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Otology section

Recurrence of conductive hearing loss after stapes surgery: a narrative review

Recidiva di ipoacusia trasmissiva dopo chirurgia della staffa: una narrative review

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SUMMARY

Among the functional failures of stapes surgery is recurrent conductive hearing loss, which can occur after a variable period of hearing improvement, from days/months up to many years after surgery. The most common cause of recurrent conductive hearing loss is prosthesis displacement, while fibrous adhesions or stapedotomy hole/oval window re-obliteration due to otosclerosis, occur less frequently. High resolution computed tomography plays an important role in the identification of the cause of hearing loss recurrence. Parallel to this, intra-operative exploration of the middle ear is crucial to confirm the cause of failure and address its treatment, possibly restoring hearing. While generally worse than after primary surgery, hearing outcomes after revision stapes surgery have improved thanks to advancements in pre-operative assessment, intra-operative view and technical refinements.

KEY WORDS: endoscopic ear surgery, otosclerosis, stapes surgery, revision surgery, stapedotomy, endoscopic stapes surgery, conductive hearing loss, stapedectomy

RIASSUNTO

Tra le cause di fallimento funzionale della chirurgia della staffa si annovera la recidiva di ipoacusia trasmissiva, che può verificarsi dopo un periodo variabile di miglioramento dell'udito, da giorni/mesi fino a molti anni dopo l'intervento chirurgico. Le cause più comuni di ipoacusia trasmissiva ricorrente includono lo spostamento della protesi, mentre le aderenze fibrose o la ri-obliterazione della platinotomia/finestra ovale dovuta all'otosclerosi, si verificano meno frequentemente. La TC ad alta risoluzione svolge un ruolo importante nell'identificazione della causa della recidiva di ipoacusia trasmissiva. Parallelamente, l'esplorazione intra-operatoria dell'orecchio medio è cruciale per confermare la causa del fallimento funzionale e gestire correttamente il suo trattamento, con la finalità di migliorare l'udito. Nonostante i risultati generalmente peggiori rispetto a quelli della chirurgia primaria, i risultati della revisione di stapedotomia sono nel tempo migliorati grazie ai progressi nella valutazione pre-operatoria, nella visione intra-operatoria, ed al perfezionamento della tecnica chirurgica.

PAROLE CHIAVE: *chirurgia endoscopica dell'orecchio, otosclerosi, chirurgia della staffa, chirurgia di revisione, stapedotomia, chirurgia endoscopica della staffa, ipoacusia trasmissiva, stapedectomia*

Introduction

Functional failure of primary stapes surgery can occur due to persistent conductive hearing loss, recurrent conductive hearing loss after a variable period of hearing improvement, or surgical complications, as in the case of post-operative vertigo, tinnitus, or sensorineural hearing loss. In the case of recurrent conductive hearing loss (CHL), a good functional outcome can be seen for a variable duration from days/months up to many years after surgery, before the occurrence of new CHL [1]. The most common causes of recurrent CHL af-

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ter stapes surgery is prosthesis displacement, while fibrous adhesion or stapedotomy hole/oval window re-obliteration, due to otosclerosis, occur less frequently. These are among the most frequent indications to revision stapes surgery [2,3].
Revision stapes surgery, due to the presence of major pitfalls such as scarring tissue or extended erosion of the long process of the incus, is often burdened by higher failure rates. Indeed, while primary stapes surgery can be considered a standardised surgery, with relatively consistent and satisfactory hearing outcomes in most cases, revision surgery has less predictable and successful functional outcomes [4-6].
The audiological results of primary surgery reported in the literature are very good, allowing to reduce the air-bone gap (ABG) within 20 dB for the frequencies 500-3,000 Hz (PTA 500-3,000) in 93%-98% of cases and within 10 dB in 72%-94% of cases [7-9]. Conversely, the results reported in the literature for revision surgery show significantly worse results, with an ABG within 20 dB for PTA 500-3,000 ranging between 40% and 92%, and an ABG closure (< 10 dB) between 9% and 80.5% [10-15].
In addition, the incidence of neurosensory damage and iatrogenic cophosis ("dead ear") must be considered with an incidence that is up to 20% for the former and up to 14% for the latter, according to different series [13,16,17].
It should be noted that the variability of the data on revision stapes surgery in the literature is extremely large for series before 1995, when some techniques and materials were not yet introduced or widely available. Moreover, the diffusion of high-resolution computed tomography (HRCT) has led in recent years to perform this radiological imaging routinely before revision surgery, thus improving the preoperative diagnostic accuracy of hearing failure. The introduction and diffusion of the CO_2 laser, malleostapedotomy technique, ionometric bone cement and improvement of the accuracy of pre-operative imaging with HRCT have allowed an overall improvement of functional results after 1995, with not only better but also more predictable results [18,19]. In fact, an ABG < 20 dB is reported in 75% to 86% of cases and < 10 dB only in 45% to 80% of cases. However, a proportion of severe sensorineural damage or "dead ear", on average lower than in previous studies and less variable among the authors (up to 2%), persists and this should be a topic to discuss during patient counselling.

