

# Outcome of stapes surgery for tinnitus recovery in otosclerosis

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## Abstract

**Introduction:** Stapes surgery is mainly used to improve hearing in otosclerosis; however, many patients report alleviation of tinnitus after surgery. **Objective:** to evaluate the effectiveness of stapes surgery for improving tinnitus symptoms. **Materials and Methods:** This prospective study included 29 patients with surgically proven otosclerosis, who had undergone stapedectomy or stapedotomy. We compared symptomatic (tinnitus, hearing loss, and vertigo) and audiological findings obtained before and after surgery. Using Newman's method the level of discomfort caused by tinnitus was scored from grade I to V pre- and postoperatively. **Results:** The mean preoperative tinnitus discomfort grade was 2.72, at day 1 after surgery it was 1.29, and after 1 month it had decreased to 0.96, indicating a significant improvement in the level of tinnitus discomfort ( $p < 0.0001$ ). One month after surgery 82.8% of patients had a complete or partial absence of tinnitus. **Conclusion:** We conclude that stapes surgery is quite effective for treatment of tinnitus as well as improvement of hearing. When deciding upon management in patients with otosclerosis the presence of tinnitus should be considered as well as hearing level.

**Keywords:** otosclerosis, stapes surgery, tinnitus.

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## INTRODUCTION

Otosclerosis is a common cause of progressive hearing loss in patients with an intact tympanic membrane. Dizziness and balance problems are a feature of otosclerosis in roughly 25% of cases. In addition, 40 to 55% of patients complain of subjective tinnitus. The pathological process underlying the disease is an inflammatory lysis and remodeling of the bony labyrinth and a variety of etiologies such as genetic, vascular, viral (especially Measles), and hormonal factors are believed to play a role in the development of the condition. It affects 1% of Caucasians and is more prevalent in females. Patients are frequently between 15 to 50 years old on presentation and one half of patients also have a positive family history of the disease<sup>1-4</sup>.

Several treatment options such as hearing aids, fluoride, biphosphonates, and stapes surgery are available<sup>1</sup>. Stapes surgery includes various techniques to replace fused parts of the stapes. The technique has been shown to improve hearing, is well established with a long history, and has been proven to be effective in several studies. Although surgery is not traditionally indicated for treating tinnitus alone, many patients report alleviation of tinnitus after surgery<sup>5-15</sup>.

The goal of this study was to determine the incidence of tinnitus, and its discomfort level in otosclerosis patients, using the Newman method<sup>16</sup>, and to evaluate the effectiveness of stapes surgery for improving tinnitus as well as hearing levels.

## MATERIALS AND METHODS

This prospective study included 29 patients with otosclerosis aged between 13 and 65 years old. The study protocol was approved by the ethics committee of Mashhad University of Medical Sciences and informed consent was obtained from all patients. The requirement for surgery was based on hearing loss, not the presence of tinnitus. All stapes surgeries were performed from 2008 to 2010 by two attending surgeons. The exclusion criteria were previous stapes surgery on the same ear and unconfirmed stapedius fixation during surgery. Patients' data, including age, gender, family history of otosclerosis, and the occurrence of vertigo, were recorded in a checklist.

Stapes surgery was performed under general anesthesia in 12 patients and local anesthesia in 18 patients depending on the patient's or surgeon's preference. Stapedectomy was performed in 4 cases and 25 patients underwent stapedotomy, where the same technique was used for all procedures. A total of 25 Teflon-piston and 4 titanium (Big Easy) prostheses, one of which was offset (inclined), were used in this study.

Before and after the surgery standard audiometry including speech recognition threshold (SRT), speech discrimination score (SDS), air bone gap (ABG), pure tone average for air conduction (AC) and bone conduction (BC) at 4 frequencies (0.5, 1, 2, 4 kHz), and a tympanogram were performed in all patients. The level of discomfort caused by tinnitus was graded using Newman's method with scores from grade I to V. Follow-up visits were conducted on the first day, the end of the first week, and the end of the first month after surgery and the patients were asked about tinnitus and vertigo. The grade of tinnitus present was determined at each of the post-operative visits and postoperative audiometry was done one month after surgery.

Statistical analysis was performed using SPSS (Version 13). Fisher's Exact test and Student's paired *t*-test were used to compare hearing levels and tinnitus discomfort levels before and after surgery. We evaluated the association of presumed risk factors with the outcome of surgery on tinnitus using Pearson's correlation and Student's independent *t*-test. A *P*-value of less than 0.05 was considered significant.

