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ORIGINAL ARTICLE

Long-term results of a hearing test in patients operated for chronic otitis media

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:

Introduction: Chronic otitis media is characterized by tympanic membrane perforation and conductive hearing loss. In the active form of this disease, there will also be periodic or permanent otorrhea. With a number of surgical techniques available depending on intraoperative findings, otosurgery is the treatment of choice in such cases, the extent of which depends on the type and extent of the pathological changes.

Material and Method: We carried out an analysis of 79 patients with chronic otitis media undergoing surgery at the Department of Otolaryngology, Jagiellonian University Medical College in Kraków between 2005 and 2014. Total audiometry was used as a part of hearing assessment, before the surgery, 6 months after the surgery and in the distant 10-year observation period. In addition, each patient completed the questionnaire and was examined by an otolaryngologist.

Results: The analysis included 79 patients operated on due to chronic otitis media. The mean bone conduction (for frequencies 500,1000 and 2000 Hz) before surgery was 31.8 dB, it did not differ significantly ($p = 0.355$) after 6 months after surgery (32.8 dB), while it significantly increased ($p < 0.001$) in a distant 10-year control of 43.4 dB. The mean air conduction (for frequencies 500, 1000 and 2000 Hz) before the procedure was 57.6 dB, it significantly improved in the early control by 50.5 dB, at $p < 0.001$. In long-term follow-up it increased again to 61.3 dB and was significantly different from the early postoperative period ($p < 0.001$). The mean air-bone gap for frequencies 500, 1000 and 2000 Hz before surgery was on average 26.4 dB, it was significantly ($p < 0.001$) reduced in the postoperative period by 17.6 dB. The level of air-bone gap remained at a similar level in distant control.

Conclusions: (1) A completely preserved ossicular chain in the absence of active chronic otitis media is the best prognosis for stable hearing improvement over the years with normal inner ear function; (2) Reoperation worsens the long-term results of a hearing test compared to the first operation.

KEYWORDS: chronic otitis media, long-term postoperative hearing improvement, tympanoplasty

ABBREVIATONS

COM – chronic otitis media
PORP – partial ossicular replacement prosthesis
TORP – total ossicular replacement prosthesis

INTRODUCTION

Chronic otitis media (COM) is characterized by conductive hearing loss, possible perforation of the tympanic membrane and periodic or permanent otorrhea in active form. The risk factors in COM are recurrent acute otitis media, inadequate antibiotic therapy, impaired Eustachian tube functions, cleft palate, male gender and a positive family history of inflammation in parents and relatives.

The treatment of choice for chronic otitis media is surgery, the scope of which depends on the type and extent of the pathological changes. The primary aim of surgical treatment is: removal of lesions, restoration of drainage and ventilation of the middle ear, improvement of hearing and protection of the middle ear from water in order to improve the patient's quality of life.

Tympanoplasties, as this is the term used for middle ear surgery, is divided into canel wall up and canal wall down depending on the behavior of the posteroanterior wall of the external auditory canal. Middle ear procedures include plastic surgery of the external auditory canal (canaloplasty), plastic surgery of the tympanic membrane (myringoplasty), and in the case of the ossicular chain damage also their reconstruction (ossiculoplasty).

The treatment of chronic otitis media involves three possible ways of surgical approach: transcanal, intra-aural, and extra-auricular. Reconstruction of the tympanic membrane involves the use of the perichondrium or temporal fascia as graft material, using the underlay technique.

In the reconstruction of the ossicular chain, depending on the degree of damage to the middle-ear conductive system, graft materials from the patient's own body (e.g. modeled incus, palisade from the patient's cartilage, etc.) or alloplastic prostheses are used. From the perspective of hearing improvement, it is essential to preserve adequate stapes mobility and self-ventilation of the tympanic cavity through the Eustachian tube.

Given the complexity of middle ear surgery, an international consensus has emerged on the categorization of tympanoplasty.

