The stability of short-term hearing outcome after stapedotomy: a prospective database study

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Conclusion: Current guidelines recommend reporting short-term results of >12 months after treatment of conductive hearing loss. This study suggests that short-term hearing results after stapedotomy recorded at the 3-month follow-up are without loss of vital information compared with data from the currently recommended >12-month follow-up. The use of 3-month data in reporting outcome could reduce the bias inherent to the loss to follow-up at 12 months.
Objective: To investigate the stability of the short-term post-operative hearing after stapedotomy for otosclerosis.
Method: Prospective database study. 371 cases with otosclerosis were registered in the database between August 2004 and June 2013; we included the 166 primary cases and 37 revision cases that had attended both follow-ups.
Results: The mean changes in post-operative hearing thresholds between the 3-month and 12-month follow-up in both primary and revision cases were minimal and clinically insignificant. 3–5 % of primary cases and 14–16 % of revision cases experienced a change of ≥10 dB for the worse of one or more parameters between follow-ups. Results were also stable when considering a range of traditional success criteria. Other complications following surgery were infrequent and typically resolved long term.

Keywords: *otosclerosis, stapedotomy, hearing, surgical outcome, database.*

Introduction

Few surgical interventions are as successful as stapes surgery and most patients, who are often young or middle-aged adults, achieve substantially better subjective and objective hearing after surgery [1]. Short-term results after surgical treatment of conductive hearing loss including stapes surgery for otosclerosis should be reported after a post-operative follow-up of at least 12 months according to guidelines issued in 1995 by the American Academy of Otolaryngology – Head and Neck Surgery (AAO-HNS) Committee on Hearing and Equilibrium [2]. One of the aims of setting a standard for reporting should be defining the period at which the surgical outcome regarding hearing and complications can be considered stable. However, the recommendation of the current guidelines is based on expert consensus on this issue rather than strong evidence for the lack of a more immediate stability of the surgery.

In our clinical experience the hearing results at the post-operative visit at 3 months are comparable to the results at 12 months. This second follow-up could be an unnecessary use of resources if it does not add information for patients or surgeons. Moreover, many patients consider it inconvenient especially if they are satisfied with the surgery, leading to a large loss to follow-up that reduces the power of the 12-month results.

The aim of this study was to use a prospective stapes surgery database to compare 3-month and 12-month post-operative hearing results and complications in order to determine the need for the 12-month follow-up visit after stapedotomy. Our hypothesis is that the post-operative outcome after stapedotomy for otosclerosis is stable at 3 months and the need for long-term follow-up is minimal for most patients.

Material and methods

Database

The stapes surgery database is designed specifically for the prospective registration of outcome in stapes surgery and was developed by the senior author MSS as a separate branch of the previously reported OTOKIR database [3]. The stapes surgery database runs in MS-Access (Microsoft, Redmond, WA, USA) and works in much the same way as the OTOKIR database: data is entered by the surgeon peroperatively and at follow-ups at 2-6 months and >12 months. Interruption from follow-up due to early revision is recorded to avoid bias in reporting the outcome [3]. Minimal manual data entry is supported by easy import of audiometric data from the local AuditBase5 system (AuditData, Taastrup, Denmark) by an SQL routine. The database automatically calculates and reports pure-tone averages (PTA) for bone conduction (BC), air conduction (AC) and air-bone gap (ABG) according to the AAO-HNS guidelines [2]. If the hearing threshold at 3 kHz is not

measured (Scandinavian audiometric consensus includes 2 and 4, but not 3 kHz), the database automatically calculates it as the average of the hearing thresholds at 2 and 4 kHz and logs this as a calculated value [4].

