

Long-Term Follow-Up of Tinnitus in Patients with Otosclerosis After Stapes Surgery

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Abstract: We prospectively studied 48 otosclerosis patients over a 2-year interval. Forty-four had stapedotomy, and four had stapedectomy. Demographics, clinical history, and pre- and postoperative audiometry results were recorded. A questionnaire asking about tinnitus (intensity, pitch) and including a visual analog scale quantifying the degree (1-10) of annoyance caused by the tinnitus was completed pre- and postoperatively (4-10 months and 14-48 months, respectively). Ninety-one percent of the otosclerosis patients reported the presence of tinnitus, and 39.58% reported severe disabling tinnitus (SDT; 7-10 on the visual analog scale). High-pitch (whistle) tinnitus was present in most patients, and white noise (radio static, waterfall, rain) was present in others. No patient described the tinnitus as a low-tone noise (buzzing). Ninety-one percent of patients reported tinnitus reduction or total remission after surgery. Ten of 19 patients with SDT reported complete remission of tinnitus, 7 reported improvement postoperatively, and 2 reported no change. No patient reported worsening of tinnitus. Small postoperative air-bone gaps (four tonal average) correlated with remission or reduction of tinnitus in SDT patients. Tinnitus pitch, gender, and age of patients were not related to decrease of tinnitus postoperatively. A larger preoperative air-bone gap correlated with larger reduction of tinnitus after successful surgery. A lower preoperative bone conduction level correlated with more intense tinnitus before surgery and greater reduction postoperatively. We contacted 25 patients from 14 to 48 months after surgery, and all reported that their tinnitus status had not changed since the early follow-up. Tinnitus is very prevalent in otosclerosis patients; almost one-half of patients have SDT preoperatively, and stapes surgery improves this symptom in 91% of cases. Preoperative air-bone gap and bone conduction level and a postoperative air-bone gap seem to influence the degree of postoperative tinnitus reduction.

Key Words: long-term follow-up; otosclerosis; stapes surgery; tinnitus

In 1981, Shea [1] stated that tinnitus in otosclerosis is caused by focuses of the disease involving the inner ear and is not affected by stapedectomy. In 1994, Shea et al. [2] presented five cases of endolymphatic hydrops associated with otosclerosis or stapes surgery (or both): One patient had the hydrops preoperatively, one had hydrops associated with poststapedectomy fistula, and three others had delayed endolymphatic hydrops after stapedectomy. All five patients had

tinnitus, and their symptoms decreased with treatment for hydrops.

In 1995, Causse and Vincent [3] determined the frequency of tinnitus in 643 otosclerosis patients preoperatively. After surgery, the symptom was cured in 77.8% of patients with 500-Hz tinnitus, in 38.4% of patients with 2,000-Hz tinnitus, in 17.4% of patients with 4-kHz tinnitus, and in 2.9% of patients with 8-kHz tinnitus. They stated that restoration of the normal elasticity of the oval-window mechanism corrects the distorted vibrations of the inner-ear fluids that cause low-tone tinnitus in otosclerosis patients.

In 1997, Ramsay et al. [4] presented the results of operations on 246 otosclerosis patients (89% stapedectomy, 11% stapedotomy) in relation to tinnitus. In 58% of their patients, tinnitus continued after surgery; 11%

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actually reported worsening of the symptom postoperatively, but most believed that the tinnitus was less disturbing after surgery. The authors found no relation between tinnitus reduction and hearing results after stapes surgery.

In 1990, Oliveira et al. [5] searched the temporal bone collection at Massachusetts Eye and Ear Infirmary (1,200 bones) for patients with a significant history of tinnitus during their lifetime. Light-microscopy study of 83 temporal bones of tinnitus patients revealed that 18% had endolymphatic hydrops, 11% had otosclerosis, and 11% had normal temporal bone histology. Nine other pathological diagnoses were present in a small number of bones.

From this review, it is clear that otosclerosis is a major pathological diagnosis associated with tinnitus, and this symptom is very common in otosclerosis patients. Even though some papers have been published about the effect of stapes surgery on tinnitus, we still need to clarify important issues regarding tinnitus, otosclerosis, and stapes surgery: What is the prevalence of tinnitus in otosclerosis patients? What proportion of the symptom is severe disabling tinnitus (SDT)? Do patients with SDT improve after stapes surgery? If so, for how long?

We have attempted to answer these questions in a prospective study. We quantified tinnitus on a visual analog scale (1–10) preoperatively and after stapes surgery at two points: 4–14 months and 14–48 months postoperatively. We studied gender, age, and several audiometric parameters, searching for correlations with tinnitus changes after stapes surgery.

