

The late results of 4000 Hz frequency bone conduction after tympanoplasty

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Article history: Received: 23.02.2017 Accepted: 06.09.2017 Published: 31.10.2017

ABSTRACT:

Introduction: Surgical treatment of conductive hearing loss runs the risk of damage to the inner ear in the mechanism of acoustic trauma.

Aim: The aim of this study was to evaluate the function of the organ of Corti, expressed as bone conduction threshold at the frequency of 4000 Hz for selected operations: mastoidectomy and canal wall-down procedure.

Material and methods: The material was collected among patients with chronic otitis media in the Department of Otolaryngology and ENT Oncology, Collegium Medicum of Nicolaus Copernicus University in Bydgoszcz in 2004–2009. All patients were examined with pure tone audiometry threshold before surgery and at least three years after surgery. The analyzed group of patients was divided into subgroups depending on the type of operation according to Tos classification and procedures for resection: mastoidectomy and canal wall-down procedure. The results were statistically analyzed.

Results: In the analyzed period of three years after surgery there was no statistically significant difference between groups, although there were higher values for tympanoplasty type 1 with mastoidectomy compared with tympanoplasty type 1 without mastoidectomy - respectively 25.67 dB and 18.53 dB. In the study there was no statistically significant difference in bone conduction threshold for frequency 4000 Hz within the type 2 tympanoplasty according to Tosa comparing canal wall-up and canal wall-down procedure.

Conclusions: Mastoidectomy or canal wall-down procedure do not affect the bone conduction threshold for a frequency of 4000 Hz after tympanoplasty in long term observation.

KEYWORDS:

sensorineural hearing loss, tympanoplasty, mastoidectomy, canal wall-up procedure, canal wall-down procedure

INTRODUCTION:

Surgical treatment of conductive hearing loss may cause damage to the inner ear by an acoustic or mechanical trauma while manipulating the ossicles, especially the stapes [1,3]. Tympanoplasty involves resection requiring a drill. The tool emits noise, which can reach high intensity within the tympanic cavity, which in turn is located in the close proximity to the cochlea. Most bone is resected in the cases of mastoidectomy and the posterior-wall resection of the auditory meatus.

Bone conduction threshold at 4000 Hz frequency is the most sensitive parameter to evaluate the spiral organ activity. Hearing loss at 4000 Hz for bone conduction is an accepted indicator of the postoperative damage of the cochlea (e.g. due to acoustic damage during the mastoidectomy, or as a result of manipulations to the ossicles, especially the stapes) [1,2,3,4]

AIM:

The aim of the study was to evaluate the activity of the spiral organ, expressed by the threshold of bone conduction at 4000 Hz after resection procedures: mastoidectomy or posterior-wall resection of the auditory meatus, during a long-term observation.

MATERIAL

Materials for the study were collected among patients treated for chronic otitis media in the Department of Otolaryngology and Laryngological Oncology, Collegium Medicum of Nicolaus Copernicus University in Bydgoszcz between 2004 and 2009. Among patients, 46 (53.5%) were females and 40 (46.5%) were males. The mean age was 40.5. The youngest patient was 18 years old, while the oldest one was 72 years old.

METHOD

The analysis included a selected group of 86 patients, who were subjected to the postoperative examination. Time period between the surgery and the examination ranged between 3 and 7 years, with the mean value of 5.43 years. Since the time of operation, patients denied any history of hearing-damaging factors such as an acoustic trauma, work in the noise, taking any ototoxic medications etc.

The inclusion criteria included: chronic otitis media and a full medical documentation. Patients were operated by two experienced otolaryngology surgeons.

Other laryngological conditions and systemic diseases, which might have affected hearing such as hypertension, diabetes, atherosclerosis, as well as a mechanical trauma of the middle and inner ear, an acoustic trauma and the incomplete medical documentation excluded a patient from the studied group. Only 13 patients in the studied group were older than sixty (15.1%).