Diagnosis of recurrent conductive hearing loss after stapes surgery

The possible causes of recurring CHL after stapedoplasty are mainly related to the dislocation of the prosthesis either from the stapedotomy hole or from the long process of the incus [2,3]. The prosthetic dislocation can be associated with a localised erosion or fracture of the long process of the incus (Fig. 1), lateralisation of the footplate, or obliterating otosclerosis with closure of the stapedotomy hole (Fig. 2). All these situations can be combined in various ways, as detailed in Table I.
According to the patient's history, prosthetic dislocation determines progressive or sudden onset of CHL. In some cases, the pattern of hearing loss could help in identifying the cause and type of dislocation: if hearing loss occurred after induced pressure change (Valsalva manoeuver, high-altitude travel, air travel) or head trauma, the prosthesis is generally dislocated at the level of the stapedotomy hole. On the other hand, in the case of progressive or step-by-step hearing deterioration, erosion of the long process of the incus and secondary prosthetic dislocation are more likely [2,3].

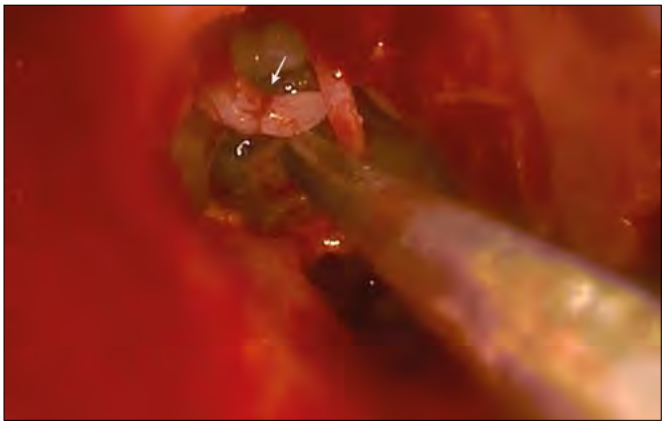

Figure 1. Intraoperative view during endoscopic revision stapes surgery for recurrent hearing loss, showing fracture of the long process of the incus. The white arrow indicates the fracture line.

Figure 2. Intraoperative view during endoscopic revision stapes surgery showing another cause of recurrent hearing loss: obliteration of the previous stapedotomy hole and of the adjacent oval window (white arrow).

Table I. Summary of causes of recurrent conductive hearing loss after stapes surgery, with related anatomical sites of interest and associated issues to be considered during revision surgery.

