

# Postoperative bone conduction threshold changes in patients operated on for chronic otitis media – analysis

## Analiza pooperacyjnej zmiany progu przewodnictwa kostnego u chorych operowanych z powodu przewlekłego zapalenia ucha środkowego

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### ABSTRACT:

**Background:** Postoperative hearing improvement is measured as Air-Bone gap changes. Changes in bone conduction thresholds as a results of otosurgery is also discussed.

**Aim:** We discuss factors that have influence on bone conduction thresholds changes in individuals operated due to chronic otitis media.

**Material and methods:** The prospective analysis involves the patients operated on middle ear due to chronic infection in the Department of Otolaryngology at the Jagiellonian University of Krakow in the years 2010-2013. 457 otosurgeries were performed in this period of time.

**Results:** 293 first time operated on patients with chronic otitis media were analysed. Statistically significant bone conduction improvement was noticed after myringoplasty and in individuals with intact ossicular chain. No bone conduction thresholds improvement was observed with defects to the ossicles.

**Conclusions:** Unchanged mucous lining middle ear spaces and intact ossicular chain are crucial for bone conduction improvement after otosurgery. Scars, especially in round window, are poor prognostic factor for hearing improvement. Cleaning of the middle ear from granulation has an positive influence for bone conduction thresholds changes.

### KEY WORDS:

middle ear, bone conduction thresholds, otosurgery

### STRESZCZENIE:

**Wstęp:** Miarą pooperacyjnej poprawy słuchu jest zmiana wartości rezerwy ślimakowej. Dyskutowany jest także wpływ czynności układu przewodzącego ucha środkowego na odpowiedź ucha wewnętrznego.

**Cel pracy:** Celem prowadzonych badań jest analiza czynników mających wpływ na zmianę przewodnictwa kostnego u chorych operowanych z powodu przewlekłego zapalenia ucha środkowego.

**Materiał i metoda:** Badanie miało charakter prospektywnej analizy chorych operowanych z powodu schorzeń ucha środkowego w Klinice Otolaryngologii UJ CM w Krakowie w latach 2010-2013. W analizowanym przedziale czasu wykonano 457 pierwszorazowych operacji usznych.

**Wyniki:** W pracy rozpatrywano 293 chorych operowanych po raz pierwszy z powodu przewlekłego zapalenia ucha środkowego. Statystycznie istotną poprawę przewodnictwa kostnego obserwowano u części chorych po myringo-

plastyce, przy niezmienionym łańcuchu kosteczek słuchowych. Nie obserwowano poprawy przewodnictwa kostnego u chorych z rekonstruowanym łańcuchem kosteczek słuchowych.

**Wnioski:** Niezmieniona wyściółka ucha środkowego oraz zachowany łańcuch kosteczek słuchowych są czynnikami prognostycznie korzystnymi odnośnie do pooperacyjnej poprawy wartości przewodnictwa kostnego. Zrosty w jamie bębenkowej, a zwłaszcza w niszy okienka okrągłego, są czynnikiem niekorzystnym pod względem rokowań co do poprawy przewodnictwa kostnego u chorych z myringoplastyką. Usunięcie zmian ziarninowych z jamy bębenkowej ma korzystny wpływ na czynność ucha wewnętrznego.

**SŁOWA KLUCZOWE:** ucho środkowe, przewodnictwo kostne, otochirurgia

## INTRODUCTION

The clinical picture of chronic otitis media includes tympanic membrane perforation, ear discharge, as well as conductive or mixed hearing loss. The disease can be classified into several types according to the type of mucous membrane lesions: simple otitis media, chronic otitis media with cholesteatoma, granulomatous otitis media and otitis media associated with specific diseases.

Ear surgery is the treatment method of choice in cases of chronic inflammatory lesions. Conservative treatment should be implemented only in exacerbations, in which there is a need to control the ear discharge and to achieve a “dry ear”.

The aim of surgical procedures is to remove the pathology, ensure proper drainage and to reconstruct the sound conduction system.

