

Effects of Stapedectomy on Tinnitus in Patients with Otosclerosis

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Abstract: Tinnitus frequently accompanies hearing loss in patients with otosclerosis and has been correlated with distinct otosclerotic pathologies. The objective of our study was to evaluate the effect of stapedectomy on tinnitus in patients with otosclerosis. Forty patients were retrospectively interviewed for assessment of preoperative versus postoperative levels of tinnitus distress using the standardized Klockhoff-Lindblom (K/L) classification system. Audiometric data also were examined with respect to tinnitus grades. Of the 40 patients, 34 (85%) had improved K/L tinnitus grades after stapedectomy, 5 (12.5%) had no change, and 1 (2.5%) had a worse K/L grade postoperatively. Twenty-one (52.5%) patients reported complete resolution of tinnitus. Postoperative air-bone gap was less for patients with decreased tinnitus than for those with no change. Significant improvement was seen in the degree of tinnitus distress after stapedectomy for otosclerosis.

Key Words: otosclerosis; stapedectomy; tinnitus

Subjective tinnitus is any abnormal noise perceived by a patient but having no existing external acoustic stimulus as its source. Estimates indicate that in the United States, more than 35 million people experience tinnitus beyond a transient duration and that approximately 10 million people experience symptoms troubling enough to interfere with normal working and leisure life [1]. Although the vast minority of patients complaining of tinnitus have concomitant treatable ear disorders, tinnitus frequently accompanies hearing loss as a significant presenting symptom in patients with otosclerosis. The exact cause of tinnitus in this setting has not been adequately explained, and its relation to otosclerosis is infrequently discussed in the literature.

However, surgical repair of otosclerosis has been shown to affect tinnitus, and the extent of this impact

varies significantly across studies [2–6]. Previous examinations of the effect of stapedectomy on tinnitus in otosclerosis have proceeded without the use of a classification system that distinguishes levels of tinnitus distress. Klockhoff and Lindblom [7] devised a classification system that can distinguish degrees of tinnitus distress. The system consists of seven grades, from 0 to 3, differing from one another with respect to prevalence or intensity (or both; Table 1). The Klockhoff-Lindblom (K/L) tinnitus-grading system has been shown to demonstrate good inter-rater reliability and was selected for use in this study as an effective measure of the level of tinnitus distress [8]. The primary objective of this study was to examine closely the effect that stapedectomy had on tinnitus in patients with otosclerosis, using a classification system that made possible the distinction between greater and lesser degrees of tinnitus distress.

PATIENTS AND METHODS

Ours was a retrospective study of 357 patients with a diagnosis of otosclerosis between the years 1993 and 2000, 40 of whom had undergone stapedectomy surgery, had documented preoperative tinnitus, and were available for interview at the time of study. The surgeries were performed by a single surgeon at the Loyola University

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Table 1. Klockhoff and Lindblom Classification System for Distinguishing Levels of Tinnitus Distress

Grade	Description
0	None
0.5	Slight, ^a periodic
1.0	Slight, continuous or moderate, ^b periodic
1.5	Continuous, fluctuating from slight to moderate
2.0	Continuous, moderate or fluctuating from slight to severe, ^c intermittent, severe
2.5	Continuous, fluctuating from moderate to severe
3	Continuous, severe

^a Audible only in a quiet environment.

^b Audible in an ordinarily noisy environment but divertible (i.e., not observed when attention is focused on work, etc.).

^c Constantly noticed in all ordinary acoustic environments, even when concentrating on work, etc.

of Chicago, Foster McGaw Hospital. The procedures involved use of 36 Robinson-Bucket, 1 McGee Piston, 1 Goldenberg, and 2 Teflon wire prosthetic devices. The patients selected for study were screened for medical illnesses and use of medications known to be associated with the presence of tinnitus. Twenty-five (62.5%) of the 40 patients were women, the range of age was 18–75 years, and the duration of their preoperative tinnitus ranged from 1 month to 2 years. No patient had had previous treatment for tinnitus.

Preoperative and postoperative audiometric data were not available for all patients. Available data were analyzed in accordance with the Committee on Hearing and Equilibrium of the American Academy of Otolaryngology–Head and Neck Surgery (AAO-HNS) guidelines [9]. For computation of the four-tone pure-tone average (i.e., using frequencies at 0.5, 1, 2, and 3 kHz), data for the 3-kHz frequency often were not available, so a value was derived by averaging data from 2 and 4 kHz, as the committee suggested.