Causes of recurring conductive hearing loss	Site	Associated problems
Dislocation of the prosthesis	From the stapedotomy hole	Short prosthesis
		Scar tissue
	From the incus	Erosion of the long process of the incus
		Fracture of the long process of the incus
Fracture of the long process of the incus	Incus	Excessive prosthesis crimping
		Erosion and fracture of the long process after prosthesis dislocation from the stapedotomy hole
Lateralisation of the footplate	Footplate	Erosion of the long process of the incus
		Obliterating otosclerosis
Obliterating otosclerosis with closure of the stapedotomy hole	Footplate	Dislocation of the prosthesis
		Erosion of the long process of the incus

Lesinski et al. proposed several mechanisms for prosthetic migration. First, in cases with the use of a sealing membrane, some collagen contracture of the membrane itself lifted the prosthesis above the stapedectomy or stapedotomy fenestration, with greater lateralisation occurring in thicker sealing materials, in decreasing order fascia, fat, perichondrium, and vein. Second, adhesive tissue is frequently found between the prosthesis and the promontory, facial ridge, or pyramidal eminence. In general, the prosthesis was displaced toward that structure by the pulling forces of collagen contracture of the neomembrane. No clear mechanism of prosthesis displacement has been identified in cases of failure after stapedotomy without graft interposition. However, if no adhesions were found, the prosthesis was not perpendicular to the plane of the footplate but displaced in the angulated direction from the forces evoked by the vibrating incus. In other occasions, the prosthesis had migrated away from the oval window because of faulty crimping; i.e., the loop around the incus neck was found flattened, and the prosthesis migrated off the incus. In 5% (13/260) of patients, the prosthesis was found attached to the incus neck, but too short to reach the neomembrane. Less than 1% of these patients were found to have a prosthesis that was loosely attached to an intact incus with no other abnormalities [3].

HRCT is the gold standard exam that allows identification of the cause of recurrent CHL with considerable accuracy. While HRCT can detect prosthetic dislocation from the stapedotomy hole, less accurate is the diagnosis of an erosion or fracture of the long process of the incus, unless the distal fragment is displaced itself [4,12]. In a recently published study by Fernandez et al, of the 18 consecutive cases of recurrent CHL after primary stapes surgery who had a pre-operative HRCT scan, pre-operative imaging was diagnostic for prosthesis dislocation in 3 cases (Figs. 3, 4), while it did not permit to pre-operatively understand the cause of hearing failure in 14 cases showing a normal position of the prosthesis. No cases of round window obliteration were observed [4].

Figure 3. Temporal bone high resolution computed tomography, axial view. On the left, the end of the prosthesis appears dislocated from the oval window.

Figure 4. Temporal bone high resolution computed tomography, coronal view. On the left the oval window is empty and the prosthesis is displaced upwards towards the Fallopian canal. It is not possible to assess if the incus long process is eroded from this imaging. Only exploratory tympanotomy could clarify the cause of prosthesis displacement.

Intra-operative findings during revision stapes surgery for recurrent hearing loss: the role of the endoscope

In cases where pre-operative assessment of the cause of recurrent CHL is not possible, an exploratory tympanotomy allows for proper identification of the cause of stapes surgery failure, thanks to the close view on the ossicular chain, oval window, and prosthesis [13,17].

The use of the endoscope in stapes surgery has shown excellent results that are comparable to those with the microscopic technique, according to several reports [20,23].

Regarding revision stapes surgery, accumulating evidence has led to consider not only that totally endoscopic revision stapes surgery is safe and effective in experienced hands, but also that the endoscopic approach allows an extremely detailed exploration of the entire middle ear cavity through a transcanal approach, without the need for an endaural or retroauricular approach and with the possibility to diagnose and manage all possible intra-operative scenarios during revision surgery. This represents a greater advantage of the endoscopic technique compared to the classic microscopic approach.

In the experience of the senior authors, in a study involving 34 patients, a cause of persistent or recurrent hearing loss was detected in all patients during endoscopic tympanotomy. Of those, 2 presented with persistent CHL and 32 with recurrent CHL. The intra-endoscopic findings were numerous and occasionally combined (the number in brackets indicates the number of patients found to have that specific endoscopic situation): partial erosion (10) or extensive erosion (1) of the incus, fracture of the incus (1), and incus luxation (1); fixed malleus (1); incorrect anterior stapedotomy hole (1), re-closed stapedotomy hole (14), absent stapedotomy hole (2), fibrous tissue at the level of the stapes (6) – as shown in Figure 5; short prosthesis (7), long/intravestibular prosthesis (1), absent prosthesis (2), attached to the incus-out of stapedotomy hole (12), detached from incus-inside stapedotomy hole (1), detached from incus-out of stapedotomy hole (13). Such a detailed description of intratympanic findings could have been more difficult under straight microscopic view.

