The effect of stapedotomy on tinnitus in patients with otospongiosis

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Abstract

Stapedotomy is primarily performed to treat hearing loss secondary to otospongiosis, although some patients find that the accompanying tinnitus is more bothersome than the hearing loss. We prospectively studied 23 consecutive patients with tinnitus secondary to otospongiosis who had undergone stapedotomy, and we compared their pre- and postoperative medical and audiologic findings. Patients’ annoyance with their tinnitus was quantified by means of a visual analog scale, and their air-conduction thresholds were determined by measurements of a 4-frequency pure-tone average (0.5, 1, 2, and 4 kHz). Statistical analysis was performed using the paired Student’s t test and Fisher’s exact test. In the group as a whole, the mean tinnitus annoyance visual analog scores were 8.34 preoperatively and 1.56 postoperatively, a highly significant difference. Clinically, 22 of the 23 patients (95.7%) achieved satisfactory control of their tinnitus (improvement or complete resolution) following stapedotomy. With respect to hearing loss, all patients clinically improved postoperatively, and audiometry confirmed improvement at all 4 frequencies between 0.5 and 4 kHz. An air-bone gap of less than 10 dB was noted in 17 patients (73.9%). We conclude that in addition to improving hearing, stapedotomy also provides good control of tinnitus.

Introduction

Most cases of tinnitus are caused by disorders in the cochlea or auditory nerve. The physiopathology and evolution of tinnitus that is exclusively associated with conductive hearing loss has not been widely studied.

According to the literature, between 65 and 87% of patients with otospongiosis experience tinnitus. In these patients, tinnitus can precede the perception of hearing loss and represent a patient’s primary complaint. Causse and Vincent reported that tinnitus secondary to otosclerosis may be caused by poor vibration of the inner ear fluids. An increase in the resistance of the acoustic vibration of the annular ligament of the stapes footplate results in a decrease of vibration in inner ear fluids. The decrease occurs primarily at the low frequencies, explaining why the audiometric gap is larger in these tones. The decrease in afferent information at the low frequencies is probably responsible for the increase in auditory cortex sensibility in perceiving low-frequency sounds. Therefore, an excess of feedback could generate tinnitus via a complex interaction between afferent and efferent pathways, a circumstance that is not specific to otospongiosis. On the other hand, Glasgold and Altmann suggested that the agglutination of red cells inside the small vessels of the auditory system triggers the development of tinnitus in patients with otospongiosis and other types of hearing loss.

Stapedotomy is primarily performed to restore hearing in patients with otospongiosis, regardless of the presence or absence of tinnitus. As a rule, surgery involves removing the upper structure of the stapes, perforating the footplate, and introducing a prosthesis that connects the perforation to the incus, thereby reestablishing sound conduction up to the oval window. When performed by experienced surgeons, stapedotomy improves hearing in approximately 96% of patients. Moreover, in most cases (63%), the air-bone gap is closed to within 10 dB or less, which is defined as a successful outcome.

Tinnitus is not traditionally considered to be an indication for stapedotomy in patients with otospongiosis, but tinnitus is sometimes more bothersome than hearing loss. Therefore, we conducted a prospective study to determine whether stapedotomy provides a significant benefit for patients with otospongiosis whose tinnitus has negative effects on their quality of life.

Patients and methods

We examined the records of all patients in the Department of Otorhinolaryngology at our institution. Patients were eligible for study consideration if (1) they had constant unilateral or bilateral tinnitus associated with any degree
of hearing loss, (2) they were suspected of having otospongiosis, and (3) stapedotomy was not contraindicated on clinical or audiologic grounds. Exclusion criteria included previous surgery in an affected ear. Ultimately, we selected 23 patients with otospongiosis—12 men and 11 women, aged 24 to 54 years (mean: 37)—as suitable candidates for stapedotomy and inclusion in our study. The study protocol was approved by our institution’s ethics committee, and written informed consent was obtained from each patient.