Patients were contacted individually at the time of study and were asked to grade their degree of tinnitus distress preoperatively and postoperatively using the K/L classification system. These K/L tinnitus grades were correlated with audiometric results when available.

RESULTS

Tables 2–4 show the audiometric results represented in compliance with the AAO-HNS level 1 and level 2 guidelines, respectively. Of the 40 patients analyzed, 34 (85%) showed improved K/L tinnitus grades after stapedectomy, 5 (12.5%) showed no change after stapedectomy, and 1 patient (2.5%) had a worsened K/L grade postoperatively (Fig. 1). Twenty-one (52.5%) of the patients reported complete resolution of tinnitus

Table 2. Level I Audiometric Results

	Mean ± SD	Range	Number
Postoperative air-bone gap*	11.2 ± 9.3	1.3–38.3	18
Closure of the air-bone gap*	14.0 ± 12.4	–9.4–40.0	17
Change in high-tone bone conduction*	5.4 ± 10.4	–8.3–30.0	17

* All values measured in decibels.

after stapedectomy, and 19 (47.5%) had some degree of tinnitus distress remaining. Despite low sample size, the postoperative air-bone gap was significantly lower for patients with improved K/L tinnitus grades than it was for patients whose tinnitus grade did not change (9.6 ± 6.9 dB, $n = 16$, versus 23.8 ± 20.3 dB, $n = 2$; $p = .04$; Fig. 2). Similarly, patients with complete resolution of tinnitus had a lower postoperative air-bone gap as compared to that of patients with symptoms of tinnitus remaining after stapedectomy (6.0 ± 4.0 dB, $n = 8$, versus 15.3 ± 10.4 dB, $n = 10$; $p = .03$; see Fig. 2).

Closure of the air-bone gap was not significantly greater in patients with improved K/L tinnitus grades than it was for patients with no change in K/L tinnitus grade (14.6 ± 12.7 dB, $n = 15$, versus 9.7 ± 11.9 dB, $n = 2$; $p = .61$). Additionally, it was not greater in patients with resolved tinnitus than in those with some persisting tinnitus (19.0 ± 13.0 dB, $n = 8$, versus 9.6 ± 10.6 dB, $n = 9$; $p = .12$). Similarly, patients with resolved tinnitus did not have a significantly different measure of postoperative overclosure (i.e., the apparent improvement in bone conduction hearing due to the Carhart phenomenon, measured as the preoperative minus postoperative high pure-tone bone-conduction average at 1, 2, and 4 kHz) as compared with that of patients with residual tinnitus (8.6 ± 13.2 dB, $n = 8$, versus 3.0 ± 6.9 dB, $n = 9$; $p = .32$). The sample sizes for these comparisons were consistently small, however. Patient age, gender, duration of hearing loss, and duration of tinnitus were not associated with changes in the K/L tinnitus grade.

We should note that for the patients with no change of or worsened postoperative K/L tinnitus grade, the respective preoperative K/L tinnitus grade was always 2 or greater. Conversely, of the 27 patients with a preoperative K/L tinnitus grade of 2 or greater, 6 (22%) reported no change of grade or a worsened grade postoperatively.

DISCUSSION

Stapedectomy for otosclerosis has been reported to have an unpredictable effect on the symptom of tinnitus [5]. This may be the case especially when the etiology

Table 3. Level 2 Preoperative Audiometric Results with Klockhoff-Lindblom Preoperative Tinnitus Grade