The improvement in hearing is indicated by the grade of the air-bone gap closure, which is considered an element of auditory ossicular chain reconstruction. Total air-bone gap closure, synonymous with the restoration of proper hearing (if there is no sensory hearing loss component), can be achieved if the ossicular chain is completely preserved and exhibits physiological mobility. Virtually, it corresponds with pure myringoplasty in chronic otitis media or stapedoplasty in otosclerosis.

The influence of the middle ear conduction system on the functioning of the inner ear has been discussed for a long time. The preservation of the Carhart's notch in patients undergoing surgical treatment due to otosclerosis is an example of the bone conduction threshold change after middle ear surgery.

The studies conducted by Vartiainen et al. performed on 181 patients who were treated due to chronic otitis media revealed the following results: no change in bone conduction threshold was observed after the procedure in 92% of patients, improvement was noted in 5% of patients, and deterioration was ob-

served in 3% of patients. Improvement in the range of 11 to 25 dB was observed after severe lesions were removed from the tympanic cavity.

On the average, improvement in bone conduction is observed in almost 10% of patients treated surgically because of chronic inflammatory lesions of the middle ear [1,2,3,4,5].

In the light of the presented data, the types of pathological lesions within the middle ear and their influence on middle ear function require further analysis.

## AIM OF THE STUDY

The aim of the study was to analyze factors that influence changes in bone conduction in patients operated on because of chronic otitis media.

## MATERIAL AND METHOD

The study comprised a prospective analysis of patients treated surgically for the first time due to chronic otitis media at the Department of Otolaryngology in Cracow between 2010 and 2013.

The patients were classified into the groups presented in Table 1 with respect to the pathology of the middle ear lining and the type of tympanoplasty performed.

The authors prepared a form that included symptoms reported by patients in the preoperative period, preoperative hearing test, lesions observed in middle ear surgery and the type of sound conduction system reconstruction. Postoperative hearing test was performed 6 and 12 months after surgical treatment.

Changes in bone conduction, expressed as the mean value for speech frequency (500, 1000, 2000 Hz), were analyzed for each patient group distinguished earlier.

**Tab. 1.** Characteristics of the patient group operated on because of chronic otitis media.

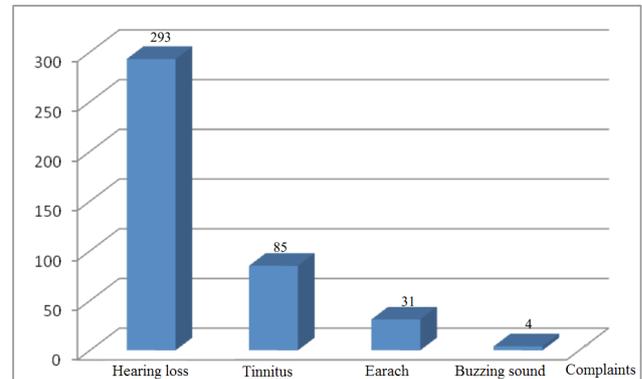
Group No.	No. of patients	Characteristics of patients
<b>Groups with myringoplasty, without ossiculoplasty (151 patients)</b>		
group 1	24	Control group– myringoplasty, physiological middle ear space lining (dry perforation)
group 2	27	myringoplasty, without ossiculoplasty, no discharge reported by the patient, but with scars and other lesions
group 3	38	myringoplasty, without ossiculoplasty, discharge reported by the patient
group 4	34	myringoplasty, without ossiculoplasty, scars in middle ear spaces
group 5	28	myringoplasty, without ossiculoplasty, granulation tissue in middle ear spaces
<b>Groups with ossiculoplasty (142 patients)</b>		
group 6	24	ossiculoplasty, additionally modeled own ossicle (malleus or incus) placed on an intact stapedus; cholesteatoma
group 7	22	ossiculoplasty, additionally modeled own ossicle (malleus or incus) located on an intact stapedus; without cholesteatoma
group 8	32	ossiculoplasty, tympanic membrane graft located on an intact stapedus
group 9	38	ossiculoplasty, tympanic membrane graft located on the stapedus plate (palisade created of cartilage strips between the plate of the stapedus and a tympanic membrane graft)
group 10	26	ossiculoplasty, ear ventilation tube placed on anormal stapedus

The results were analyzed statistically. Results for which  $P < 0.05$  were considered statistically significant.