Every patient was subjected to pure tone audiometry before and at least 3 years after surgery. The studied group was divided into subgroups, depending on type of tympanoplasty according to Tos classification as well as resection procedures: mastoidectomy and posterior-wall resection of the auditory meatus. The collected data were statistically analysed [5].

RESULTS

In the of 86 patients, 98 tympanoplasties were performed. Six patients underwent surgery on both sides, with at least a 12-month interval between interventions.

According to Tos classification, 51 patients (52.0%) underwent type 1 tympanoplasty, including 21 patients who were subjected only to myringoplasty without mastoidectomy. Also, 29 patients (29.6%) underwent type 2 tympanoplasty, while 12 patients (12.2%) were subjected to type 3 tympanoplasty, and 6 patients (6.1%) underwent type 4 tympanoplasty.

Closed tympanoplasty was performed in 75 cases (76.5%), while open surgery - in 23 cases (23.5%).

In order to evaluate the activity of the inner ear according to the type of the performed surgical procedure (mastoidectomy and posterior-wall resection of the auditory meatus), the analysis of long-term results of pure tone audiometry at 4000 Hz frequency with respect to the type of the procedure was conducted (Figure 1).

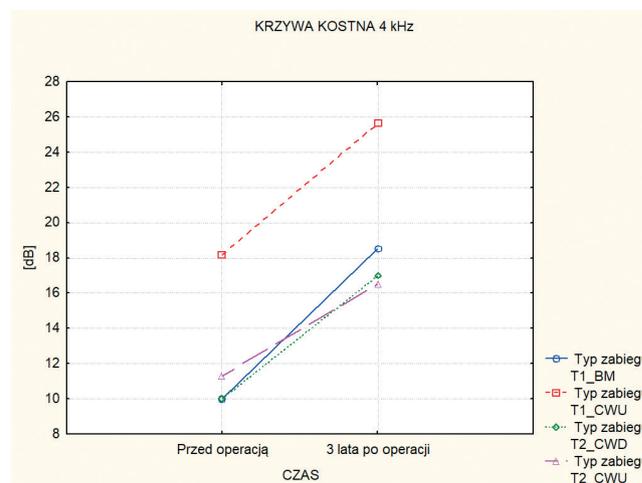


Fig. 1. Threshold of bone conduction at 4000 Hz frequency, with respect to the type of procedure (mastoidectomy, posterior-wall resection).

Thresholds of bone conduction at 4000 Hz were compared between the group of patients undergoing type 1 tympanoplasty without mastoidectomy, and patients, in whom type 1 tympanoplasty was performed together with mastoidectomy.

Difference between thresholds of bone conduction at 4000 Hz between the compared groups were statistically significant. Thresholds of bone conduction in group of tympanoplasty type 1 without mastoidectomy were lower, compared to those in the group, where type 1 tympanoplasty was accompanied by mastoidectomy (Table I).

The results 3 years after operation showed no significant difference between the groups, despite higher values in group where tympanoplasty type 1 was performed with mastoidectomy, compared to the group, where tympanoplasty type 1 was performed without mastoidectomy –25.67 dB and 18.53 dB respectively.

The results show that performing mastoidectomy does not affect significantly bone conduction thresholds at 4000 Hz frequency, which means it does not damage the inner ear (Table 2)

Thresholds of bone conduction at 4000 Hz between the group where type 2 tympanoplasty was performed without posterior-wall resection (closed technique), and the group where patients underwent type 2 tympanoplasty with posterior-wall resection of the external auditory meatus (open technique) were compared.

On the preoperative examination in patients with both open and closed technique, no statistically significant differences

Tab. I. Bone conduction at 4000 Hz frequency before the procedure, with respect to mastoidectomy being performed or not ($p=0.0479$).

