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CASE REPORT

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Transmembranous piston extrusion after stapedotomy: A rare complication

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ABSTRACT

To report an adverse event after successful otosclerosis surgery: piston extrusion through the tympanic membrane, and its surgical solution. Four patients with a history of stapes surgery in context of otosclerosis presented with recurrent conductive hearing loss due to piston extrusion. Otoscopy, audiometric assessment and CT-imaging were conducted to assess the encountered conductive hearing loss and extrusion of the prosthesis. Revision stapes surgery was performed with interposition of cartilage between tympanic membrane and piston-loop. Pre- and postoperative audiometry and otoscopic evaluation. Revision surgery resulted in postoperative ABG within 15 dB. No recurrent extrusion was seen after the mentioned surgical procedure including use of cartilage graft. In case of piston extrusion (trans-tympanic membrane), revision stapes surgery with interposition of a cartilage layer between tympanic membrane and piston is advocated to prevent recurrence.

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Piston extrusion; stapedotomy; otosclerosis; transmembranous

Introduction

Since the early sixties of the past century middle ear surgery with stapes replacement procedure has been the mainstay of treatment of otosclerosis [1–4]. In the beginning stapes mobilization or semicircular canal fenestration were techniques leading to (partial) hearing improvement, though with a considerable recurrence rate and complications (such as sensorineural hearing loss, vestibular complaints) [5,6]. Improvements in these techniques resulted first in stapedectomy and later to stapedotomy: a broadly accepted and in most cases successful surgical intervention, resulting in a rather acceptable long-term resolution of the conductive component in the hearing impairment [3]. Need for revision surgery is rare (<5%) and is indicated in cases of recurrence of conductive hearing loss [7]. Main reasons underlying this failure is a destabilized prosthesis (e.g. incus erosion, inappropriate prosthesis length) or rather a 'fixed' prosthesis [7–9]. Revision surgery is then indicated to alleviate the air-bone gap (ABG) . However, the procedure may be challenging, and hearing results are inferior to results after primary surgery. Additionally, it is associated with an increased risk of sensorineural hearing loss due to cochlear trauma [6,7,9–11].

Type of stapes prosthesis application during primary otosclerosis surgery varies and is amongst others depending on surgeon's preference and philosophy of the medical center. The variety of prostheses included Causse loop piston (Teflon, Medtronic®), Fisch teflon Wire or Richards (Olympus®), all titanium piston ('Big Easy', Medtronic Xomed®) or the K-piston (Kurz® Medical). None of these seem to outperform one or the other in terms of hearing outcome, long term success rate, ease of insertion or complication rate. Either prosthesis has its pros and cons regarding need for crimping, positioning with surgical forceps, 'memory' of the material [1,2].

In this retrospective case report study, we report on a rare complication after successful otosclerosis surgery on the long term in four different patients. Type of procedure, type of applied prosthesis and duration of follow up are registered; pitfalls and pearls will be reviewed and assessed to better understand the pathophysiology and provide a treatment strategy.

Material and methods

All patients were referred to the outpatient clinic of our tertiary referral center due to complaints of

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recurrent and progressive hearing impairment after previous otosclerosis surgery. Data were collected from the medical records of these patients, including demographic data, patient's medical history, type of procedure and piston, clinical findings, postoperative complications, and audiometric results (Table 1).

Results

Patient 1

In a 53-year-old female a right-sided stapedotomy procedure (teflon wire prosthesis Richards®, Olympus) was performed 15 years prior to this visit. Otoscopy revealed a partially extruded prosthesis through the posterior part of the tympanic membrane (TM); audiometry showed an air conduction (AC) loss of 47 dB (Pure Tone Average (PTA): 0.5–1–2 kHz) and a bone conduction (BC) loss of 23 dB. Preoperative CT scan showed bilateral signs of otosclerosis mixed type (fenestral and cochlear spots visible), piston luxation was demonstrated in the right middle ear (Figure 1(A)). During revision surgery the stapedotomy opening was re-entered, and piston was replaced by a Causse Teflon (Medtronic®) large loop piston (diameter 0.6 mm); between the TM and the prosthesis loop a small piece of tragal cartilage was placed. Postoperative course was uneventful and after 6 weeks audiometry showed a resolution of the conductive loss (AC) 28 dB PTA).

Patient 2

This 48-year-old-woman presented two years after successful stapedotomy on the right ear. An all Teflon (Causse, Medtronic®) piston was found in the ear canal with an intact TM. Revision surgery with repositioning of a large loop Teflon prosthesis provided closure of the air bone gap. However, recurrent extrusion occurred 12 months thereafter during follow up (Figure 2(A)). Second revision surgery with positioning of a Teflon piston, this time with tragal cartilage interposing between prosthesis and TM, resulted in long term alleviation of conductive hearing impairment (AC 33 dB, BC 23 dB PTA after 12 months).