Case selection and analysis

We extracted cases with the diagnosis of otosclerosis operated between August 2004 and June 2013 with audiometric data recorded pre-operatively, at the 3-month follow-up (follow-up between 2–6 months) follow-up and at the 12-month follow-up (follow-up of 12 months or more). The cases were all operated by one of three experienced stapes surgeons at our department. Cases of primary surgery were operated trans-canal in general anesthesia with 532 nm diode-laser stapedotomy. In almost all cases only gel-foam was used in the stapes niche and cases received either a Nitinol-SMart or flourplastic-platinum prosthesis according to surgeon preference. Revision surgery was done in a similar way as re-stapedotomy (70 %), malleo-stapedotomy (24 %) or as exploration only (5 %).

Cases were analyzed according to primary or revision surgery as registered by the database with supplemental subgroup analyses for primary cases according to prosthesis type and revision cases according to type of surgery. Mean PTA of ABG (½,1, 2 and 3 kHz) and of AC (½,1, 2 and 3 kHz) as well as speech-reception threshold (SRT) pre-operatively, at short-term (2–6 months follow-up) and at the long-term (>12 months, typically 12-15 months) follow-up, was calculated and reported with SD and 95 % confidence intervals (CI) according to the AAO-HNS guidelines [3]. The change in ABG, AC and SRT between short-term and long-term follow-up was plotted and a change of 10 dB or more considered being clinically significant. Status of vertigo, tinnitus, the facial nerve and the chorda tympani pre- and post-operatively, as well as post-operative complications (perforations, infection and anacusis) were also analyzed.

The data were analyzed using Excel 2011 for Mac OS X (Microsoft, Redmond, WA, USA) and SPSS (SPSS Inc., Chicago, IL) version 21 for Mac OS X was used to analyze changes between follow-ups using paired t-test, and differences between included and excluded cases and sub-group analyses using independent samples t-test and ANOVA.

Results

A total of 381 cases of stapes surgery were registered in the database including cases of both primary and revision stapes surgery. The mean age was 44.5 years and 65 % of all cases were female. Including only the 371 cases of otosclerosis, there were 303 cases of primary surgery and 68 revision cases. Of these cases, 166 primary cases and 37 revision cases had attended both

follow-ups with audiometry and were included for further study. No statistically significant differences were found regarding age, gender or pre-operative hearing thresholds between included and excluded cases (Table I). There was some loss to follow-up: 64 cases (17.3 %) did not attend the 3-month follow-up, 95 cases (25.6 %) did not attend the 12-month follow-up, and 65 cases (17.5 %) had not yet reached time for the long-term follow-up (using 15 months as cut-off).

The hearing outcome after primary stapedotomy and revision surgery is presented in Table II. A considerable change is found between pre-operative hearing thresholds and post-operative thresholds as expected. Revision cases were found to have inferior pre-operative and post-operative hearing thresholds compared with primary cases. The mean change in hearing thresholds between 3-months and 12-months follow-up was found to be minimal for primary cases with a slight improvement at 12 months. The type of prosthesis did not significantly affect outcome except for SRT at 12-months, which was better for the NitinolSMart prosthesis ($p<0.005$)(supplemental material, Table S-I). For revision cases, the mean change between follow-ups was also minimal and without statistical significance (Table II). As expected, more complex cases of revision surgery with malleo-stapedotomy had a significantly poorer outcome regarding AC and ABG than revision surgery with stapedotomy alone (supplemental material, Table S-II).

We plotted the hearing thresholds at 12 months post-operative against the corresponding hearing thresholds at 3 months for ABG, AC and SRT (Figure 1A–C) and found that only few cases experienced a change of 10 dB or more between follow-ups. We therefore analyzed the change between follow-ups in increments of 10 dB (Table III). An absolute change in hearing thresholds between follow-ups of less than 10 dB was found for 93.4 % of cases of primary stapedotomy when considering the AC, 89.8 % when considering the ABG and 84.8 % when considering the SRT. In addition, a majority of the cases with a change of 10 dB or more had a change between follow-ups for the better; only between 3.0–4.8 % of all cases had a change for the worse across one or more of the audiometric measures. Similarly for revision cases; the majority had a change between follow-ups of less than 10 dB—ranging between 73.0–83.3 % of cases depending on the outcome measure—with 13.5–16.2 % of cases having a change for the worse between follow-ups.