	AC 0.5 kHz	AC 1 kHz	AC 2 kHz	AC 3 kHz	AC 4 kHz	BC 0.5 kHz	BC 1 kHz	BC 2 kHz	BC 3 kHz	BC 4 kHz	K/L TG
1	45	35	30	30	30	15	15	35	30	25	2
2	60	50	35	37.5	40	10	25	30	27.5	25	3
3	50	45	45	35	25	10	20	35	27.5	20	3
4	50	40	30	22.5	15	5	20	10	7.5	5	2
5	75	65	60	50	40	45	30	25	25	25	3
6	60	60	40	37.5	35	5	10	5	12.5	20	0.5
7	40	40	30	30	30	15	10	20	17.5	15	2
8	55	60	50	40	30	20	35	30	32.5	35	2
9	55	60	55	52.5	50	20	10	25	22.5	20	1
10	—	—	—	—	—	—	—	—	—	—	1
11	80	80	105	110	115	60	75	70	72.5	75	1
12	60	55	65	60	55	10	15	25	20	15	1
13	20	25	35	40	45	0	5	15	15	15	2.5
14	70	65	45	45	45	20	40	30	27.5	25	2.5
15	45	45	60	72.5	85	40	35	60	65	70	2.5
16	70	65	75	72.5	70	25	40	50	42.5	35	1.5
17	—	—	—	—	—	—	—	—	—	—	1
18	40	35	15	20	25	5	20	15	15	15	1
19	40	35	75	67.5	60	10	20	40	40	40	3
20	50	40	40	52.5	65	10	10	30	42.5	65	1
21	45	40	30	30	30	20	15	20	20	20	3
22	—	—	—	—	—	—	—	—	—	—	1
23	—	—	—	—	—	—	—	—	—	—	1
24	25	25	20	40	60	10	20	25	32.5	40	2.5
25	75	70	70	70	70	45	40	45	45	45	2.5
26	55	60	65	67.5	70	25	30	60	65	70	2.5
27	60	65	75	70	65	15	25	80	62.5	45	2.5
28	80	90	65	62.5	60	50	45	45	37.5	30	1
29	70	65	55	52.5	50	25	25	40	35	30	2.5
30	60	60	50	40	30	20	30	30	25	20	3
31	55	50	60	50	40	5	10	20	22.5	25	3
32	55	65	70	62.5	55	5	10	20	25	30	3
33	60	60	50	47.5	45	20	40	30	17.5	5	2.5
34	—	—	—	—	—	—	—	—	—	—	0.5
35	—	—	—	—	—	—	—	—	—	—	2
36	65	60	50	52.5	55	20	25	20	20	20	2
37	50	45	30	30	30	15	15	20	20	20	2.5
38	65	65	55	42.5	30	50	55	40	25	10	2
39	40	70	100	95	90	10	45	70	70	70	2.5
40	40	40	30	30	30	15	10	20	17.5	15	2

AC = air conduction [in decibels of hearing loss]; BC = bone conduction [in decibels of hearing loss]; K/L = Klockhoff-Lindblom; TG = tinnitus grade.

of the tinnitus is unknown. However, tinnitus in association with a conductive hearing loss in the setting of otosclerosis may show more consistent improvement after successful stapedectomy surgery than has previously been thought [2–6]. Evident from this study is that when degrees of tinnitus distress can be rendered distinguishable from one another using a standardized classification system, absolute relief of the symptom—and relative improvement in the level of distress associated with the symptom—can be frequent and marked.

This study avoids potential confounding factors, such as that of having various surgeons perform stapedectomy (with possible idiosyncrasies in methodology)

and differences in choice of prosthetic device. A major limitation in the study, however, was a lack of attainable, complete postoperative audiometric data. The audiometric data that were collected demonstrated that both decrease and relief of tinnitus were statistically associated with an improved postoperative air-bone gap. To elucidate further the relationship between changes in the symptom of tinnitus and additional audiometric measures, a greater sample of patients with complete audiometric data may be needed.

Explanation of how successful stapedectomy may improve tinnitus remains to be completely understood. Some have postulated that freedom from the toxic

Table 4. Level 2 Postoperative Audiometric Results with Klockhoff-Lindblom Postoperative Tinnitus Grade