Patient 3

A 54-year-old woman came to the outpatient clinic five years after a successful malleostapedotomy (AC 57 dB, BC 25 dB PTA). Partial piston extrusion (Malleable Teflon Loop prosthesis, Medtronic®) was visible during otoscopy (Figure 2(B)). During revision surgery a new piston (Malleable loop prosthesis) was placed around the malleus, with a piece of tragal cartilage below the TM. Restoration of conductive loss was encountered six weeks after surgery, though a deterioration of the perceptive hearing loss (from 25 to 40 dB PTA) was encountered after short term follow up.

Patient 4

This man of 49 years old presented with functional deafness 14 years after stapedotomy on the left ear (otosclerosis mixed type, type Shuknecht Teflon wire piston); the loop of the prosthesis was visible in the posterior region perforating the TM and the luxation was confirmed on CT-imaging (Figure 1(B)). During revision surgery on the left ear, an arrosion of the incus' long process was seen and a Causse Large loop prosthesis was positioned in the stapedotomy opening, below the TM with a piece of tragal cartilage. Closure of the air-bone gap and restoration of functional hearing was attained (48 dB PTA) after seven weeks of follow-up.

Discussion

We presented four cases with an uncommon cause of stapes surgery failure with recurrent conductive hearing loss: piston luxation and extrusion through the TM. The extrusion may occur long after the procedure and with different prosthesis types (titanium and/or telfon). Revision surgery was successful in all presented cases and resulted in postoperative ABG within 15 dB (Table 1). No recurrence was encountered after cartilage interposition between the prosthesis and TM.

It is described that revision stapes surgery leads to less favorable hearing results than primary surgery, though still is considerable and clinically relevant hearing gain in most of the cases: postoperative ABG to within 20 dB PTA [8–16]. Severe adverse events and complications seem to occur more often during revision surgery. This might be due to adhesions to the footplate or fibrosis, leading to increased risk of sensorineural hearing loss when opening the previously stapedotomy opening. Also, reduced exposition (bleeding, scar tissue) might interfere with optimal surgical outcome. Therefore, it seems that primary surgery leads to optimal hearing outcome [17]. Table 2 shows an overview of hearing results after revision surgery in large study series. Heterogeneity exists among reported studies concerning e.g. measured

Table 1. Baseline characteristics (left) and hearing results (right) of the included cases.

Baseline characteristics							Hearing results						
Case	Gender (age in years)	Side	Otological history	Primary surgery	Otoscopy	Revision surgery (time after previous surgery) + material used	PTA BC pre (dB)	PTA AC pre (dB)	PTA BC post (dB)	PTA AC post (dB)	ABG pre (dB)	ABG post (dB)	Follow-up[a] (month)
1	F (53)	Right	- SNHL left	Stapedotomy – Causse Teflon Wire	Extrusion piston, partly through posterior quadrant ear drum and dislocated piston on CT (Figure 1A)	Stapedotomy (13 years) – Causse all teflon large loop piston fluorplastic teflon prosthesis 0.6 × 0.6 mm	30	75	30	37.5	45	7.5	31
2[b]	F (48)	Right	– 2014: stapedotomy left	Stapedotomy – Causse Teflon Loop L 4.5mm D 0.4mm	1. Piston in meatus (Figure 2A)	1. Stapedotomy (2 years) – Causse large loop piston L 4.25 D 0.4 mm	27.5	48.75	18.75	26.25	21.25	7.5	12[c]
					2. Piston extrusion, partly through ear drum.	2. Stapedotomy (1 year) – placement tragal cartilage on posterior quadrant of eardrum	23.75	65	23.75	37.5	41.25	13.75	31
3	F (54)	Left	– 2015 Sept. Tympanoplasty left, disconnected incudostapedial joint. Removal of long limb of incus. PORP placement. – 2015 Nov. Re-tympanoplasty left: PORP in situ, stapes intact. Fixation of stapes footplate.	Malleostapedotomy + revision surgery to close fistula	Extrusion piston, almost entirely through ear drum (Figure 2B)	Malleostapedotomy (5 years) – Causse loop piston malleable shaft prosthesis L 12 mm D 0.4 mm – placement tragal cartilage flap on piston-loop	27.5	62.5	42.5	56.25	35	13.75	7
4	M (49)	Left	– 2000 bilateral mixed hearing loss after trauma -> otosclerosis. * Stapedotomy left (2007) and right (2018).	Stapedotomy – Shuknecht Teflon Wire	Piston loop through posterior quadrant eardrum/luxation piston on CT-imaging. (Figure 1B)	Stapedotomy (14 years) – Causse Teflon Large Loop Fluoroplastic large loop piston L 6.0 mm D 0.4 mm – placement tragal cartilage flap on piston	NA	NA	50	53.75	**NA**	**3.75**	5