	[DB] MEAN	PU-95%	PU+95%	N	SD	SE	MINIMUM	MAXIMUM	Q ₂₅	ME	Q ₇₅
T1_BM	10.00	5.02	14.98	17	9.68	2.348	0.00	35.00	5.00	10.00	15.00
T1_CWU	18.17	13.30	23.03	34	18.10	2.44	0.00	60.00	5.00	20.00	32.50

T1_BM – tympanoplasty type 1 according to Tos classification without mastoidectomy (Myringoplasty)

T1_CWU – type 1 tympanoplasty according to Tos classification with mastoidectomy (posterior-wall resection of the auditory meatus),

dB – decibel

N – number of patients in the group

SE – error of standard deviation of the mean

Me – median

PU – upper and lower confidence limits for the mean,

SD – standard deviation of the mean

Q₂₅ – upper quartiles

Q₇₅ – lower quartiles

Tab. II. Bone conduction at 4000 Hz three years after surgery with respect to mastoidectomy being performed or not ($p=0.2335$).

	[DB] MEAN	PU -95%	PU +95%	N	SD	SE	MINIMUM	MAXIMUM	Q ₂₅	ME	Q ₇₅
T1_BM	18,53	8,67	28,39	21	19,18	4,653	0,00	65,00	5,00	15,00	30,00
T1_CWU	25,67	17,01	34,32	30	23,18	4,233	0,00	90,00	5,00	22,50	40,00

T1_BM – tympanoplasty type 1 according to Tos classification without mastoidectomy (Myringoplasty),

T1_CWU – type 1 tympanoplasty according to Tos classification with mastoidectomy (posterior-wall resection of the auditory meatus),

dB – decibel

N – number of patients in the group,

SE – error of standard deviation of the mean

Me – median

PU – upper and lower confidence limits for the mean

SD – standard deviation of the mean

Q₂₅ – upper quartiles

Q₇₅ – lower quartiles

between the thresholds of bone conduction at 4000 Hz were observed in the case of type 2 tympanoplasty according to Tos classification (Table 3).

Three years after surgery, no statistically significant difference between closed and open type 2 tympanoplasty was observed.

The results show that posterior-wall resection of the external auditory meatus does not affect bone conduction at 4000 Hz, which means it does not cause damage to the inner ear (Table 4)

DISCUSSION

For the evaluation of the influence of mastoidectomy on the inner ear function, the analysis of the results of bone conduction in pure tone audiometry at 4000 Hz frequency was performed. Mean values of the thresholds after procedure of both type 1 tympanoplasty with and without mastoidectomy were compared. Despite higher values in the group, where mastoidectomy was also performed – 27.5 dB, compared to the group where patients did not undergo mastoidectomy – 18.5 dB, respectively, statistically significant difference between both

groups was not found. The results show that performing mastoidectomy does not significantly worsen bone conduction thresholds at 4000 Hz. The same analysis was performed for the groups of patients, who were subjected to type 2 tympanoplasty. The results of bone conduction at 4000 Hz three years after surgery were compared between the groups with either close or open technique, and any statistically significant difference was not found (16.5 dB and 17 dB respectively). The results show that posterior-wall resection does not worsen bone conduction threshold at 4000 Hz, which means it does not cause damage to the inner ear.

Mastoidectomy, and especially posterior-wall resection of the auditory meatus, are resection procedures, which require removal of fragments of the temporal bone using a drill. The noise emitted by the tool reaches the intensity of 80-120 dB within the operated site [6,7,8], while in the cochleostomy it can reach even more than 130 dB [7]. Therefore, there is a possibility of damaging the inner ear by an acoustic or mechanical trauma during manipulation of the ossicles, especially the stapes. In this study, such mechanism of the cochlear trauma was not observed. The results are in accordance with the literature. The majority of authors did not report a permanent decrease in bone conduction

Tab. III. PBone conduction at 4000 Hz before surgery, with respect to open and closed technique in type 2 tympanoplasty according to Tos classification (p=0.8438)

	[DB] MEAN	PU -95%	PU +95%	N	SD	SE	MINIMUM	MAKSIMUM MAXIMUM	Q ₂₅	ME	Q ₇₅
T2_CWD	10,00	0,18	19,82	6	7,91	3,536	0,00	20,00	5,00	10,00	15,00
T2_CWU	11,30	5,43	17,18	23	13,59	2,833	0,00	50,00	0,00	5,00	20,00

