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ORIGINAL ARTICLE

The surgical treatment results of otosclerosis at the Department of Otolaryngology Silesian Medical University in Zabrze in years 2000–2010

Authors' Contribution:
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

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ABSTRACT:

Background: Otosclerosis is a cause of 5–9% of all hearing loss. The most effective treatment of otoslerosis is stapedotomy.

Aim: The aim of this study was to evaluate the results of otosclerosis surgical treatment and to examine the impact of disease stage, time of the signs, age and sex on the results.

Material and methods: 105 patients who underwent operation due to otosclerosis at the Department of Otolaryngology University Hospital in Zabrze at the age of 18–65 were analyzed. In 25 patients stapedotomy was bilateral. 130 cases of treated ears were included in the statistical analysis. The state of hearing after operation was evaluated with regard to guidance of Hearing and Balance Committee of American Academy of Otolaryngology – Head and Neck Surgery and with consideration of suggestions made by European Academy of Otolaryngology and Neurootology. Mean values of bone and air conduction, air bone gap before, one year after treatment, and at least 4 years after surgery were compared. The influence of stage of the disease in terms of Shambaugh index, lasting of signs, age and sex were evaluated with regard to change of mean hearing loss according to Bell Telephone Laboratories.

Results: On the basis of hearing examination evaluating improvement in air and bone conduction and reduction of cochlear reserve, very good and good treatment results were obtained in over 90% of patients in short and long term observations. No influence of disease stage, time of signs lasting, age and sex on the results of treatment – with regard to change in mean hearing loss was shown.

KEYWORDS: otosclerosis, stapedotomy, surgical treatment results

INTRODUCTION

Otosclerosis is a temporal bone disease with focal remodeling and immobilization of the stapes within the oval window. Its symptoms include progressive, usually bilateral, asymmetric hearing loss and persistent tinnitus (80% of patients) [1]. Otosclerosis accounts for 5-9% of all hearing losses and 18 to 22% of conductive hearing losses [2]. It is about two times more frequent in females than in males. The symptoms develop in people in their 20s and 30s. The most common location of osteosclerotic lesions is the region of the oval window (its anterior part), but they may also be found: surrounding the round window, in semicircular canals, internal auditory canal, nerve endings of the superior ampullary and lateral branches of the vestibular nerve [3]. Total ossification of the oval window is called obliterating otosclerosis and results in severe conductive hearing loss. The term malignant otosclerosis refers to bone remodeling not only within the oval and round windows, but also affecting inner ear structures, causing progressive mixed hearing loss until total deaf [4].

In diagnosis of otosclerosis, history taking and physical examination of the patient play a significant role, along with tonal, speech

and impedance audiometry, tuning fork tests, and sometimes medical imaging. In diagnosis of otosclerosis, medical imaging is increasingly more popular, such as high-resolution computed tomography (HRTC). In many laryngological centers, HRCT practically replaced Schüller ear radiograms and it is routinely done prior to surgery in patients with conductive or mixed hearing loss [5]. The ultimate confirmation is by detecting immobilization of stapes and osteosclerotic masses during exploratory tympanotomy of the inner ear. Currently, the only therapeutic mode that improves hearing in otosclerotic patients is stapes surgery. The most common procedure is the small-window stapedectomy, named stapedotomy by Fischer and Perkinson. During this procedure, suprastructure of the stapes is removed and a small hole is made in the plate, in which a small prosthesis is inserted, suspended on the incus [6,7]. This method has many modifications. The foramen in the stapes base can be made using a needle, manual perforator, diamond drill or laser. All methods facilitating therapy serve the purpose of obtaining the best therapeutic outcomes lasting for the longest time possible.

The aim of this study was to assess outcomes of surgical treatment in patients with otosclerosis based on the analysis of hearing before and after stapedotomy, as well as to investigate the influence of following factors on the results: advancement of the disease, duration of symptoms prior to surgery (hearing loss, tinnitus), sex and age.