PATIENTS AND METHODS

A questionnaire asking about tinnitus was prospectively applied at the Department of Otolaryngology of the Brasília University Medical School to all patients scheduled to have stapes surgery for otosclerosis: Was it present in the ear to be operated on? Was the symptom bilateral? In a visual analog scale from 1 to 10, where 1 represented a very mild intensity and 10 an unbearable level of intensity, the patients were asked to indicate the subjective intensity of their tinnitus: Was tinnitus constant, occasional, occurring very often, or present only rarely? What did the tinnitus sound like: whistle, waterfall, rainfall, buzzing, or other?

After surgery, the same questionnaire was applied early (4–14 months) and late (14–48 months), when possible. All patients underwent pure-tone audiometry and a word discrimination test preoperatively and at each postoperative review (early and late). We recorded the type of operation (stapedectomy vs. stapedotomy) and any problems that occurred during surgery. Complications in the early and late follow-up were noted.

We recorded results of surgery measured by comparing four pre- and postoperative tonal average air-bone gaps. This protocol was applied prospectively during a 2-year period. All patients were operated on by senior residents of the otolaryngology department at Brasília University Medical School under the supervision of two senior staff otologists.

The Ethics Committee on Research Involving Human Subjects of the Brasília University Medical School approved this protocol before the investigation was begun.

RESULTS

Table 1 shows demographic data from this cohort. Forty-eight patients were enrolled; 29 (58.0%) were female, and 19 (42%) were male. Forty-four patients (91.6%) had subjective tinnitus. Gender and age did not influence the preoperative incidence of tinnitus.

Table 2 shows the incidence of SDT (7–10 on the visual analog scale) preoperatively. Sixteen (84.21%) of 19 patients with SDT were female; only 3 (15.78%) were male. Age, however, did not correlate with the preoperative incidence of SDT.

Table 3 shows overall reduction of tinnitus after surgery. Table 4 quantifies postoperative tinnitus abatement overall. Twenty-eight (63.3%) of the 44 patients with preoperative tinnitus experienced total remission of the symptom after surgery; 9 (20.45%) had significant improvement; and 3 (6.81%) had slight decrease of the symptom postoperatively. Four (9.09%) patients reported no change of tinnitus after surgery.

Table 1. Demographic Data from Cohort

| | No. of Patients (%) | No. of Patients with Subjective Tinnitus (%) | No. of Patients Without Tinnitus (%) |
|---------------|---------------------|--|--------------------------------------|
| Female | 29 (58.0) | 26 (89.6) | 3 (10.34) |
| Male | 19 (42.0) | 18 (94.7) | 1 (5.26) |
| Total | 48 | 44 (91.6) | 4 (8.1) |
| Age* (yr) | 16–62 | — | — |
| Mean age (yr) | 44.5 | — | — |

* 23 subjects older than 40 years; 25 subjects younger than 40 years.

Table 2. Patients with Severe Disabling Tinnitus

| | No. of Patients (%) |
|-------------|---------------------|
| Female | 16 (84.21) |
| Male | 3 (15.78) |
| Total | 19 (39.6) |
| Age < 40 yr | 9 (47.33) |
| Age > 40 yr | 10 (52.63) |

Note: Severe disabling tinnitus: 7–10 on the visual analog scale.

Table 3. Overall Postoperative Results from Cohort

| Result | No. of Patients (%) |
|-------------|---------------------|
| Improvement | 40 (90.9) |
| No change | 4 (9.09) |
| Worsening | 0 |

Note: At 2-10 months.

Table 4. Degree of Improvement (General)

| Degree | No. of Patients (%) |
|--------------------------------------|---------------------|
| Total remission | 28 (63.3) |
| Significant improvement [#] | 9 (20.45) |
| Slight improvement | 3 (6.81) |
| No change | 4 (9.09) |

[#] At least two points on the visual analog scale.

Table 5 shows postoperative results for SDT patients. Ten (52.6%) of 19 SDT patients reported total remission of tinnitus postoperatively (all female); 6 (31.70%) reported significant abatement of the symptom after surgery (four female). One female patient reported slight reduction of tinnitus, and two patients (one male and one female) reported no change after surgery.

Table 6 shows that the preoperative air-bone gap had no bearing on the intensity of tinnitus. Tables 7 and 8, however, show that larger preoperative air-bone gaps predict total remission of tinnitus postoperatively in both SDT and less intense cases. Table 9 shows that

Table 5. Degree of Improvement of Severe Disabling Tinnitus

| Degree | No. of Patients (%) |
|-------------------------|------------------------------|
| Total remission | 10 of 19 (52.6) ^a |
| Significant improvement | 6 of 19 (31.70) ^b |
| Slight improvement | 1 ^c |
| No change | 2 ^d |

^a All female.

