

# Stapedotomy Favorable Outcome on Osteosclerosis Patient's with High Pitch Tinnitus

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## Abstract

**Background:** Otosclerosis is a primary disease of the temporal bone and otic capsule with autosomal dominant transmission and variable expression. The exact pathogenesis and factors affecting tinnitus in otosclerosis patients are unknown. This study aims to find the effect of stapes surgery on improving tinnitus in otosclerosis patients.

**Aim:** This study aims to find the effect of stapes surgery on improving tinnitus in otosclerosis patients.

**Methods:** Twenty-nine otosclerosis patients with preoperative tinnitus were enrolled in the study. Patients were divided into three groups; patients with high pitch tinnitus (>2 kHz), patients with medium pitch frequency (500-2000 Hz), and patients with low pitch frequency (<500 Hz). In addition, a visual analog scale was used to evaluate tinnitus severity.

**Results:** In our study, 15 (51%) patients' tinnitus showed significant improvement, 5 (17%) patients' tinnitus converted to medium and low frequency, and nine (31%) patients' tinnitus remained unchanged. The majority of subjects (24, 83%) have decreased VAS scores ( $p=0.001$ ), and 5 (17%) patients remained unchanged. Results of pre and postoperative ABG showed that 82.3% of subjects ( $n=27$ ) have postoperative  $ABG < 10$ , and 18% ( $n=6$ ) have ABG of 10 to 20. The patient's mean ABG was decreased from  $35.9 \pm 10.7$  dB before surgery to  $9.03 \pm 7.9$  dB after surgery ( $p=0.001$ ).

**Conclusion:** Patients high pitched tinnitus may be a better candidate for stapes surgery, although others can also benefit from surgical intervention.

**Conflicts of Interest:** The Authors declare no conflicts of interest.

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## Introduction

Otosclerosis is a primary disease of the temporal bone and otic capsule with autosomal dominant transmission and variable expression (1). Conductive hearing loss, sensory neural hearing loss, pure sensory hearing loss, and tinnitus are common symptoms and signs of otosclerosis (2).

Tinnitus is a perception of a sound that doesn't exist; its incidence in otosclerosis is 65–85% (3). Tinnitus is an unnatural sound sensation that certain patients with hearing loss experience. Tinnitus may occur in varying degrees in patients with otosclerosis in

conjunction with their hearing loss. According to a survey of 1014 consecutive cases of clinical otosclerosis, 65% of patients with otosclerosis-related hearing loss experience tinnitus (4).

Otosclerosis surgery replaced affected stapes with prosthesis to improve sound conduction from the middle ear to the inner ear. However, complete hearing loss and worsened tinnitus after surgery are rare complications of this technique (5, 6).

This study aimed to evaluate the stapes surgery effectiveness in patients with tinnitus.

## Methods

### Patient Selection

After approval of the study protocol by the Shahid Beheshti University of Medical Sciences ethical committee (IR.SBMU.MSP.REC.1398.064) and the Iranian Registry of Clinical Trials (IRCT) (IRCT20191114045437N1), our non-randomized clinical trial study was conducted on patients with otosclerosis referred to otolaryngology and head and neck surgery department of Loghman Hakim Hospital, Tehran, Iran who were candidates for stapedotomy and complained of tinnitus between 2014 to 2018. For data gathering, Convenience sampling was used.

Patients with other possible tinnitus etiology such as acoustic trauma, blood biochemistry abnormalities including anemia, vitamin B12 deficiency, thyroid function test abnormalities, revision surgery, and previous ear surgery history were excluded. After a detailed otorhinolaryngology examination, hearing loss type and thresholds were evaluated regarding tuning fork tests and audiometric findings. Finally, after obtaining the informed consent, the study included patients with hearing loss (Air-bone Gaps (ABG)  $\geq$  20 dB and Rinne (-) with 512, 1024 tuning forks).

Subjects were divided into three groups; A) patients with high pitch tinnitus ( $>2$  kHz) (17 subjects), B) patients with medium pitch frequency (500–2000 Hz) (5 subjects), and C) patients with low pitch frequency ( $<500$  Hz) (7 subjects).