MATERIALS AND METHODS

A total of 105 patients aged 18-65 who underwent surgical treatment due to otosclerosis at the Department of Laryngology in Zabrze over the years 2000-2010 were enrolled in this study. In 25 of them, the procedure was bilateral. The results were analyzed after 130 stapes surgeries. The hearing condition after procedure was assessed according to guidelines of the Hearing Committee of the American Academy of Otolaryngology – Head and Neck surgery, considering suggestions by the European Academy of Otology and Neuro-Otology. The mean values of bone (PK0, PK1, PK2) and air (PP0, PP1, PP2) conduction were compared at the following frequencies – 500, 1000, 2000, 4000Hz, as well as mean cochlear reserve (RS0, RS1, RS2) prior to, one year (early observation) and at least 4 years (late observation) following stapedotomy. Also, changes of the Percentage Hearing Improvement Index (*Wskaźnik Procentowej Poprawy Słuchu* - WPPS) were assessed. The influence of disease stage (according to the Shambaugh Index), duration of symptoms (hearing loss, tinnitus), sex and age on therapeutic outcomes was assessed by a change in mean hearing loss according to the Bell Telephone Laboratories. Based on our own questionnaires, changes in subjective perception of hearing improvement, diminished tinnitus and vertigo were evaluated one year and at least 4 years after procedure.

In the opinion of the Bioethics Commission of the Medical University of Silesia in Katowice, the study did not require their assessment due to the lacking features of a medical experiment (Opinion No KNW/0022/KB/189/12 dated November 13, 2012). For the statistical analysis, t-test for dependent means was used, considering the large number of some results. For the groups of small or uneven size, Wilcoxon test was used (a nonparametric test for dependent variables). The p-value lesser or equal to 0.05 was considered statistically significant. Statistica 98 software was used.

RESULTS

Comparing mean threshold values for air (PP0) and bone (PK0) conduction before the procedure, as well as during early (PP1, PK1) and late (PP2, PK2) observation, a statistically significant decrease in air (Fig.1) and bone (Fig.2) conduction defect was observed.

The greatest improvement was noted at the frequency of 500Hz, and the least improvement at 4000Hz. For bone conduction, the opposite was observed – the greatest improvement was at 4000Hz, and the least – at 500Hz. The differences were statistically significant (p=0.02) (Tab.1).

The cochlear reserve after surgery was calculated based on the postoperative audiograms of air and bone conduction. One year after surgery, very good results (reserve of 0-10dB) was achieved in 99 cases (76.15%), good (11-20dB) in 19 (14.61%), satisfactory (21-30dB) in 8 (6.15%) and unsatisfactory (above 31dB) in 4 (3.07%). In the late observation, the very good results were still seen in 96 cases (73.84%), good in 21 (16.92%), satisfactory in 9 (6.92%) and unsatisfactory in 4 (3.07%). No statistically significant differences were observed between early and late observation. Mean cochlear reserve for the entire group of patients was 21.84dB. One year after surgery, it decreased to 3.67dB, and during late observation - it was 4.91dB. Comparing mean pre- and postoperative cochlear reserve, the observed improvement was statistically significant (p=0.001) (Fig.3).

Evaluating the percentage hearing improvement index after one year (WPPS1), the very good results were achieved in 118 cases, good in 10, and a small improvement was observed in 2 cases. During late observation (WPPS2), the very good results were still observed in 111 cases, good in 9, a small hearing improvement in 9 patients as well, and a lack of improvement was seen in 1 case.