The success of surgery and changes according to different success criteria between the follow-up at 3 months and 12 months are presented in Table IV. Success was defined as post-operative hearing thresholds with ABG≤10 dB, ABG≤20 dB, AC≤30 dB, SRT≤30 dB or the Belfast Rule of Thumb (AC≤30 dB or inter-aural difference≤15dB). For primary cases the success rate across the different criteria ranged between 78.9–95.2 % and for revision cases between 40.5–81.1 %. This was stable between follow-ups regardless of success criterion with only a minimal change for the

better or worse between the short-term and long-term follow-up ranging from 1.2–6.6 % of primary cases and 0.0–16.2 % of revision cases.

Post-operative complications and changes between follow-ups are summarized in Table V. Post-operative-onset tinnitus and chorda tympani defects (dysgeusia) were the most common complications with an incidence of 4.8 % and 13.8 %, respectively, in primary surgery and 5.4 % and 8.1 %, respectively, in revision surgery. In most cases, complications had resolved by the long-term follow-up and only 5 cases in total had a change for the worse or had new complications arising between follow-ups. Even though a few patients experienced post-operative tinnitus, it should also be noted that of the 106 patients undergoing primary surgery who had pre-operative tinnitus, 74 (69.8 %) had no tinnitus or a markedly better level of tinnitus at the 12-month post-operative follow-up.

One patient had a facial nerve branching around the stapes footplate and suffered a partial palsy at 3 months, which was completely resolved by the 12-month follow-up. Out of the total of 381 cases found in the database, there were three cases of postoperative anacusis (0.79 %): two cases after primary stapedotomy and one following revision malleo-stapedotomy. In all these cases, anacusis presented before 3 months and did not resolve but because these patients had no 12-month follow-up record they were not included in this study and are not found in Table V.

Discussion

In this prospective database study comparing the short-term post-operative hearing results after stapedotomy for otosclerosis, we found that the hearing outcome for the majority of patients was stable between the 3-month and 12-month follow-up across different audiometric parameters and success criteria and independent of prosthesis type. Further, post-operative complications mostly resolved at 12 months with few patients experiencing a change for the worse or a new complication between follow-ups.

Although prospective studies on the outcome of stapes surgery are scant, some outstanding and large database studies exist. In a leading clinic, the Otology-Neurotology database was used to record 3,050 cases of stapedotomy and found surgery to be safe and effective in treating hearing loss from otosclerosis [1]. Adhering to the AAO-HNS guidelines, only the long-term results of 12 months or more were presented—and the short-term stability is therefore unreported in this series. Some cases were followed up for up to 164 months and the very long-term decline in hearing was not found to exceed the rate of hearing loss attributable to presbyacusis [1]. The loss to follow-up at >12 months was a considerable 43.8 %.

The International Common Otology Database is a multi-center audit database, and a report on the outcome of 660 procedures similarly found stapes surgery to be effective [5]. Both the 3-month and 12-month results were reported, albeit not further analyzed or compared. The mean change between follow-ups appears to be without clinical significance, but more details, for example on the number of patients with a change for the better or the worse between follow-ups, would be needed for any conclusions on the stability of surgery from these data. The loss to follow-up was 7.9 % at 3 months, which is lower than in our study. In contrast, a higher loss to follow-up of 64.7 % was found at >12 months. Additionally, it was reported that a consistent and high-quality input to the database by the contributing surgeons was difficult to maintain [6]. The database was also used to study dysgeusia (defect of chorda tympani) after surgery, reporting an incidence of up to 39 % at 3 months and 27 % at 6 months, demonstrating that dysgeusia often resolves over time [6]. The incidences were lower in the nerve-preserving group and comparable to the incidences in our study.