### Surgical technique

All patients were operated on under general anesthesia with an endaural incision. After modified Rosen incision, tympanometry flap elevation, and chordal bony removal with a curette or drill, mobility of the ossicular chain was inspected and palpated to establish the diagnosis. All patients were operated on using Fisch's reversal steps stapedotomy technique (7). The distance between the lateral surface of the long incus process and the stapes footplate

was measured with a malleable measuring rod. Small fenestra was performed with 0.5 or 0.7 mm drills. Meticulous care was taken to prevent the aspiration of the fenestra and the placement of the prosthesis immediately after forming the fenestra. Small fenestra was not sealed before placement of the prosthesis. The mobility of the prosthesis is assessed by gentle palpation of the malleus.

Audiometry (0.125–8 kHz) and tinnitus matching were done with a Madsen Itera (GN Otometrics, Germany) audiometer with Sennheiser HDA-200 supra-aural headphones (Sennheiser electronic GmbH & Co. KG, Germany) following the modified Hughson-Westlake threshold seeking method. Tympanometry was performed before and six months after surgery.

To assess tinnitus loudness Visual Analog Scale (VAS), a numerical scale ranging from 1 to 10, was used before and six months after surgery (8). A score of  $\geq 2$  points change on the VAS was regarded as a significant improvement after surgery (9, 10).

### Statistical Analysis

Data were analyzed using SPSS (version 16.0) software (Statistical Procedures for Social Sciences; Chicago, Illinois, USA). Descriptive statistics were presented as proportions or medians (25-75% percentiles). All continuous measurements were tested for normality using the Kolmogorov-Smirnov and Shapiro-Wilk tests. As measurements did not display a normal distribution, the Mann-Whitney U test was used to compare independent groups. Categorical data were compared using the Pearson Chi-Square test. Repeated-measures analysis of variance (ANOVA) was used to compare the three groups. The  $p < 0.05$  was accepted as significant.

## Results

Thirty-five patients with a diagnosis of tinnitus and an approved diagnosis of otosclerosis were eligible participants in this study. Six patients were excluded from the study because of a

decline in audiometric test evaluation (4 cases) and revision surgery (2 cases).

This study examined twenty-one females and eight males with a mean age of  $37.12 \pm 3.1$  years old. There was no worsened tinnitus among patients with preoperative tinnitus, and none of the cases had sensorineural hearing loss.

In group A, tinnitus was significantly improved in 12 subjects (71%), and tinnitus

frequency changed to medium and low frequency in three patients (18%). Also, two (11%) patients claimed no change in tinnitus frequency. Three subjects (60%) experienced no changes in group B, and tinnitus in 2 subjects (40%) changed to low-frequency tinnitus. In group C, tinnitus frequency was a significant improvement in three patients (43%), and four patients experienced no change (57 %) (Table 1) (Table 2).

**Table 1.** Changes in tinnitus frequency after surgery

| Tinnitus frequency | Significant improvement | Unchanged | Change to other groups | P-value |
|--------------------|-------------------------|-----------|------------------------|---------|
| High frequency     | 12 (71%)                | 2 (11%)   | 3 (18%)                | 0.003*  |
| Medium frequency   | –                       | 3 (60 %)  | 2 (40 %)               | 0.003*  |
| Low frequency      | 3 (43%)                 | 4 (57 %)  | –                      | 0.003*  |

**Table 2.** Mean difference of tinnitus before and after surgery

|                          | Tinnitus (kHz)<br>(Pre Operation) |             | Tinnitus (kHz)<br>(After six months) |             |
|--------------------------|-----------------------------------|-------------|--------------------------------------|-------------|
|                          | Mean $\pm$ SD                     | Range       | Mean $\pm$ SD                        | Range       |
| Low frequency (p=0.001)  | 0.27 $\pm$ 3.9                    | 0.125 – 0.5 | 0.25 $\pm$ 2.2                       | 0.125 – 0.5 |
| Mid frequency (p=0.003)  | 1.7 $\pm$ 3.8                     | 0.5 – 2     | 1.5 $\pm$ 3                          | 0.5 – 2     |
| High frequency (p=0.001) | 4.3 $\pm$ 1.4                     | 2 – 6       | 4.1 $\pm$ 1                          | 2 – 6       |

The majority of subjects (24, 83%) have decreased VAS scores (p= 0.001), and 5 (17%) patients remained unchanged. On the other hand, high pitch tinnitus had a more favorable outcome than the two other groups (p= 0.003). Results of pre and postoperative ABG showed that 82.3% of subjects (n=27) have postoperative ABG<10, and 18% (n=6) have ABG of 10 to 20. In addition, the patient's mean ABG was decreased from  $35.9 \pm 10.7$  dB before surgery to  $9.03 \pm 7.9$  dB after surgery (p= 0.001).