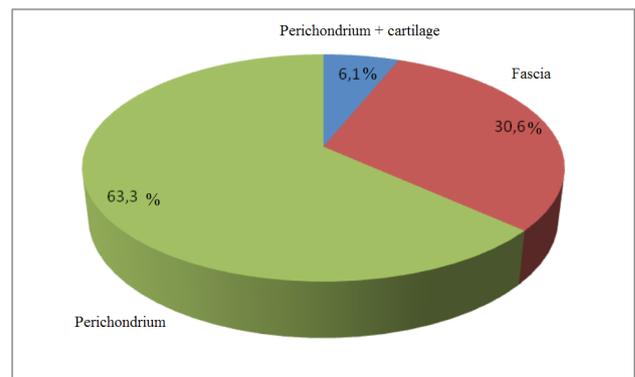
## RESULTS

Ear surgery was performed from 2010 to 2013 in 457 patients at the CM UJ Department of Otolaryngology. The youngest patient was 6 years old, the oldest 80. The mean age was 40.84 years. In the discussed time period, 293 patients were treated for the first time because of chronic otitis media, and that group was included in the study. It comprised 152 females and 141 males. The youngest patient undergoing surgery was 22 years, the oldest one was 66. The mean age was 43.96 years.

All patients complained of hearing loss before surgery. Tinnitus was reported by 30% of the patients (Fig. 1). Almost 70% of patients reported constant or intermittent discharge from the affected ear.

**Fig. 1.** Complaints reported by patients in the preoperative period

Perichondrium acquired from the tragus of the auricle was chosen for tympanic membrane reconstruction in most cases. Temporal muscle fascia was used less frequently. In a few cases the perichondrium reinforced with cartilage of the tragus was used (Fig. 2).

**Fig. 3.** Material used for tympanic membrane reconstruction

Closed tympanoplasty was performed in 215 patients, whereas open tympanoplasty was performed in the remaining 78 patients. In 60 patients surgery involved the tympanic membrane only. Atticoantromastoidectomy was performed in 120 patients in order to achieve proper insight into the middle ear spaces in which a pathological process was determined (Fig. 3).

The researchers attempted to determine whether the observed change in the mean value for bone conduction within each group at the 6- and 12-month follow-up was statistically significant. It was achieved by analyzing the variance of the outcomes with respect to time.

The behavior pattern of bone conduction was observed for each group (Tab. 2, Tab. 3).

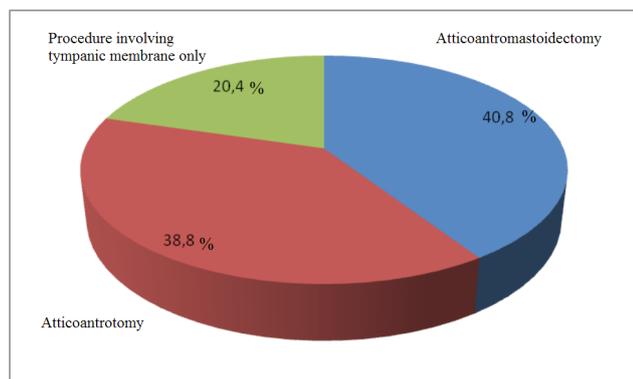


Fig. 3. Structure involvement in the procedure.

Following abbreviations were used for our considerations:

X gr. 'i' = mean value for bone conduction for the 'i' group,

in which 'i' indicates the number of the analyzed group (1 – 10)

SD gr. 'i' = standard deviation of the mean value for bone conduction in the 'i' group, in which 'i' indicates the number of the analyzed group. (1 – 10)

Statistically significant changes in mean bone conduction were observed in the group of patients with dry tympanic membrane perforation and intact auditory ossicular chain (**group 1**). The mean value for bone conduction observed at the 12-month follow-up was significantly lower than the preoperative mean value for bone conduction, and statistically equal to the mean value for bone conduction measured 6 months after the procedure. The mean value for bone conduction 6 months after the procedure was significantly lower than its preoperative mean value.