T2_CWD – type 2 tympanoplasty according to Tos classification with resection of the posterior wall of the external auditory meatus

T2_CWU – type 2 tympanoplasty according to Tos without resection of the posterior wall of the external auditory meatus

dB – decibel

N – number of patients in the group

SE – error of standard deviation of the mean

Me – median

PU – confidence limits for the mean

SD – standard deviation of the mean

Q₂₅ – upper quartiles

Q₇₅ – lower quartiles

Tab. IV. Bone conduction at 4000 Hz frequency three years after surgery, with respect to closed and open technique in type 2 tympanoplasty according to Tos classification (p=0.9606).

	[DB] MEAN	PU -95%	PU +95%	N	SD	SE	MINIMUM	MAKSIMUM MAXIMUM	Q ₂₅	ME	Q ₇₅
T2_CWD	17,00	1,42	32,58	6	12,55	5,612	5,00	35,00	5,00	20,00	20,00
T2_CWU	16,52	9,96	23,09	23	15,18	3,166	0,00	45,00	0,00	20,00	30,00

T2_CWD – type 2 tympanoplasty according to Tos classification with resection of the posterior wall of the external auditory meatus

T2_CWU – type 2 tympanoplasty according to Tos without resection of the posterior wall of the external auditory meatus

dB – decibel

N – number of patients in the group

SE – error of standard deviation of the mean

Me – median

PU – confidence limits for the mean

SD – standard deviation of the mean

Q₂₅ – upper quartiles

Q₇₅ – lower quartiles

threshold [6,9,10,11,12], at most temporary [13]. However, it is difficult to compare those reports directly, because they differ in studied frequencies and the observation period. Increasing hearing threshold due to an acoustic or mechanical trauma affects primarily high frequencies and it is accepted that the audiometry of high frequencies is suitable for diagnosis of this kind of injury [14]. It has been shown that in 37.5% of cases, the hearing impairment affected high frequencies (over 8000 Hz) [14]. However, many authors prefer threshold at 2000 Hz and 4000 Hz frequencies as they are crucial for understanding speech, and permanent deficits in this range has not been proven [10,12,13]. The reliability of those reports is limited by the small number of the studied patients: 24, 51 and 65 respectively [14,13,9].

The observation period is also a subject of debate. The study evaluated the long-term results. The hearing threshold before tympanoplasty was compared with the result obtained at least 3 years after surgery. In the literature, the observation period has usually been shorter (3 weeks, 8 weeks, 6 months respectively) [12,9,13], and often it is limited to mainly first days after operation (1st day or 4th day, respectively) [13,12]. The concept of short observation period is reasonable, because the longer the observation period, the more factors may cause damage to the inner ear. Therefore,

there is no information regarding long-term results in the cited publications. However, in our opinion, long-term observation is equally important, or even more important considering patient and their hearing. In order to limit the influence of postoperative factors, criteria of inclusion to the examined group were very strict, including patient's age. Despite the long observation period, statistically significant differences between the group of patient who underwent mastoidectomy, and the control group where mastoidectomy was not performed was not found, and no statistically significant difference between posterior-wall resection group and the control group (without posterior-wall resection of the auditory meatus) was found.

Some studies focus on total hearing loss (the so-called 'dead ear'), the occurrence of which is estimated to be 0.2% to 1% [15,16]. In our study, this type of complication was not observed.

CONCLUSIONS

Performing mastoidectomy or posterior-wall resection of the auditory meatus does not increase the bone conduction threshold at 4000 Hz frequency in long-term observation.

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Word count: 1800 Tables: 4 Figures: 1 References: 16

Access the article online: DOI: 10.5604/01.3001.0010.5312 Table of content: <https://otolaryngologypl.com/resources/html/articlesList?issuelid=10369>

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Competing interests: The authors declare that they have no competing interests.

Cite this article as: Nazwisko: The late results of 4000 Hz frequency bone conduction after tympanoplasty; *Otolaryngol Pol* 2017; 71 (5): 13-18