## RESULTS

A total of 29 patients with a mean age of 39 years (range: 13-65) were included in the study, 20 were female and 9 were male. Four patients had a family history of otosclerosis in their first degree relatives. One patient had pure conductive hearing loss and all others had a concomitant bone conduction deficit to some extent (mixed hearing loss). In 16 patients hearing loss was bilateral and we selected the ear with the worst hearing for stapes surgery. Before the procedure all patients had negative Rinne tests at 512 Hz in the ear selected for surgery.

Tinnitus was present in 26 patients (89.7%) before surgery. According to Newman's grading method, 2 patients had grade I tinnitus, 4 patients had grade II, 11 patients had grade III, and 9 patients had grade IV tinnitus. None of the patients had grade V discomfort caused by tinnitus. Grade IV and V tinnitus is considered to be severe disabling tinnitus and 9 cases were included in this group; the other 17 patients with tinnitus had mild to moderate discomfort. There was no significant association between tinnitus severity and other parameters such as age, sex, and family history of otosclerosis. Furthermore, the patients' levels of tinnitus discomfort were not associated with their preoperative hearing levels (SRT, ABG, and AC) (Table 1).

On the first day after surgery, tinnitus was aggravated in 3 patients, unchanged in 5 patients, and improved in 21 patients. One week after surgery tinnitus was worsened in one patient, unchanged in 5 patients, and improved in 23 patients in comparison with the preopera-

**Table 1.** Correlation between tinnitus severity and presumed risk factors.

	K <sup>2</sup>	t	p-value
Sex	6.34		0.18
Family history of otosclerosis	4.74		0.32
Age		0.5	0.62
Preop SRT		0.22	0.825
Preop AC		1.18	0.25
Preop ABG		0.07	0.62

tive status. On the third visit, one month after surgery, 24 patients had complete or partial recovery (82.8%) from tinnitus and in 5 patients their tinnitus remained unchanged. The recovery from tinnitus discomfort after surgery is shown in Table 2.

Interestingly, 2 of the 3 patients who did not have tinnitus before surgery experienced a short episode of tinnitus postoperatively which disappeared completely within one month of surgery. The mean grade of discomfort caused by tinnitus was 2.72 before surgery, which decreased to 1.29 on the first day after surgery, 1.11 at the end of the first week, and 0.96 at the end of the first month. This improvement in tinnitus symptoms is statistically significant ( $p < 0.0001$ ). The improvement in the grade of tinnitus discomfort in the 9 patients with the severely disabling form (grade IV) was significantly greater than that observed in the patients with mild to moderate tinnitus (a decrease of 2.65 vs. 1).

Moreover, in the two groups the hearing improvement was almost similar, i.e. the changes in hearing parameters did not show significant differences.

Before surgery 3 patients (10.3%) had true vertigo. Vertigo happened during the surgery in 9 out of the 18 patients who did not receive general anesthesia. In the first day after the operation, 2 patients had severe vertigo which required medical therapy and another 13 patients reported mild vertigo. At the follow-up visit after one week 12 patients suffered from mild vertigo. One month after surgery 3 patients had mild vertigo and the rest of them had no balance complaints.

The mean of the pre- and post-operative SRT, ABG, AC, and BC results are presented in Table 3. Post-operative SRT, mean AC threshold, and ABG were significantly reduced one month after surgery ( $p < 0.001$ ), indicating an improvement in hearing, but the changes in SDS and BC thresholds were not significant.

**Table 2.** Course of tinnitus after Stapes surgery.

	Complete recovery	Partial recovery	Unchanged	Worsening
1st postop day	5 (17.2%)	16 (55.2%)	5 (17.2%)	3 (11.40%)
1st postop week	7 (24.1%)	16 (55.2%)	5 (17.2%)	1 (3.5%)
1st postop month	16 (55.2%)	8 (27.6%)	5 (17.2%)	0

**Table 3.** Hearing level before and after Stapes surgery.

	Pre-op Audiometry	Post-op Audiometry
SRT	58.8	38.83
SDS	93.1	95.8
ABG	32.38	13.75
Mean air conduction	56.18	34.83
Mean bone conduction	24.1	20.95

SRT: Speech reception threshold; SDS: Speech discrimination score; ABG: Air bone gap.