Table 2. Mean value for bone conduction in groups without ossiculoplasty, with myringoplasty, at the time of surgery, 6 and 12 months afterwards (statistically significant change in bone conduction indicated by red color)

Time (months)	X gr. 1	SD gr. 1	X gr. 2	SD gr. 2	X gr. 3	SD gr. 3	X gr. 4	SD gr. 4	X gr. 5	SD gr. 5
0	28.54	12.72	27.43	15.36	23.50	11.20	25.63	16.72	21.19	7.88
6	18.40	11.94	20.80	14.26	16.97	10.31	23.13	14.79	16.19	7.29
12	20.69	11.37	20.86	11.28	18.11	10.62	22.35	13.89	15.71	6.53

Table 3. Mean value for bone conduction in groups with ossiculoplasty at the time of surgery, 6 and 12 months afterwards.

Time (months)	X gr. 6	SD gr. 6	X gr. 7	SD gr. 7	X gr. 8	SD gr. 8	X gr. 9	SD gr. 9	X gr. 10	SD gr. 10
0	27.57	19.07	30.07	13.80	34.58	19.03	25.35	10.97	29.74	13.14
6	26.74	17.30	24.77	12.37	34.27	16.87	23.42	13.09	29.74	14.43
12	26.04	16.61	26.43	13.93	35.62	16.59	23.59	12.43	25.25	14.16

Neither 6, nor 12 months after surgery did the authors observe any statistically significant changes in the mean value for bone conduction in **group 2**. Typical simple chronic otitis media symptoms were characteristic of this group of patients. Removal of hyperplastic lesions that involved middle ear lining followed by myringoplasty did not lead to any statistically significant changes in bone conduction, as stated during follow-up appointments.

The change in bone conduction was statistically significant in **group 3**. The main symptom reported preoperatively by patients in that group was ear discharge. Improvement (i.e. decrease in mean bone conduction values) was observed after 6 months and it was still apparent at the 12-month follow-up appointment. The mean value for bone conduction measured 6 months after the procedure was statistically equal to the mean value for bone conduction 12 months after surgery.

Removing scars from the tympanic membrane in patients with an intact auditory ossicular chain, i.e. in **group 4**, did not lead to any statistically significant changes that could be observed during follow-up appointments.

A statistically significant change in bone conduction was observed in patients without ossiculoplasty with granulation tissue (**group 5**).

In all groups (**groups 6-10**), in which destruction of the ossicular chain was observed, no statistically significant changes in bone conduction values were observed for speech frequencies, independently of the type of the procedure that was performed in those patients in order to reconstruct the middle ear conduction system.

## DISCUSSION

The change in air-bone gap, especially significant for the speech frequency range (500-2000Hz), is a measure of improvement in hearing after middle ear surgery. It should be taken into account that the reconstruction of the middle ear sound conduction system leads to an alteration in the response of the inner ear.

Improvement in bone conduction is observed in almost 10% of patients treated surgically because of chronic otitis media [1,2,3,4,5].

Many researchers have been trying to figure out the relationship between the severity of the pathological process within the middle ear and its influence on the inner ear, which would manifest itself as an increase in bone conduction threshold.

Numerous analyses indicate that such a relationship is indisputable [2,3]. Significant observations were made in patients with middle ear lining pathology (advanced cholesteatoma) or auditory ossicle destruction. The above-mentioned factors seem to influence the functioning of the inner ear indirectly by affecting the mechanics of the auditory ossicular chain.

Pathology within the middle ear lining can interfere with the restoration of full relationships between the bone conduction threshold and the auditory ossicular chain. Preserving all ossicles after the removal of pathological lesions creates optimum environment for the improvement in hearing.