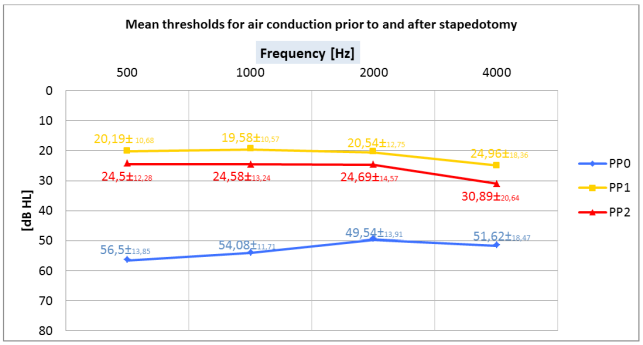

Fig. 1. Mean thresholds for air conduction prior to and after stapedotom

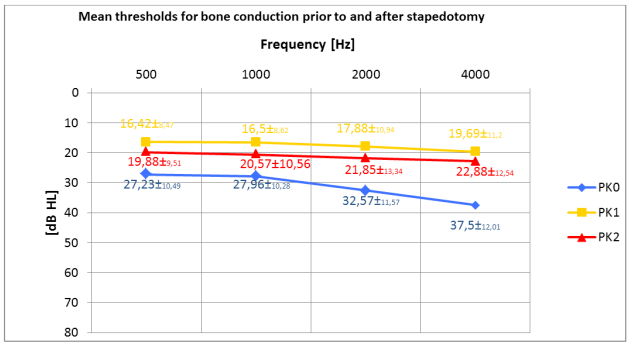

Fig. 2. Mean thresholds for bone conduction prior to and after stapedotomy

To assess the influence of disease advancement on therapeutic outcomes, the patients were divided into three groups prior to surgery, according to the Shambaugh classification. The most numerous group were patients with the highest progression of otosclerosis (group C, 81 ears – 62.3%). Group B contained 41 ears (31.53%), while group A – 8 ears (6.15%). Mean hearing loss prior to surgery (N0%), during early (N1%) and late (N2%) observation were analyzed in relation to the disease advancement according to Shambaugh. The greatest improvement of mean hearing loss was noted in the group with the highest stage of the disease (group C) during both early and late observation. The differences were statistically significant, which allowed to draw the conclusion that the stage of the diseases does not influence the outcomes of surgical treatment of otosclerosis.

To assess the influence of symptom duration prior to surgery on therapeutic outcomes of stapedotomy, the patients were divided into three groups – with symptoms persisting less than 3 years, 3 to 10 years and more than 10 years. The greatest hearing improvement was noted in the group with the longest duration of symptoms, both during early (32.39%) and late (24.90%) observation. The smallest improvement of mean hearing loss was noted in the group with the shortest duration of symptoms, both during early (25.84%) and late (22.70%) observation. The differences were not, however, statistically significant ($p>0.05$).

To assess the influence of age on the results, the patients were divided into three groups – the youngest patients aged 18-33, middle-aged 33-49 and the oldest 50-65. The greatest hearing improvement was noted in the middle-aged group, both during early and late observation. The smallest improvement of mean hearing loss was noted in the oldest group, both during early and late observation. No statistically significant differences were seen between the age groups.

Based on the questionnaires, changes in subjective perception of tinnitus, hearing improvement and decreased vertigo were

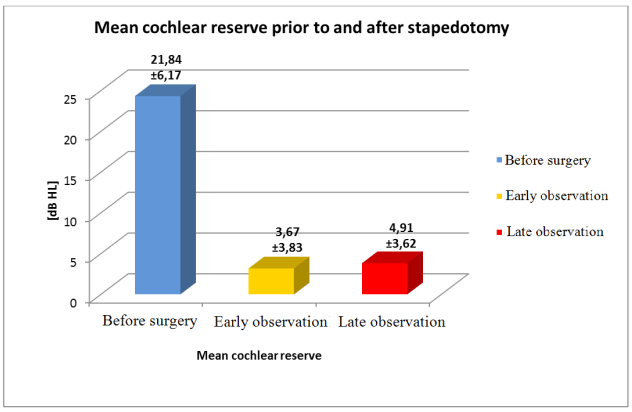

Fig. 3. Cochlear reserve distribution prior to and after stapedotomy

evaluated. Prior to surgery, tinnitus was reported by 92% of patients. On subjective assessment of tinnitus, total resolution was reported by 68%. Prior to surgery, vertigo was reported by 41% of patients. One year after surgery – by 17%, during late observation – by 19%. The differences were statistically significant ($p<0.05$).

DISCUSSION

Numerous publications assessing the efficacy of surgical treatment of otosclerosis present very good postoperative results on both short- and long-term observation. Most otosurgeons prefer stapedotomy due to the lower rate of complications. Stapedotomy causes hearing improvement in more than 90% of patients and decrease or resolution of tinnitus in most of them [8,9,10,11].