## DISCUSSION

Progressive conductive hearing loss is the major clinical symptom of otosclerosis. Patients with otosclerosis often also suffer from subjective tinnitus that can be severe and disabling. In this study, tinnitus was present in 89.7% of our otosclerosis patients, 31% of whom suffered from severe disabling tinnitus. Similarly, Ayache reported the presence of tinnitus in 74% of otosclerosis patients, 24.6% of whom had severe disabling tinnitus<sup>5</sup>. In studies by Oliveira and Del Bo, 91% and 56% of patients, respectively, were reported to be annoyed by tinnitus<sup>6,17</sup>. In our study 3 patients did not complain of tinnitus before surgery, in 2 of them tinnitus ensued after surgery but was completely resolved within one month. In Del Bo's study tinnitus started in 7% of patients postoperatively, contrary to Ayache, who reported *no* similar cases<sup>5,17</sup>.

One month following surgery we observed that complete recovery from tinnitus had occurred in 65.5% of patients and a partial improvement in 17.2% of patients. Tinnitus status in 5 patients remained unchanged and none of them worsened after surgery. All previous studies on the subject have also indicated the occurrence of a significant improvement in tinnitus discomfort after stapes surgery. A summary of these articles is presented in Table 4. The studies differ in follow-up duration and methods for measuring the level of tinnitus discomfort. For example, Sobrinho stated that there was no change in tinnitus status 2 years after surgery in comparison to early postoperative results<sup>12</sup>. Also, according to Szymanski, tinnitus status after surgery is unrelated to the length of follow-up<sup>10</sup>.

In this study discomfort from tinnitus before surgery was not associated with hearing level. So what is the cause of tinnitus in otosclerosis except the conductive hearing loss? Causse and Vincent proposed that

**Table 4.** Outcomes of tinnitus recovery after Stapes surgery in previous studies.

Authors	Year of Study	No. of Cases	Complete recovery	Partial recovery	Unchanged
Gersdorff	1990	50	64%	16%	14%
Sakai	1995	51	51%	17%	27%
Ramsay 9	1997	268	48.20%	33.20%	7.80%
Oliviera 6	2002	48	52.60%	36.80%	10.50%
Ayache 5	2003	62	55.40%	32.40%	8.80%
Szymanski 10	2003	149	73%	17%	10%
Sparano 11	2004	40	52.50%	32.50%	8.80%
Sobrinho 12	2004	48	53.00%	38.00%	9%

some causes of tinnitus in otosclerotic patients could include poor vibration of the inner ear fluid, fixation of the foot plate, proteolysis of Corti hair cells, acoustic trauma, and spiral ligament hyalinization that impairs blood supply to the inner ear via the stria vascularis<sup>18-19</sup>. Tinnitus in otosclerosis could also be attributed to stapes immobility and conductive hearing loss which may be capable of causing limited and reversible changes in central auditory pathways. Cochlear lesions may also have a limited role<sup>20</sup>. Stapes surgery not only reduces conductive hearing loss but also improves the mechanics of the cochlear fluid, as explained by Szymanski<sup>10</sup>, and this may account for tinnitus recovery without hearing improvement in some patients.

In another approach, Gristwood studied 1014 otosclerotic patients who had a 65% incidence of tinnitus and observed that preoperative tinnitus was significantly correlated with gender, mean AC, mean BC, and ABG. However, it wasn't associated with age, duration of hearing loss, and degree of footplate involvement<sup>21</sup>. Similarly, in this study we didn't find any risk factors for predicting tinnitus discomfort before surgery or its recovery one month later.

In terms of predicting post-operative outcomes, Ayache and Szymanski stated in their studies that there was not any parameter that could predict the tinnitus status postoperatively<sup>5,10</sup>. However, Gersdorff and Sakai showed that the surgical technique used was important in the outcomes related to tinnitus and that better results were achieved by stapedotomy as opposed to stapedectomy<sup>7-8</sup>. In contrast, Marchese and House achieved similar hearing results (ABG closure) with both techniques<sup>13-14</sup>. Sparano and Sobrinho indicated that smaller postoperative ABG was associated with better tinnitus recovery<sup>11-12</sup>, but in Terzic's study gap closure was not associated with tinnitus improvement<sup>22</sup>. In our study significant hearing improvement was achieved after surgery with ABG measurements of less than 20 dB one month after surgery observed in 24 patients (82.8%). In addition, tinnitus recovery after surgery was positively correlated with conductive hearing recovery (SRT, mean AC, ABG).

## CONCLUSION

Stapes surgery can successfully improve tinnitus as well as hearing levels in patients with otosclerosis. Thus, patients suffering from discomfort caused by tinnitus could be good candidates for stapes surgery.

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