	AC 0.5 kHz	AC 1 kHz	AC 2 kHz	AC 3 kHz	AC 4 kHz	BC 0.5 kHz	BC 1 kHz	BC 2 kHz	BC 3 kHz	BC 4 kHz	K/L TG
1	15	10	5	10	15	—	—	—	—	—	0
2	25	25	15	20	25	10	5	15	12.5	10	0
3	20	15	20	20	20	10	5	15	12.5	10	0
4	25	20	10	22.5	35	15	10	5	10	15	1
5	—	—	—	—	—	—	—	—	—	—	3
6	—	—	—	—	—	—	—	—	—	—	0
7	—	—	—	—	—	—	—	—	—	—	2
8	15	15	10	12.5	15	10	0	10	5	0	0
9	20	10	10	10	10	—	—	—	—	—	0
10	—	—	—	—	—	—	—	—	—	—	0
11	90	105	120	115	110	—	—	—	—	—	2
12	20	15	15	17.5	20	10	5	20	22.5	25	0
13	35	35	20	20	20	5	20	20	17.5	15	0
14	30	25	10	17.5	25	—	—	—	—	—	0
15	55	45	55	67.5	80	40	30	40	52.5	65	1
16	—	—	—	—	—	—	—	—	—	—	0
17	10	10	10	22.5	35	—	—	—	—	—	0
18	15	0	5	10	15	—	—	—	—	—	0.5
19	25	25	35	40	45	15	10	35	35	35	0.5
20	10	5	20	45	70	—	—	—	—	—	0
21	30	15	25	35	45	15	10	20	30	40	0.5
22	15	10	10	35	60	—	—	—	—	—	0
23	20	10	5	12.5	20	—	—	—	—	—	0
24	35	35	25	42.5	60	30	25	30	42.5	55	0
25	60	55	45	60	75	45	40	45	52.5	60	2.5
26	—	—	—	—	—	—	—	—	—	—	0.5
27	—	—	—	—	—	—	—	—	—	—	2
28	25	35	25	30	35	23	25	25	25	25	0
29	—	—	—	—	—	—	—	—	—	—	0.5
30	15	20	30	32.5	35	—	—	—	—	—	1.5
31	50	35	55	65	75	5	5	20	22.5	25	3
32	50	35	30	35	40	5	10	10	7.5	5	0.5
33	—	—	—	—	—	—	—	—	—	—	0
34	5	5	10	22.5	35	—	—	—	—	25	0
35	35	30	40	50	60	30	25	30	40	50	0.5
36	30	15	15	22.5	30	20	15	20	22.5	25	0
37	—	—	—	—	—	—	—	—	—	—	0
38	80	70	55	47.5	40	50	60	45	30	15	1.5
39	35	55	60	65	70	10	35	60	60	60	1.5
40	—	—	—	—	—	—	—	—	—	—	2

AC = air conduction [in decibels of hearing loss]; BC = bone conduction [in decibels of hearing loss]; K/L = Klockhoff-Lindblom; TG = tinnitus grade.

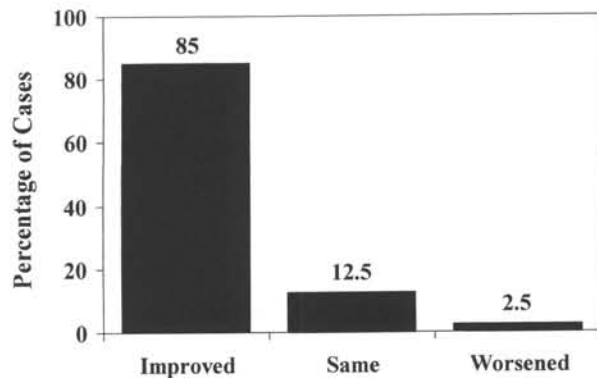


Figure 1. Comparison of preoperative and postoperative Klockhoff-Lindblom tinnitus grades.

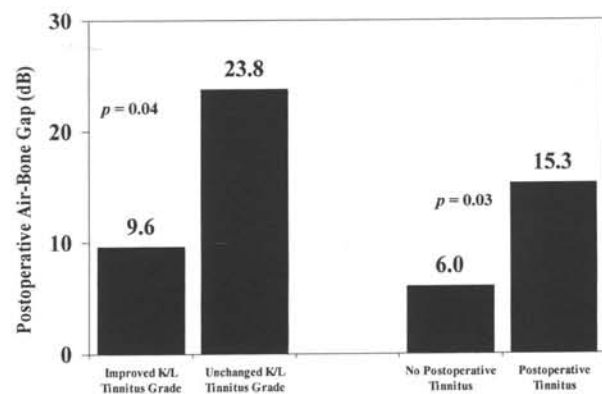


Figure 2. Comparison of postoperative air-bone gap.

factors liberated by the otosclerotic focus into the labyrinthine fluid may be involved [10]. Also suggested is that relief from tinnitus after successful stapedectomy may be due to an auditory effect whereby increased conductive hearing input drowns out spontaneous output from the cochlear nerve or nuclei [4]. Recently, the predictors of tinnitus in otosclerosis were shown to be paradoxical as compared to the determinants of tinnitus in the general population [11]. Although the scientific understanding of the relationship between corrected conductive hearing loss and reduced tinnitus distress continues to develop, it remains of crucial importance for the etiology of tinnitus to be sought in newly presenting patients. As our study demonstrates, by successfully treating the cause when possible, we may attain significant measures of relief.

SUMMARY

Forty patients with tinnitus and otosclerosis were retrospectively reviewed and interviewed to determine the effect of stapedectomy on their tinnitus. Thirty-four patients (85%) had improvement, 12.5% had no change, and 1 patient (2.5%) complained of worsened tinnitus. Successful air-bone gap closure also correlated with reduction in tinnitus distress.

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