.1, De Rossi, S.1, Conti, A.1, Marchioni, D.1, 2019 Oct 17. Endoscopic stapedotomy: safety and audiological results in 150 patients. Eur. Arch. Oto-Rhino-Laryngol. https://doi.org/10.1007/s00405-019-05688-y ([Epub ahead of print]).

Cohen, M.S., Landegger, L.D., Kozin, E.D., Lee, D.J., 2016 Mar. Pediatric endoscopic ear surgery in clinical practice: lessons learned and early outcomes. Laryngoscope 126 (3), 732—738.

Das, A.1, Mitra, S.1, Ghosh, D.1, Sengupta, A.1, 2019 Jul 9. Endoscopic stapedotomy: overcoming limitations of operating microscope. Ear Nose Throat J. https://doi.org/10.1177/0145561319862216, 145561319862216, [Epub ahead of print].

Fernandez, I.J.1, Bonali, M.2, Fermi, M.2, Ghirelli, M.2, Villari, D.2, Presutti, L.2, 2019. The role of endoscopic stapes surgery in difficult oval window niche anatomy. Eur. Arch. Oto-Rhino-Laryngol. 276 (7), 1897—1905.

Guder, E., Bottcher, A., Pau, H.W., et al., 2012. Taste function after stapes surgery. Auris Nasus Larynx 39, 562—566.

Gulsen, Secaattin, Karatas, Erkan, 2019. Comparison of surgical and audiological outcomes of endoscopic and microscopic approach in stapes surgery. Pak J Med Sci 35 (5), 1387—1391.

Hunter, J.B., Rivas, A., 2016. Outcomes following endoscopic stapes surgery. Otolaryngol. Clin. 49, 1215—1225.

Hunter, J.B., Zuniga, M.G., Leite, J., et al., 2016. Surgical and audiologic outcomes in endoscopic stapes surgery across 4 institutions. Otolaryngol. Head Neck Surg. 154, 1093—1098.

Iannella, G., Magliulo, G., 2016. Endoscopic versus microscopic approach in stapes surgery: are operative times and learning curve important for making the choice? Otol. Neurotol. 37, 1350—1357.

Iannella, G., Marcotullio, D., Re, M., et al., 2017. Endoscopic vs microscopic approach in stapes surgery: advantages in the middle ear structures visualization and trainee's point of view. J Int Adv Otol 13, 14—20.

Kojima, H., Komori, M., Chikazawa, S., et al., 2014a. Comparison between endoscopic and microscopic stapes surgery. Laryngoscope 124, 266—271.

Kojima, H., Komori, M., Chikazawa, S., et al., 2014b. Comparison between endoscopic and microscopic stapes surgery. Laryngoscope 124, 266—271.

Marchioni, D., Mattioli, F., Alicandri-Ciufelli, M., Presutti, L., 2009. Trans-canal endoscopic approach to the sinus tympani: a clinical report. Otol. Neurotol. 30, 758—765.

Moneir, W.1, Abd El-Fattah, A.M.1, Mahmoud, E.1, Elshaer, M.1, 2018 Sep. Endoscopic stapedotomy: merits and demerits. J. Otolaryngol. 13 (3), 97—100.

Naik, C.1, Nemade, S.2, 2016. Endoscopic stapedotomy: our viewpoint. Eur. Arch. Oto-Rhino-Laryngol. 273 (1), 37—41.

Neel, G.S., Kau, R.L., Bansberg, S.F., Lal, D., 2017. Comparison of 3 mm versus 4 mm rigid endoscope in diagnostic nasal endoscopy. World journal of otorhinolaryngology - head and neck surgery 3 (1), 32—36.

NogueiraJúnior, J.F., Martins, M.J., Aguiar, C.V., Pinheiro, A.I., 2011. Fully endoscopic stapes surgery (stapedotomy): technique and preliminary results. Braz J Otorhinolaryngol 77, 721—727.

Nogueria Junior, J.F., Martin, M.J.B., Aguiar, C.V., Pinheiro, A.I., 2011. Fully endoscopic stapes surgery (stapedotomy): technique and preliminary results. Braz J Otorhinolaryngol 77, 721—722.

Pothier, D.D., 2013. Introducing endoscopic ear surgery into practice. Otolaryngol. Clin. 46, 245—255.

Tarabichi, M., 2000. Endoscopic management of cholesteatoma: long-term results. Otolaryngol. Head Neck Surg. 122, 874—881.

Vincent, R., Sperling, N.M., Oates, J., Jindal, M., 2006. Surgical findings and long-term hearing results in 3,050 stapedotomies for primary otosclerosis: a prospective study with the otology-neurotology database. Otol. Neurotol. 27, S25—S247.

Yung, M.W., 2001. The use of middle ear endoscopy: has residual cholesteatoma been eliminated? J. Laryngol. Otol. 115, 958Y61.

Yung, M.W., Oates, J., Vowler, S.L., 2006. The learning curve in stapes surgery and its implication to training. Laryngoscope 16, 67—71.

Yung, M., Smith, P., Hausler, R., et al., 2008. International common otology database: taste disturbance after stapes surgery. Otol. Neurotol. 29, 661—665.