The influence of auditory ossicular chain mechanics on the values of bone conduction is expressed at most as the improvement in bone conduction threshold for the frequency of 2000 Hz in patients in whom a reduction of air-bone gap for the frequencies of 500, 1000, 2000 and 4000 Hz was achieved. Tonndorf believes that the biggest value for the aberration within bone conduction for the frequency of 2000 Hz is caused by the decrease in the resonance within the auditory ossicular chain or by its elimination. The change in bone conduction caused by the ankylosis of stapedus in otosclerosis, described in 1958 by Carhart [6,7], may be an example that illustrates this phenomenon. The resonance of the auditory ossicular chain in humans is estimated at 1500-2000 Hz.

This effect is also observed in disorders that involve the remaining ossicles [8].

The toxic influence of mediators of the inflammatory process within the middle ear on inner ear physiology was proposed as a possible explanation for the pathology in bone conduction. It is also underlined that biochemical alterations in the perilymph and endolymph may be induced by the influence of substances that penetrate from the middle ear through the round window.

In many cases these mechanical and biochemical factors act simultaneously. It is believed that bone conduction impairment in chronic otitis media may be caused by a chronic inflammatory process. However, it can also be of iatrogenic origin resulting from the manipulations performed on the auditory ossicular chain, as well as from the noise that accompanies the opening of the temporal bone [9,10].

Mean values for bone conduction were measured before surgical treatment and after 6 and 12 months of follow-up for the purposes of the statistical analysis. Gaussian or near-Gaussian distribution, a condition essential to perform the statistical analysis, was observed for all time periods.

The repair of dry tympanic membrane perforation with no accompanying pathology resulted in significant improvement in bone conduction observed 6 months after surgery. The improvement was still apparent 12 months after the procedure. The treatment method implemented in that group restored the relationship between the middle ear mechanics and the inner ear function in the most physiological way.

The post-operative outcome concerning bone conduction improvement was the same in the group reporting discharge before surgery and the group who had not reported this symptom earlier due to the fact that appropriate pharmacotherapy, which enabled to achieve a "dry ear", was implemented before tympanic membrane reconstruction.

Reports concerning negative influence of lesions located in the round window area on bone conduction are widely known [10,11,12]. The analysis of the patient treated surgically at the CM UJ Dept. of Otolaryngology confirms this observation. No statistically significant improvement in bone conduction after surgery was observed in patients with scars within the tympanic membrane. One could try to explain it by the tendency of the ossicles to exhibit limited mobility despite even partial restoration of scars after the procedure. The highest risk of not gaining improvement in bone conduction is observed in cases of scars located in the space of the round window.

The removal of granulomatous lesions appeared to be a favorable prognostic factor influencing inner ear physiology. In those cases, not only were the lesions within the lining removed, but also toxic influence of inflammatory mediators on the functioning of the inner ear was eliminated. In that group, however, no improvement in hearing, expressed as the change in air-bone gap, was observed, as post-operative improvement in hearing in those patients was not statistically significant.

No improvement of bone conduction values was observed post-operatively in patients with auditory ossicular chain destruction, independent of air-bone gap closure characteristic of the reconstruction method.

The change in bone conduction threshold curve in some patients after myringoplasty allows us to suspect that statistically significant influence of the procedure within the middle ear on the function of inner ear can be assessed only when the auditory ossicular chain is completely preserved. The change in bone conduction values after otosurgery due to otosclerosis (Carhart's notch preservation) confirms this observation. Therefore, one could draw the conclusion that only those surgical procedures that enable the restoration of physiological relationships in the ossicular chain along with the restoration

of its characteristic resonance frequency will exert a positive influence on the inner ear. Virtually, it can be achieved by performing reconstruction surgery whose results will be confirmed audiometrically by total air-bone gap closure (myringoplasty, stapedoplasty).

## CONCLUSIONS

1. Normal middle ear lining is a favorable prognostic factor for the improvement of bone conduction after myringoplasty.
2. Scars within the tympanic membrane, especially in the area of the round window, are an unfavorable prognostic factor for the improvement in bone conduction in patients with myringoplasty.
3. Removing granulomatous lesions from tympanic membrane has influence on the functioning of the inner ear in a positive way, as measured by bone conduction.
4. Intact ossicular chain is a significant prognostic factor for the improvement in bone conduction after surgery due to chronic otitis media.

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