^b Four female.

^c Female.

^d One female.

Table 6. Preoperative Air-Bone Gap and Degree of Tinnitus Intensity

| Degree | Mean Preoperative Air-Bone Gap |
|---------------------------|--------------------------------|
| Severe disabling tinnitus | 34.3 dB |
| Less intense tinnitus | 31.4 dB |

Table 7. Preoperative Air-Bone Gap and Postoperative Tinnitus Remission: Less Intense Tinnitus

| Air-Bone Gap | No. of Patients with Total Remission (%) |
|--------------|--|
| >30 dB | 12 (70.5) |
| <30 dB | 5 (29.4) |

Table 8. Preoperative Air-Bone Gap and Postoperative Tinnitus Remission: Severe Disabling Tinnitus

| Air-Bone Gap | No. of Patients with Total Remission (%) |
|--------------|--|
| >30 dB | 8 (80) |
| <30 dB | 2 (20) |

smaller postoperative air-bone gaps do not correlate with a higher number of total remissions and significant reduction of tinnitus when all tinnitus cases are combined. Table 10, however, shows that smaller postoperative air-bone gaps do correlate with larger numbers of total remission and significant reduction of tinnitus after surgery when we consider only SDT patients.

Table 11 shows that tinnitus pitch preoperatively in SDT patients does not influence postoperative tinnitus decrease. Table 12 shows that lower preoperative bone conduction levels correlate with a higher incidence of SDT preoperatively and of total remission of the symptom postoperatively.

Table 13 shows that 26 patients contacted from 14 to 48 months after surgery reported no change in tinnitus status in relation to early follow-up. Seven of these patients had SDT before surgery. Six patients had an air-bone gap greater than 20 dB after surgery. No significant vestibular symptom or sensorineural hearing loss was noted after surgery in the 48 patients studied.

DISCUSSION

Shea [1] and Causse and Vincent [3] tried to correlate pitch of preoperative tinnitus in otosclerosis patients and decrease of this symptom after stapes surgery. Both stated that only low-tone tinnitus is affected by stapes surgery. Causse and Vincent indicated that this kind of tinnitus is related to the elasticity of the oval-window mechanism, which is corrected by stapes surgery. Our patients reported either high tone (whistle) or white noise (radio static, waterfall), and the pitch of preoperative tinnitus did not correlate with postoperative improvement. This may be because we did not study tinnitus pitch more accurately before surgery.

Table 9. Postoperative Tinnitus Results and Air-Bone Gap: General

| Air-Bone Gap | Total | No. of Patients (%) | | | |
|--------------|------------|---------------------|--------------------------|--------------------|----------------|
| | | Total Remission | Significant* Improvement | Slight Improvement | No Improvement |
| 0–10 dB | 28 (58.3) | 18 (64.30) | 1 (3.6) | 1 (3.6) | 1 (3.6) |
| 10–20 dB | 14 (29.16) | 6 (42.8) | 1 (7.14) | 1 (7.14) | 2 (14.3) |
| 20–30 dB | 6 (12.5) | 4 (66.6) | 0 | 1 (16.6) | 1 (16.6) |

* At least two levels on the visual analog scale.

Table 10. Postoperative Tinnitus Results and Air-Bone Gap: Severe Disabling Tinnitus

| Air-Bone Gap | Total | No. of Patients (%) | | | |
|--------------|------------|---------------------|-------------------------|--------------------|----------------|
| | | Total Remission | Significant Improvement | Slight Improvement | No Improvement |
| 0–10 dB | 12 (63.15) | 9 (75) | 3 (25) | 0 | 0 |
| 10–20 dB | 5 (26.31) | 0 | 4 (80) | 0 | 1 (20) |
| 20–30 dB | 2 (10.52) | 0 | 0 | 1 (50) | 1 (50) |

Table 11. Postoperative Improvement and Tinnitus Pitch: Severe Disabling Tinnitus (N = 19)

| Tinnitus Type | No. of Patients | | |
|---------------|-----------------|-------------------------|----------------|
| | Total Remission | Significant Improvement | No Improvement |
| High pitch | 3 | 6 | 2 |
| White noise | 7 | 1 | — |
| Low pitch | 0 | 0 | — |

Table 12. Postoperative Tinnitus Results and Preoperative Bone Conduction: SDT

| Preoperative Bone Conduction (4 tonal average) | No. of Patients (%) | | |
|--|---------------------|------------------|---------------------------------|
| | Total | Preoperative SDT | Total Remission Postoperatively |
| <40 dB | 34 (70.8) | 15 (44.1) | 10 (66.6) |
| >40 dB | 14 (29.2) | 4 (28.50) | 0 |

SDT = severe disabling tinnitus.