Preoperative evaluation. Prior to surgery, all patients were asked about the general characteristics of their tinnitus, and all were asked to rate the degree of their tinnitus on a visual analog scale from 1 (minimal) to 10 (very bothersome). Patients also underwent audiometric assessments of pure-tone air- and bone-conduction thresholds as measured by an Interacoustics model AC30 clinical audiometer with TDH-39 earphones in a soundproof booth. Tympanometry and acoustic reflexes were recorded by an Interacoustics model AZ7 electroacoustic impedance bridge. To evaluate audiometric results concerning closure of the air-bone gap, we used the criteria contained in the Committee on Hearing and Equilibrium guidelines published in 1995, which established the use of the 4-frequency (0.5, 1, 2, and 4 kHz) pure-tone average (PTA).10

Surgery. All surgeries were performed from August 1996 through July 2002 by different otolaryngologic surgeons, usually supervised third-year residents. All surgeons used the same technique and placed the same type of prosthesis (Teflon piston).

Postoperative evaluation. All preoperative tinnitus and audiometric assessments were repeated within 90 days of surgery. Statistical comparison of pre- and postoperative findings was accomplished with the assistance of the SPSS 10 statistical analysis program. Data were compared with the use of the paired Student’s t test and Fisher’s exact test; the threshold for statistical significance was \( p < 0.05 \). In cases where patients underwent stapedotomy in both ears, only the results of the first intervention were included in our study. Postoperative follow-up ranged from 3 to 12 months.

Results

Tinnitus. Of the 23 patients, 5 (21.7%) had had tinnitus for more than 10 years, 5 for 5 to 10 years, and 13 (56.5%) for less than 5 years. Preoperatively, 21 patients (91.3%) had either severe (16 [69.6%]) or moderate tinnitus (5 [21.7%]), and the remaining 2 patients (8.7%) had mild tinnitus. The group’s mean score on the visual analog scale was 8.34.

Postoperatively, 22 of the 23 patients (95.7%) experienced a satisfactory outcome—that is, either a complete resolution of tinnitus (9/23 [39.1%]) or a significant reduction (13/23 [56.5%]). The postoperative mean score on the visual analog scale was only 1.56, which represents a significant improvement (\( p < 0.001 \)).

Hearing loss. Preoperatively, 20 patients had a pure conductive hearing loss at all 4 measured frequencies; the remaining 3 patients had a mixed hearing loss at 2 and 4 kHz. Postoperatively, mean air-conduction thresholds were significantly lower at all 4 frequencies (table 1).

Pure-tone thresholds. All 23 patients exhibited an improvement in pure-tone thresholds.

Air-bone gaps. Prior to surgery, the mean air-bone gap was 34.13 dB. Postoperatively, 17 patients (73.9%) had an air-bone gap of 10 dB or less, and all of them had a satisfactory outcome with regard to tinnitus (table 2). According to Fisher’s exact test, there was no significant association between gap closure and tinnitus improvement (\( p = 0.72 \)), which means that tinnitus improvement does not require that the gap be completely closed. The air-bone gap in the single patient who did not experience any improvement in tinnitus remained within 15 dB.

Discussion

The effect of stapedotomy on tinnitus has not been widely studied, but some data have been published. House and

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### Table 1. Mean air-conduction thresholds pre- and postoperatively

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>Preop Mean (SD)</th>
<th>Postop Mean (SD)</th>
<th>Difference (Preop - Postop)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>57.39 (12.32)</td>
<td>26.95 (13.20)</td>
<td>30.44</td>
</tr>
<tr>
<td>1</td>
<td>54.78 (9.22)</td>
<td>23.47 (13.52)</td>
<td>31.31</td>
</tr>
<tr>
<td>2</td>
<td>48.69 (10.13)</td>
<td>26.52 (12.19)</td>
<td>22.17</td>
</tr>
<tr>
<td>4</td>
<td>53.47 (17.01)</td>
<td>35.65 (20.90)</td>
<td>17.82</td>
</tr>
</tbody>
</table>

* Standard deviation.