Parallel to this, it has been shown that all intra-operative situations encountered during revision stapes surgery are manageable through an exclusive endoscopic approach, supporting the concomitant therapeutic role of this approach [4].

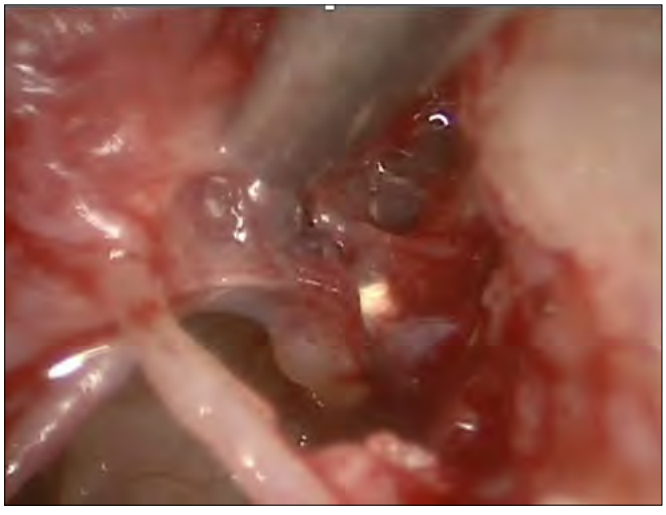

Figure 5. Endoscopic transcanal view of revision stapes surgery. The presence of fibrous and adhesive tissue around the prosthesis and the long process of the incus is another cause of recurrent hearing loss after stapes surgery. In these cases, treatment consists of removing this tissue and controlling the mobility of the ossicular chain and prosthesis.

Outcomes after revision stapes surgery in patients with recurrent conductive hearing loss

Primary stapes surgery can be considered successful if an ABG of < 10 dB is achieved [22,23]. Similarly, the success of revision surgery is generally confirmed by closure of the post-operative ABG within 10 dB. According to the literature, revision stapes surgery creates an opportunity for improving hearing in 24%-80% of cases [10-15].

When deciding on reoperation after primary stapedotomy, it should also be noted that it is usually a more difficult procedure than the initial operation, as a consequence of the need to dissect adhesions in the tympanic cavity, as well as to manage the previously used prosthesis in atraumatic way [3-6]. Furthermore, it is associated with a higher risk of complications than in the initial procedure, including hearing loss and injury to the facial nerve.

A recent experience on the use of the endoscopic technique during revision stapes surgery has shown positive results, with 89.5% of cases with post-revision ABG within 20 dB and 68.5% of cases with post-revision ABG within 5 dB. These data appear to be higher than those reported in the recent literature on stapes revision surgery with microscopic technique, but larger series with longer follow-up are needed for a proper comparison between the two techniques [8].

Conclusions

Although primary stapes surgery provides excellent functional results in a very large percentage of cases, some patients may suffer from CHL after a variable period of time.

An appropriate intra-operative diagnosis of recurrent CHL is crucial for a good outcome, hearing results being largely dependent on the cause of failure and its treatment. While HRCT plays a role in the pre-operative evaluation of revision cases, the endoscope allows detailed exploration of the middle ear cavity and is particularly suitable for intra-operative assessment of the cause of failure of previous stapes surgery. The latest advancement in pre-operative imaging and surgical techniques have improved hearing outcomes in revision stapes surgery, despite remaining less satisfactory than primary surgery.

Conflict of interest statement

The authors declare no conflict of interest.

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Author contributions

IJF conceived the idea, wrote the manuscript, critical revision of the manuscript, final approval of the submitted version. FR wrote the manuscript, final approval of the submitted version. LP conceived the idea, critical revision of the manuscript, final approval of the submitted version. GM conceived the idea, wrote the manuscript, supervised the work, final approval of the submitted version.

Ethical consideration

A formal ethical assessment in not required by the Institutional Ethical committee for this kind of studies.

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