[a]Period between revision and present. [b]Case 2 underwent two revision surgeries due to a second piston extrusion. Exact similar piston materials were used. In the second revision, a cartilage graft was placed on the posterior quadrant of the eardrum. [c]Period between first revision and second extrusion. PTA: Pure-tone average; BC: Bone conduction; AC: Air conduction; ABG: Air-bone gap; F: Female; M: Male; SNHL: Sensorineural hearing loss; NA: Not applicable. Comparison of pre- and postoperative ABG's show that revision surgery was effective in all cases.

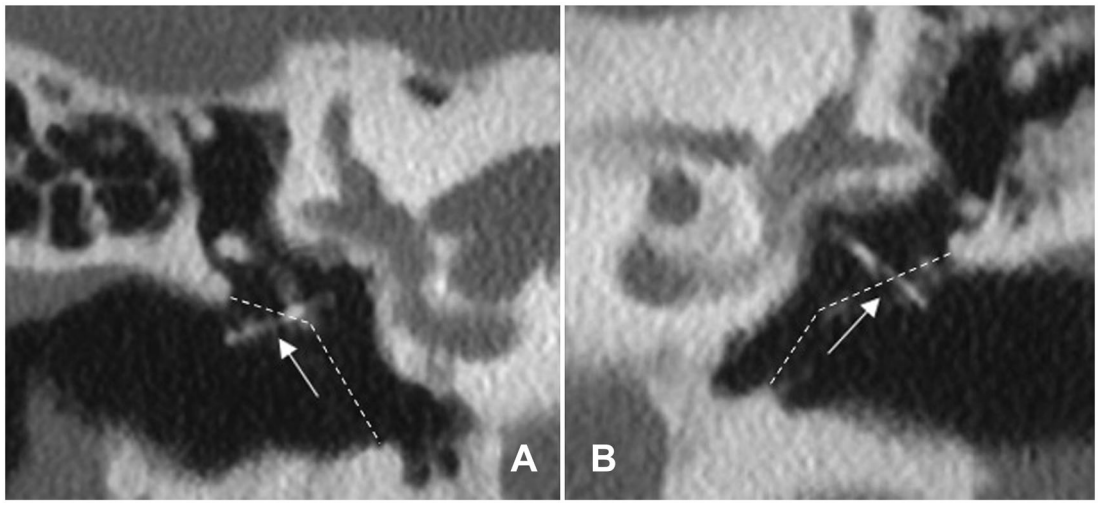

Figure 1. HRCT scan, coronal view Case 1 (A) and Case 4 (B) showing right and left middle ear respectively with luxated piston indicated by white arrows. A: loop is positioned lateral from TM; disconnection from the stapes foot plate. B: loop protruding through the TM, and absence of connection with the stapes foot plate.