## Discussion

Our findings demonstrate that high-frequency tinnitus diminishes following stapes surgery. As a result, many otosclerosis patients matter hearing at very high frequencies and attempts

to enhance surgical outcomes in this frequency range are necessary. In our study, 15 (51%) patients showed significant improvement, 5 (17%) patients' tinnitus converted to medium and low frequency, and nine (31%) patient's tinnitus remained unchanged. Previous research on the topic has also shown that following stapes surgery, tinnitus improves significantly (8, 11, 12). Although each previous study had a different duration follow-up, the same results were seen. Therefore, it is mainly due to tinnitus following surgery being independent of the duration of follow-up, according to Szymanski (13). Our results showed that patients with high-pitched tinnitus ( $\geq 2$  kHz) benefit more from stapes surgery in comparison to patients with medium and low-

pitched tinnitus (<2 kHz). A randomized prospective study on this topic demonstrated that high-frequency hearing patients benefit more following the stapedotomy surgery, which was in line with our result (14). In that study, they postulated that improved acoustic masking might be one reason for reducing tinnitus following the procedure. However, patients who have lost their high-frequency hearing due to surgery are less likely to benefit from such masking effects, and their sensory cells and neurons in the cochlea's basal turn may have been damaged. It's also possible that attention effects play a role. In this instance, better middle ear transmission would provide patients with a novel auditory environment that would distract them from their tinnitus (14). In contrast with us, studies evaluating the pitch of tinnitus pre and post-stapes surgery linked the pitch of preoperative tinnitus in individuals with otosclerosis with the resolution of this condition after stapes surgery. Both claimed that stapes surgery affects mainly low-tone tinnitus. Causse and Vincent hypothesized that this kind of tinnitus is caused by the oval-window mechanism's flexibility, which may be rectified by stapes surgery (15, 16). In our study, pre and postoperative ABG results showed that 82.3% of subjects (n=27) have postoperative ABG<10. In 2013, a study of 262 stapedotomies on 228 patients found that the AB-gap was closed to less than 10 dB in 86% of cases and nearly 20 dB in 11% of instances (17). Another research from 2015 found that 87 percent of patients following the stapes surgery had a residual AB-gap of less than 10 decibels (18). Deniz et al. published research in 2019 that looked at the variables that influence the surgical outcome in patients with otosclerosis. The authors discovered that a large AB-gap in otosclerosis patients was a poor predictor of postoperative hearing prognosis. They suggested a 34.5 dB AB-gap

cut-off value as a potential measure for predicting clinical outcomes (19). All together, we realized that our patients after stapedotomy had a good clinical outcome and stapedotomy was effective.

### Conclusion

In conclusion, whereas stapedotomy improves hearing at low frequencies, it deteriorates hearing at higher frequencies in the majority of patients in our study. The small sample size is the first limitation of this study. Another limitation is the short follow-up period. Authors believe that longer evaluations in 1 month, 6 months, 12 months, and 18 months could be essential to realize how long tinnitus needs to improve. Stapes surgery has greater effectiveness in patients with high pitch tinnitus. Thus, patients high pitched tinnitus may be a better candidate for stapes surgery, although others can also benefit from surgical intervention.

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### Conflicts of Interest

The authors declare no conflicts of interest.

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This study protocol was approved by the Shahid Beheshti University of Medical Sciences ethical committee (IR.SBMU.MSP.REC.1398.064) and the Iranian Registry of Clinical Trials (IRCT) (IRCT20191114045437N1).

### Ethics

IR.SBMU.MSP.REC.1398.064

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