Table 13. Long-Term Follow-Up (14–41 months; n = 26)

| | No. of Patients Contacted | Total Remission | Significant Improvement | Change Late Follow-Up |
|----------------------------|---------------------------|-----------------|-------------------------|-----------------------|
| SDT (7–10) | 7 | 5 | 2 | None |
| Less intense tinnitus (<7) | 19 | 3 | 16 | None |

SDT = severe disabling tinnitus.

We have measured the intensity of tinnitus preoperatively and postoperatively using a visual analog scale. This has not been conducted before. *Severe disabling tinnitus* is a term coined by Shulman et al. [6] and refers to a symptom that is intense and annoying to the point of disrupting affected patients' routine and precludes them from performing normal activities. In this study, we considered as severe and disabling a tinnitus with a 7 or higher level on the visual analog scale.

We found a prevalence of tinnitus in otosclerosis patients of 91.6% and, of these, 43.18% were SDT. Therefore, we can say that tinnitus is a very prevalent and significant symptom in otosclerosis patients. We found that female patients report SDT much more frequently than do male otosclerosis patients. However, when we look at the overall incidence of the symptom (including less intense tinnitus), we find no difference between male and female patients. Possibly women are more sensitive to the symptom and therefore have a heightened perception of tinnitus, or cochlear otosclerosis is more severe among them. After surgery, only 1 female patient reported no change in tinnitus intensity, whereas 10 reported total remission, 4 reported significant reduction (at least two levels on the visual analog scale), and 1 was slightly improved. Age did not influence the incidence of tinnitus in otosclerosis patients preoperatively or affect reduction of the symptom postoperatively.

Larger air-bone gaps preoperatively had no influence on the intensity of tinnitus but correlated with greater decrease of the symptom (including SDT) after successful surgery. Lower preoperative bone conduc-

tion correlated with a higher incidence of SDT preoperatively and a higher number of total remissions in SDT patients after surgery. Twenty-six patients were contacted 14 to 48 months after surgery: Seven were SDT patients; none reported any change from the earlier results.

Several papers published recently [7–10] reported results very similar to ours. Ayache et al. [7] found a 2.9% incidence of worsening of tinnitus after surgery; Gersdorff et al. [8] found better results for tinnitus abatement with stapedotomy than with stapedectomy. (We did only four stapedectomies, so we cannot compare the procedures in our work.) Yet Szymansky et al. [9] stated that poor hearing outcome after surgery causes tinnitus to disappear. In 2003, Gristwood and Venables [10] found results similar to ours. None of these articles quantified the intensity of the symptom, so they could not evaluate SDT.

It makes sense that larger preoperative air-bone gaps do not increase the magnitude of tinnitus before surgery, but closure of larger air-bone gaps enhances tinnitus reduction or remission in SDT. In a temporal-bone study searching for a pathological correlate for tinnitus, Oliveira and Schuknecht [5] found endolymphatic hydrops in 18% of the bones studied, normal histopathology in 11%, and otosclerosis in 11%. These were the major histopathological diagnoses found in tinnitus patients. If we consider that tinnitus starts with a biochemical alteration in the inner-ear fluids, which in the beginning will not be detectable by light microscopy but later is seen as endolymphatic hydrops, and that otosclerotic focuses in the cochlea provoke these biochemical changes in endolymph and perilymph, we tie together these major histopathological diagnoses found in temporal bones of tinnitus patients.

If the foregoing explanation is true, the only way in which stapes surgery can influence tinnitus in otosclerosis patients is by changing the conductive part of the equation. This is precisely what we found in our patients: Larger preoperative gaps when closed by successful surgery allow effective masking of the symptom.

Finally, we must comment on lower levels of preoperative bone conduction producing a higher incidence of SDT before, and of total remission after, surgery. Again, Oliveira and Schuknecht [5] found better preservation of sensory and neural structures in patients with tinnitus than in patients with the same histopathological diagnosis but without tinnitus. Possibly, tinnitus is a very early sign of cochlear lesion and tends to decrease as the lesion worsens. Of course, the ideas posited in the preceding paragraphs are far from being proved, but we believe that they comprise an interesting hypothesis to be investigated.

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