Both of these prospective database studies report a considerable hearing gain after stapes surgery. The Common Otology Database finds for primary stapes cases a mean threshold of ABG of 28.4 dB pre-operatively and 8.8 dB post-operatively and a mean gain in AC of 25.0 dB [5]; the Otology-Neurotology database finds for primary stapes cases mean thresholds of ABG of 25.6 dB pre-operatively and 1.7 dB post-operatively and of AC of 51.4 dB pre-operatively and 27.2 dB post-operatively (24.2 dB gain in AC) [1]. These results are similar to our results with thresholds for primary cases of ABG of 25.7 dB pre-operatively and 6.9 dB post-operatively and of AC of 48.1 dB pre-operatively and 22.3 dB post-operatively (25.8 dB gain in AC).

Several retrospective studies [7-18] also report significant improvement in hearing following stapes surgery and a very long-term decline in hearing after surgery but none reports on the immediate stability of surgery. The retrospective studies have various time-schedules for follow-up and some report only short-term results of <12 months [7, 8] or do not distinguish between different lengths of short-term follow-up [9]. In addition, retrospective studies are at a greater risk of selection bias, further complicating comparisons and interpretation of results [4].

Our study has some strengths and limitations: First of all, the database used is prospective and has a single entry of both preoperative and postoperative surgical data by the surgeons themselves. In addition, the database features automated import of audiometric data from the local audiometric database server. Both ensure a high quality and completeness of the data entered. Next, our database has only cases contributed by the three stapes surgeons at our institution, which limits the number of cases available for analysis; nevertheless, we found even sub-clinical levels of changes between follow-ups to be statistically significant, suggesting sufficient data for the purpose of this

study. Finally, loss to follow-up remains an issue and the considerable loss to follow-up in our study is similar to that of other prospective database studies.

Defining when the surgical outcome can first be considered stable—the immediate stability—is relevant, as reports on middle ear surgery should consider the post-operative hearing at a stable level before the onset of a long-term decline in hearing for reasons unrelated to surgery such as presbyacusis. We found hearing to be stable and complications such as post-operative-onset tinnitus and defects of chorda tympani to be less stable but often resolving rather than progressing from 3 to 12 months. Therefore, stapes surgery can be considered stable already at the short-term follow-up at 3 months as the hearing status at this point in most cases reflects the final outcome of surgery. This finding could have implications for future reports as the short-term follow-up can safely be used for reporting and suggest that studies with different follow-up schedules may be comparable.

Our findings seem to question the need for routinely scheduled follow-ups after the first follow-up visit at 3 months. Long-term follow-up has several disadvantages for example the considerable amount of resources (time, facilities, equipment, support) used at each follow-up visit for clinical examination and audiometry, and the inconvenience to the patients, especially if the follow-up visit is perceived as pointless after successful surgery. This leads to a large loss to follow-up illustrated by the prospective studies. The loss to follow-up reduces the informational value of the long-term data and thereby the reliability of the conclusions drawn. Moreover, the 1-year requirement of the AAO-HNS guidelines may discourage or exclude some clinics from reporting valuable 3-month data and in this respect the extended criteria may illustrate how ‘perfect is the enemy of good’.

If the routine long-term follow-up can be defaulted, the question of which patients to schedule for long-term follow-up then arises. Our current study is limited by sample-size, making further sub-group analyses of this question of limited use and requiring further and larger studies to adequately investigate this. However, based on our findings, the vast majority of patients experience no change or a change for the better and a suggestion could therefore be to disregard the routine long-term visit and instead request patients to make a follow-up visit as needed, for example if they notice a decline in hearing during the following year. Obviously, patients with severe complications, such as facial nerve paralysis, should receive extended follow-up. However, our findings also suggest that revision cases with stapedotomy only should not. Finally, it should be considered when introducing new techniques and new prostheses and materials that patients should receive longer follow-up to evaluate the safety and efficacy of the new interventions.