### Table 2. Postoperative air-bone gap and tinnitus status in the 23 patients

<table>
<thead>
<tr>
<th>Air-bone gap (dB)</th>
<th>Improved or resolved (n)</th>
<th>Unchanged (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤10</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>11 to 20</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>≥21</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

* There was no significant association between gap closure and tinnitus improvement (\( p = 0.72 \)).
Greenfield reported that 76% of patients who underwent stapedotomy experienced tinnitus relief. Likewise, Sakai et al found that tinnitus abated in 68% of patients who underwent either stapedotomy or partial stapedectomy. Gersdorff et al reported a complete resolution of tinnitus in 80% of patients following small-fenestra stapedotomy. Ayache et al found that tinnitus either resolved or improved after stapedotomy or stapedectomy in 88% of patients. On the other hand, Bellucci reported that tinnitus resolved or decreased in only 35% of patients who underwent stapedectomy. Our rate of tinnitus improvement after stapedotomy (95.7%) was very good and reinforces the validity of the data obtained in most other studies.

Causse and Vincent demonstrated that stapedectomy was more successful in eliminating low-frequency tinnitus (77.8% of patients at 0.5 kHz) than medium- (38.4% at 2 kHz) or high-frequency tinnitus (17.3% at 4 kHz and 2.9% at 8 kHz). In our study, we did not measure pitch- and loudness-matching, so we are unable to make a comparison with those data.

The mechanism by which stapedotomy eliminates or relieves tinnitus involves the reestablishment of functional vibration in the inner ear fluids, which causes interruption of feedback (less afferent and more efferent information). This mechanism would explain the probable relationship between a reduction in tinnitus and improvement in hearing. Hence, in other conditions where surgery can restore hearing loss—for example, stenosis of the external ear canal, tympanic membrane perforation, and bone structure fixation or interruption by middle ear effusion—it stands to reason that tinnitus would also decrease or completely disappear.

Relief of tinnitus following hearing restoration may be the result of the adequate recovery of the higher sensitivity of the auditory cortex because the afferent information has been reestablished. According to Heller and Bergman, 75 of 80 (93.8%) normal-hearing subjects developed tinnitus during a 5-minute stay inside an anechoic chamber. The central nervous system compensates for the decrease of a certain stimulus by increasing the sensitivity of the centers involved in its perception. In this case, the absence of sound or a decrease of afferent information secondary to an air-bone gap would result in an increase in the sensitivity of cochlear centers to any stimulus, including the spontaneous activity of auditory pathways, and thus have an effect on the perception of tinnitus.

It is well known that stapedotomies are most successful when performed by well-trained surgeons. Nevertheless, the operations in our study were performed by residents, and the postoperative results were surprisingly good. Postoperatively, 73.9% of our patients had an air-bone gap of 10 db or less, and no patient experienced a severe or worsening sensorineural hearing loss. However, we are aware that the results of stapedotomy are not completely predictable, and if we had studied a greater number of patients, we probably would have observed some complications of this surgery.

Tinnitus can be caused by many factors, including otologic diseases, metabolic alterations, neurologic diseases, and vascular diseases, among others. Persistent tinnitus despite stapedotomy and an air-bone gap within 15 dB, which occurred in the 1 patient in our study who did not improve, is probably caused by an underlying condition, such as glucose intolerance, excessive caffeine intake, destruction of Corti hair cells by proteolytic enzymes released from otosclerotic foci, or an inadequate supply of blood to the inner ear secondary to hyalinization of the spiral ligament of the stria vascularis ductus cochlearis, which is a natural consequence of the progression of otospongiotic disease.

In conclusion, our data are consistent with those published elsewhere in the literature. We believe that patients with otospongiosis in whom tinnitus is bothersome are good candidates for stapedotomy.

References