In our study, very good and good results were achieved in 91% of cases, considering improved threshold hearing curves, decreased cochlear reserve and WPPS. The improvement was holding despite the passing of time during late observation.

Tab. I. Change in mean threshold air and bone conduction in relation to frequency.

AIR CONDUCTION [DB]			BONE CONDUCTION [DB]	
Early observation (PP0-PP1)	Late observation (PP0-PP2)	Frequency [Hz]	Early observation (PK0-PK1)	Late observation (PK0-PK2)
36,31 ± 9,04	32 ± 8,13	500	10,81 ± 4,23	7,35 ± 3,02
34,5 ± 10,23	29,5 ± 9,08	1000	11,46 ± 4,03	7,39 ± 2,98
29 ± 8,42	24,85 ± 9,14	2000	14,69 ± 6,82	10,72 ± 3,12
26,66 ± 8,13	20,73± 8,42	4000	17,81 ± 5,13	14,62 ± 4,34

PK0 – bone conduction prior to surgery, PK1 – bone conduction one year after surgery
PK2- bone conduction during late observation (at least 4 years after surgery)
PP0 – air conduction prior to surgery, PP1 – air conduction one year after surgery
PP2- air conduction during late observation (at least 4 years after surgery)

In the study by Gierek et al., regarding the cochlear reserve, very good results were achieved in 29.1%, good in 64.6%, satisfactory in 4.7% and unsatisfactory in 1.6% [6]. In the group of 123 patients studied by Lundman, according to AAO-HNS guidelines, mean postoperative cochlear reserve of up to 10dB was achieved in 77% of patients, 11-20bD in 18% [12]. Similar results were presented by Somers. Postoperative cochlear reserve rated very good was present in 81% of patients [13]. Very good results were reported by Vincent et al., where the cochlear reserve of less than 10dB was achieved in 94.2% in the large population of 3050 patients [14]. The results of otosclerosis treatment in our study are, considering reduction of cochlear reserve, comparable with most data reported by other authors [6, 12, 13, 14].

In the available literature, 65-92% of patients with otosclerosis report tinnitus, with clear dominance of females [15, 16, 17]. In our study, 92% of patients reported tinnitus prior to surgery. On subjective assessment of tinnitus, total resolution was reported by 68%. In the study by Gierek et al., tinnitus prior to surgery was reported by 78% of patients, and total resolution was observed in 74%. Decrease in intensity was seen in 4%, while no change – in 19% of them [6]. Similar results were presented by Ayache et al., where 74% of patients reported tinnitus before surgery. Total resolution of tinnitus after surgery was reported by 55.9%, while decrease in intensity by 34%. The same intensity persisted in 8.8% [19]. Lundman reports resolution of tinnitus in 52% of patients after operation [12]. In the study by Terzic et al., 91% of patients reported tinnitus before surgery. On year after operation, 89% of them were free of this symptom [17]. In the study by Mahafz et al., 78.8% of patients reported tinnitus before surgery. Only 26.8% reported total resolution, while 62% reported decrease in intensity [15]. The results of our study concerning tinnitus reduction following stapedotomy do not differ significantly from data in the world literature [18, 20]. The result analysis of surgical treatment outcomes in otosclerosis confirms widely available reports on high efficacy of stapedotomy in patients suffering from otosclerosis during both early observation and many years after surgery.

CONCLUSIONS

- 1. Based on the analysis of hearing results (assessing improvement in air and bone conduction, reduction of cochlear reserve and WPPS), very good and good results were achieved in more than 90% of patients treated surgically for otosclerosis during both early and late observation. The results of our tinnitus and vertigo survey confirmed significant reduction of tinnitus and vertigo in patients during both early and late observation.
- 2. The analysis of relationship between the outcomes of surgical treatment for otosclerosis and selected factors demonstrated the lack of
  a. significant influence of disease advancement (assessed using the Shambaugh index) on therapeutic outcomes despite the fact that the best results were obtained in the group with the most advanced form of otosclerosis.
  b. significant influence of duration of symptoms on the results.
  c. influence of age and sex on the results of surgical treatment for otosclerosis assessed by a change in mean hearing loss.

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