Conclusion

We found that hearing after stapes surgery with stapedotomy was stable in this prospective database study: a majority of patients had a change of less than 10 dB for different hearing parameters between the 3-month and 12-month follow-up. The few patients who experienced a change in hearing between follow-ups were equally likely to experience a change for the better. The current guidelines recommend reporting long-term results of >12 months after treatment of conductive hearing loss, but our findings suggest that 3-month results of stapes surgery could be used instead. The 12-month follow-up seems to add little new value, only costs and could be defaulted for most cases of stapes surgery. In addition, the large loss to follow-up at >12 months introduces a potential bias, which can be reduced by using the more complete data obtainable at the 3-month follow-up, where loss to follow-up is less.

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Table I. Characteristics of patients with complete audiometry at both follow-ups (included cases) and patients not attending one or both follow-ups or missing audiometry (excluded cases).

	Complete audiometry at both follow-ups *n=203*		**Non-attenders/missing audiometry** *n=168*		
	Mean	SD	Mean	SD	Significance
Age, years	44.6	11.4	44.7	12.7	ns
Gender					
Male, n	71 (35.0 %)		60 (35.7 %)		ns
Female, n	132 (65.0 %)		108 (64.3 %)		
Pre-operative hearing thresholds					
AC, dB	49.5	13.8	50.6	13.4	ns
ABG, dB	26.1	10.7	27.3	10.6	ns
SRT, dB	45.2	12.2	44.7	12.4	ns

Table II. Hearing outcomes in primary stapedotomy (n=166 cases) and revision stapes surgery (n=37 cases)

		Mean (dB)	SD	95 % CI	Change in mean between short term and long term follow-up
Primary stapedotomy					
ABG	pre-operative	25.7	10.0	(24.2–27.2)	
	3 mo follow-up	7.1	7.0	(6.0–8.2)	-0.2, p=ns
	12 mo follow-up	6.9	6.7	(5.9–7.9)	
AC	pre-operative	48.1	12.4	(46.2–49.9)	
	3 mo follow-up	23.4	11.5	(21.6–25.1)	-1.1, p<0.05
	12 mo follow-up	22.3	12.2	(20.5–24.2)	
SRT	pre-operative	44.3	10.8	(42.7–45.9)	
	3 mo follow-up	19.5	10.6	(17.9–21.2)	-2.0, p<0.002
	12 mo follow-up	17.6	10.8	(15.9–19.2)	
Revision surgery					
ABG	pre-operative	27.8	13.7	(23.4–32.3)	
	3 mo follow-up	12.1	7.5	(9.7–14.6)	1.7, p=ns
	12 mo follow-up	13.8	11.8	(10.0–17.7)	
AC	pre-operative	55.4	18.1	(49.5–61.2)	
	3 mo follow-up	36.8	17.8	(31.0–42.5)	2.5 p=ns
	12 mo follow-up	39.2	20.2	(32.7–45.8)	
SRT	pre-operative	48.9	16.8	(43.5–54.3)	
	3 mo follow-up	30.7	17.5	(25.0–36.3)	-0.1, p=ns
	12 mo follow-up	30.5	18.6	(24.6–36.5)	

Table III. Change in 10 dB increments between follow-up at 3 months and 12 months.

		Change in AC		Change in ABG		Change in SRT	
		Cases, n	%	Cases, n	%	Cases, n	%
Primary surgery, n=166							
	< -30 dB	1	0.6	1	0.6	2	1.2
Change for the better	[-29 dB;-20 dB]	0	0.0	0	0.0	2	1.2
	[-19 dB;-10 dB]	5	3.0	8	4.8	15	9.1
No change	[-9 dB;9 dB]	155	93.4	149	89.8	139	84.8
	[10 dB;19 db]	2	1.2	6	3.6	4	2.4
Change for the worse	[20 dB;29 dB]	2	1.2	1	0.6	2	1.2
	> 30 dB	1	0.6	1	0.6	0	0.0
Revision surgery, n=37							
	< -30 dB	0	0.0	0	0.0	0	0.0
Change for the better	[-29 dB;-20 dB]	0	0.0	0	0.0	1	2.7
	[-19 dB;-10 dB]	1	2.7	1	2.8	4	10.8
No change	[-9 dB;9 dB]	30	81.1	30	83.3	27	73.0
	[10 dB;19 db]	5	13.5	3	8.3	3	8.1
Change for the worse	[20 dB;29 dB]	1	2.7	2	5.6	2	5.4
	> 30 dB	0	0.0	0	0.0	0	0.0