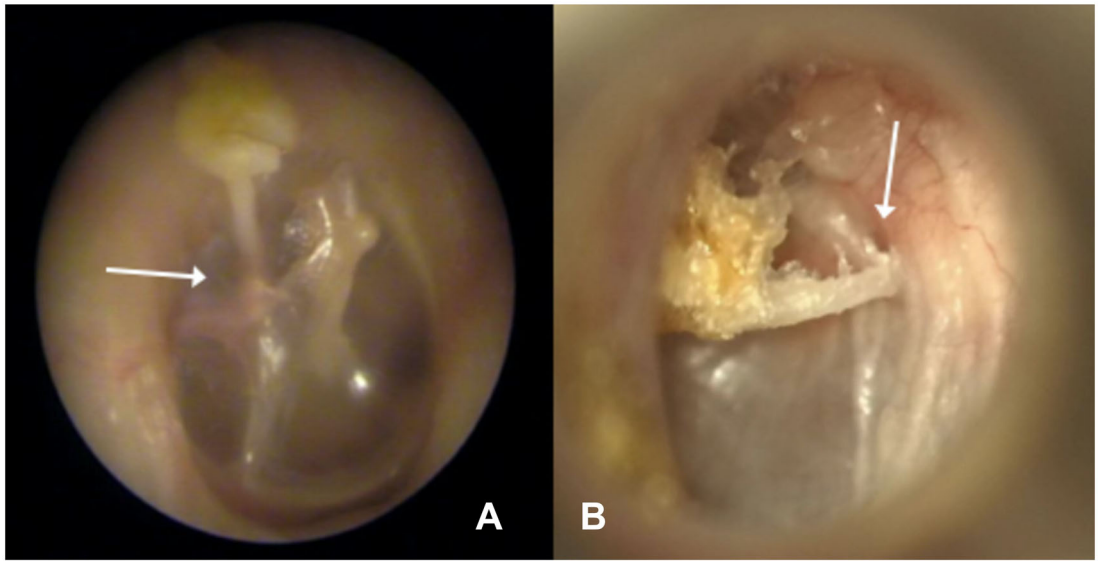

Figure 2. Otoscopy Case 2 (A) and Case 3 (B) showing ear canal with partly extruded piston (white arrows) through the TM.

thresholds (3- or 4-frequency PTA) and different inclusion criteria. The hearing results of the presented study seem to be in line with those from other large tertiary referral centers. In 60% of cases an ABG closure within 10 dB was reached (range of 38–80% between the reported large series) with a follow-up duration of approximately 1.5 years.

Reasons for failure of primary stapes surgery leading to recurrent conductive hearing loss are subdivided in surgeon-, prosthesis-, or disease-related etiologies [7]. Surgeon-related findings include poor prosthesis-incus fixation and incorrect prosthesis length. Regarding prosthesis-related etiologies, long-term hearing loss was mostly caused by incus erosion or necrosis [7]. Sometimes this might be a result from too firmly loop crimping around the incus' long process. Piston extrusion out of the oval window, possibly due to new bone formation, was another described disease-related etiology [10]. Table 2 points out that the most common failure is due to prosthesis displacement, but remarkably, extrusions through the TM as in our cases were not described.

Formerly, these allogenous prosthesis extrusions were mentioned for partial or total ossicular reconstruction prostheses without biocompatible characteristics such as stainless-steel, titanium or polyethylene when in contact with the TM [18,19]. Cartilage interposition decreased this problem, the degree of

Table 2. Outcomes of revision stapes surgery in nine large series between 1997 and 2021 to compare with revision outcome of current study.

Revision stapes surgery outcome				
Author (year)	Operations (n)	Postoperative ABG within 10 dB (%)	Most common causes of failure	Mean follow-up duration (months)
Han et al. [12]	74	45.6	Prosthesis displacement	18.2
Hammerschlag et al. [13]	250	80.4	Prosthesis displacement	7.3
Özüer et al. [14]	84	58	Prosthesis displacement	19
Gros et al. [10]	63	52.4	Prosthesis displacement	6
Babighian et al. [8]	78	53.8	Prosthesis displacement	28
Schmid et al. [15]	166	55	Prosthesis displacement (lateralization)	12
Vincent et al. [9]	652	63.4	Eroded incus	>3
Blijleven et al. [11]	66	38	Incomplete previous surgery	1.75
Schwam et al. [16]	170	40.2	Incus necrosis ± prosthesis displacement	Not reported
Current study	5	60	Piston extrusion through TM	18.5 months

ABG: Air-bone gap.

stiffness of allografts and thereby sound transduction seemed to be more efficient for hearing results. Interposition of a piece of cartilage between the prosthesis and tympanic membrane prevented extrusion during the postoperative course, as nowadays is a generally accepted solution and the mainstay of treatment for (non-otosclerosis) ossicular chain reconstruction, in the UMC Utrecht [19,20]. Patient 2 shows the positive effect of a piece of cartilage in the second revision in contrast to the first revision procedure.

Our hypothesis that the loop of the allogenous prosthesis in contact with the TM led to extrusion after short (12 months) and long term (more than 15 years). Clinical examination, however, did not indicate any signs of chronic Eustachian tuba dysfunction such as a retracted TM. Furthermore, intra-operative findings did not clarify why the prosthesis had been detached. No destruction of the piston was encountered or failure of the material. Moreover, no inflammatory response of the middle ear or TM was established. Interposing cartilage between the TM and prosthesis showed to restore the air conduction threshold.

Future research might focus on microscopic assessment of piston material integrity to gain better understanding of the pathophysiology. As surgical solution we suggest applying a cartilage layer to avoid a re-extrusion and to provide good postoperative hearing results.

Conclusion

Piston extrusion through the TM is a rare cause of stapes surgery failure which may occur long after the procedure and with different piston types. We showed that revision surgery is as successful, and prevention of re-extrusion is reached by interposing a cartilage layer between the prosthesis and TM.

Ethics statement

This study was conducted according to international medical ethical standards and in compliance with the WMA Helsinki declaration (2016) and International Ethics; Local Ethical Board number 21/713.

Patient consent

Patients' approval for the mentioned data is collected.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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