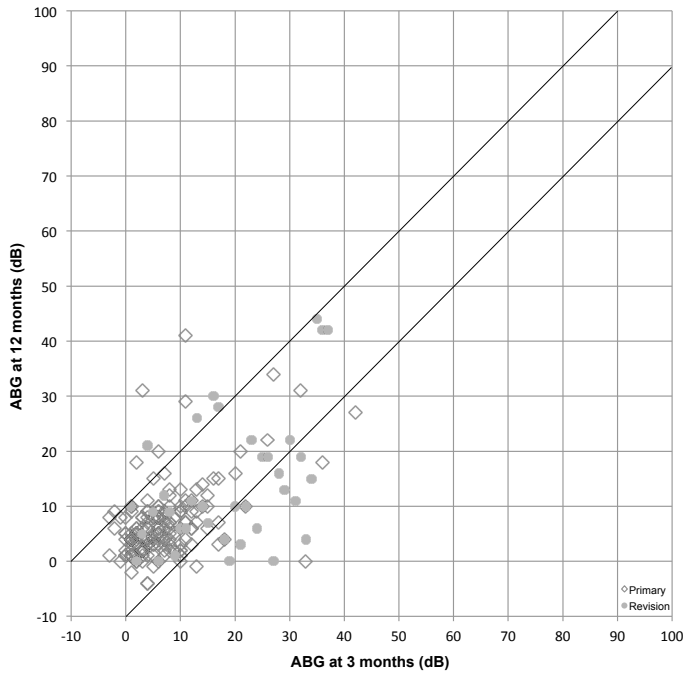
Table IV. Change between follow-up at 3 months and 12 months in different hearing success criteria.

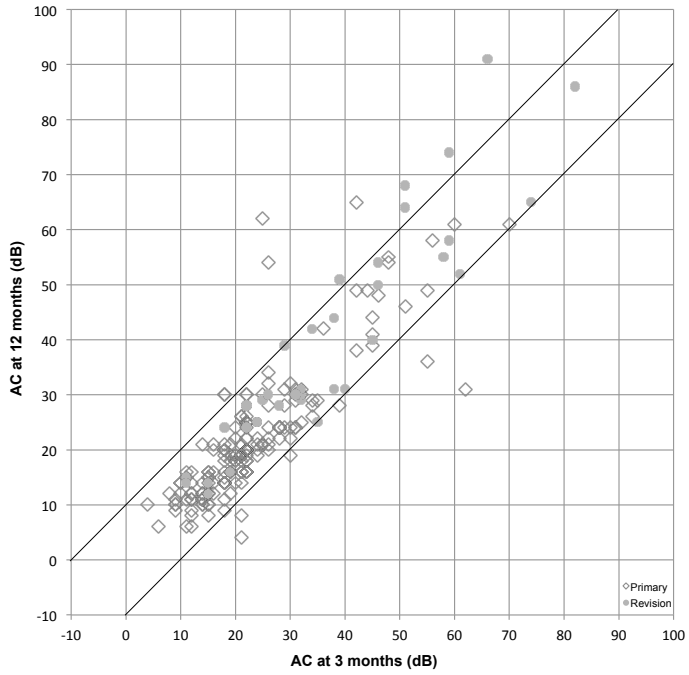
	Success criteria				
	ABG<=10dB	ABG<=20dB	AC<=30dB	SRT<=30dB	Belfast Rule of Thumb
Primary surgery, n=166					
Success at 3 months	131 (78.9 %)	158 (95.2 %)	135 (81.3 %)	151 (92.1 %)	151 (91.0 %)
Success at 12 months	141 (84.9 %)	159 (95.8 %)	140 (84.3 %)	152* (92.7 %)	149 (89.8 %)
No change between follow-ups	138 (83.1 %)	159 (95.8 %)	149 (89.8 %)	157 (95.7 %)	150 (90.4 %)
Change for the better	19 (11.4 %)	4 (2.4 %)	11 (6.6 %)	5 (3.0 %)	7 (4.2 %)
Change for the worse	9 (5.4 %)	3 (1.8 %)	6 (3.6 %)	2 (1.2 %)	9 (5.4 %)
Revision surgery, n=37					
Success at 3 months	20 (54.1 %)	30 (81.1 %)	15 (40.5 %)	23 (62.2 %)	25 (67.6 %)
Success at 12 months	19 (51.4 %)	28 (75.7 %)	18 (48.6 %)	23 (62.2 %)	27 (73.0 %)
No change between follow-ups	26 (70.3 %)	35 (94.6 %)	32 (86.5 %)	31 (83.8 %)	33 (89.2 %)
Change for the better	5 (13.5 %)	0 (0.0 %)	4 (10.8 %)	3 (8.1 %)	3 (8.1 %)
Change for the worse	6 (16.2 %)	2 (5.4 %)	1 (2.7 %)	3 (8.1 %)	1 (2.7 %)

*2 cases did not have SRT measured at 12 months

Table V. Cases with complications registered at 3 months and status of complications at 12 months.

	Status at 3 mo	Status at 12 mo			
		no change	change for better	change for worse	notes
Primary surgery, N 166					
Newly onset vertigo	0	0	0	0	
Newly onset tinnitus	8	0	7	0	1 status unknown at 12 mo
Facial nerve paralysis	1	0	1	0	
Anacusis*	0	0	0	0	*see results, final paragraph
Chorda defect	23	3	20	3	3 new defects registered at 12 mo
Post-operative infection	2	0	2	0	
Perforation	1	0	0	0	
Revision surgery, N 37					
Newly onset vertigo	0	0	0	1	1 new case at 12 mo
Newly onset tinnitus	2	0	2	1	1 new case at 12 mo
Facial nerve paralysis	0	0	0	0	
Anacusis	0	0	0	0	
Chorda defect	3	0	2	0	1 status unknown at 12 mo
Post-operative infection	0	0	0	0	
Perforation	1	1**	0	0	**scheduled for tympanoplasty due to perforation





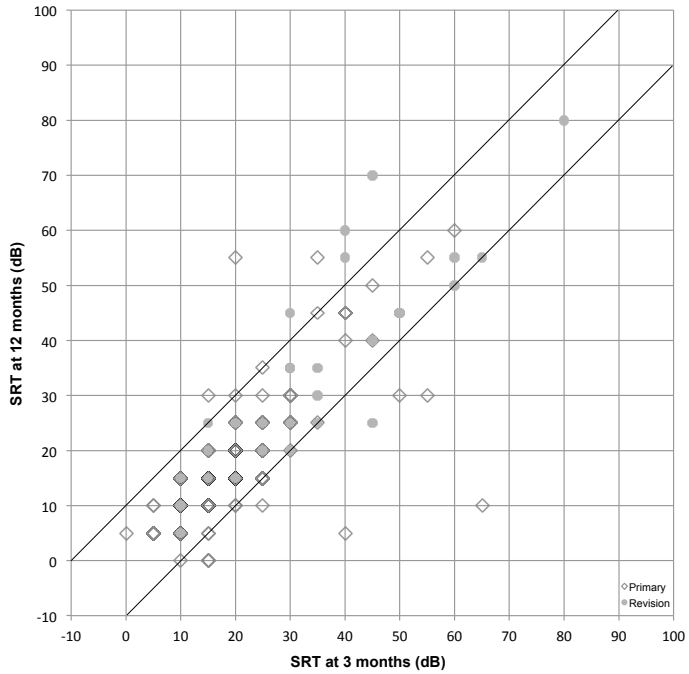


Figure 1A-C. Hearing thresholds at 12 months post-operative plotted against the corresponding hearing thresholds at 3 months postoperative for A) air-bone gap, B) air conduction and C) speech reception threshold. The diagonal lines enclose the area where the change in hearing thresholds is within 10 dB. Points below the lower diagonal line expresses change for the better between the short-term and long-term follow-up whereas points above the upper diagonal line expresses change for the worse between follow-ups.

SUPPLEMENTAL TABLES

Table S-I. Hearing outcomes in primary stapedotomy. Sugroup analysis by prosthesis type.

		Mean (dB)	SD	95 % CI	Change in mean between short term and long term follow-up
Flourplastic-platinum prosthesis (n=35)					
ABG	pre-operative	24.0	7.6	(21.4–26.6)	
	3 mo follow-up	8.0	8.9	(4.9–11.0)	-0.09, p=ns
	12 mo follow-up	8.1	9.4	(4.8–11.3)	
AC	pre-operative	47.7	11.3	(43.9–51.6)	
	3 mo follow-up	26.1	13.1	(21.6–30.6)	0.6, p=ns
	12 mo follow-up	25.5	11.5	(21.6–25.1)	
SRT	pre-operative	44.0	10.3	(40.4–47.6)	
	3 mo follow-up	23.3	13.6	(18.2–27.9)	1.2, p=ns
	12 mo follow-up	22.5	13.8	(17.7–27.3)	
NitinolSMart prosthesis (n=131)					
ABG	pre-operative	26.1	10.5	(24.3–28.0)	
	3 mo follow-up	6.8	6.4	(5.7–8.0)	0.3, p=ns
	12 mo follow-up	6.6	5.9	(5.6–7.6)	
AC	pre-operative	48.1	12.7	(45.9–50.3)	
	3 mo follow-up	22.7	11.0	(20.8–24.6)	1.2, p=0.04
	12 mo follow-up	21.4	11.5	(19.5–23.5)	
SRT	pre-operative	44.4	10.9	(42.5–46.3)	
	3 mo follow-up	18.5	9.4	(16.9–20.2)	2.3, p<0.001
	12 mo follow-up	16.3	9.6	(14.6–17.9)	

Table S-II. Hearing outcomes in revision stapedotomy. Subgroup analysis by type of surgery.

		Mean (dB)	SD	95 % CI	Change in mean between short term and long term follow-up
Stapedotomy (n=26)					
ABG	pre-operative	26.7	12.9	(21.4–32.0)	
	3 mo follow-up	10.2	6.0	(7.8–12.6)	0.4, p=ns
	12 mo follow-up	9.8	7.5	(6.7–12.8)	
AC	pre-operative	52.3	18.4	(44.9–59.8)	
	3 mo follow-up	33.4	16.9	(26.6–40.2)	-0.7, p=ns
	12 mo follow-up	34.1	17.0	(27.2–41.0)	
SRT	pre-operative	47.5	18.2	(40.1–54.9)	
	3 mo follow-up	28.3	17.5	(21.2–35.3)	0.8, p=ns
	12 mo follow-up	27.5	17.2	(20.6–34.4)	
Malleo-stapedotomy (n=9)					
ABG	pre-operative	32.3	15.7	(20.2–44.4)	
	3 mo follow-up	16.3	8.9	(9.5–23.2)	-5.9, p=ns
	12 mo follow-up	22.2	16.2	(9.7–34.7)	
AC	pre-operative	64.0	17.4	(50.6–77.4)	
	3 mo follow-up	43.9	20.1	(28.5–59.3)	-5.9, p=ns
	12 mo follow-up	49.8	24.9	(30.7–68.9)	
SRT	pre-operative	53.3	13.7	(42.8–63.9)	
	3 mo follow-up	33.9	18.0	(20.1–47.7)	-2.8, p=ns
	12 mo follow-up	36.7	22.9	(19.1–54.3)	