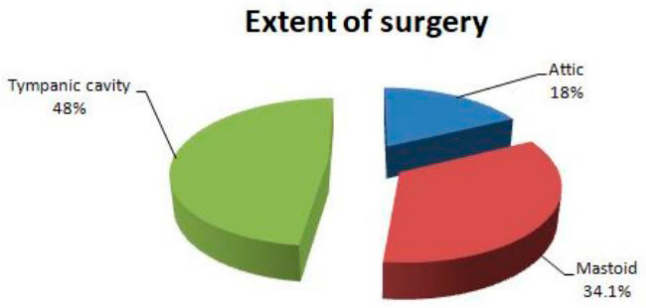

Fig. 1. The extent of surgery in the study sample.

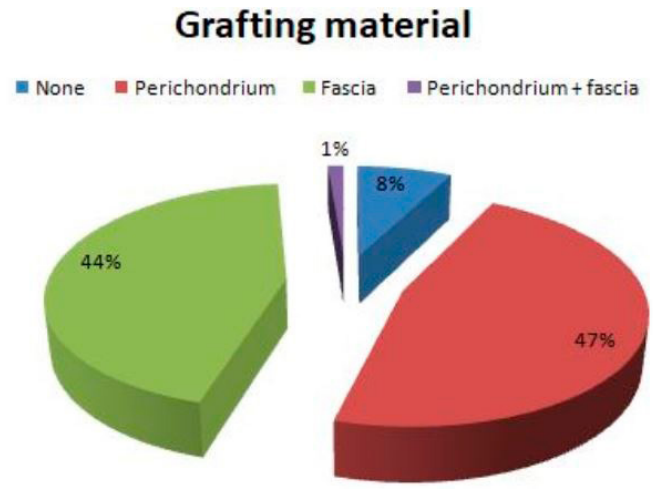

Fig. 2. Type of grafting material used for tympanic membrane reconstruction.

The classification included surgery of the mastoid and middle ear (tympanic). When it comes to the mastoid process, the number of operations (first, revision, second look), approach taken to the mastoid process, range of mastoidectomy, presence of reconstruction of the external auditory canal and possible obliteration of the mastoid process were included. In terms of middle ear surgery, the type of access to the tympanic cavity, the state and type of tympanic membrane reconstruction and the method of reconstruction of the ossicular chain were taken into account [1].

In the literature we encounter the analysis of effects of surgical treatment of chronic otitis media, however, studies assessing such long-term results (10 years) that will be included in the proposed project are scarce.

AIM

A prospective analysis of early and distant otosurgical results in patients operated due to chronic otitis media was performed.

MATERIAL AND METHOD

The material examined data obtained from 79 patients who reported for long-term follow-up after surgical treatment due to chronic otitis media at the Department of Otolaryngology CM UJ in 2005–2014. The youngest patient was 27 and the oldest was 78. The average age was 57.1. The study group consisted of 51 women and 28 men. 40 patients (50.6%) underwent surgery in the right ear and 38 (49.4%) in the left ear. In the study group, 57 patients (72.2%) were operated for the first time and did not require further surgery, while 22 (27.8%) required reoperation. In 27 subjects (34.2%) preaurical access was chosen, while in 52 (65.8%) we used extra-auricular access.

The evaluation of hearing involved the use of a pure-tone audiogram made before the surgery, 6 months after the surgery and in the distant 10-year observation period. Furthermore, each patient filled in the questionnaire and was examined by an otolaryngologist.

The obtained results were subjected to statistical analysis. The level of significance was $p < 0.05$.

RESULTS

The analysis included 79 patients. According to the survey, 38 patients (48%) reported subjective hearing improvement after otosurgery during long-term follow-up, while the remaining 41 patients (52%) did not experience hearing improvement, neither did they report a reduced sense of hearing. 25 patients (31.6%) required hearing care, of which 17 (21.5%) with air conduction hearing aids, while 8 patients (10.1%) were qualified to wear bone conduction devices on the operated ear, which resulted in significant subjective improvement of hearing. One patient suffered from sudden deafness of the operated ear, which occurred 3 years after the surgery. The implemented conservative treatment did not bring any improvement.

2 patients (2.5%) reported postoperative taste disorders in the early postoperative period. No facial nerve palsy was noted, but intraoperative deafness was found in 1 patient (1.25%). 33 patients (41.7%) reported tinnitus before surgery. In most cases it decreased, and only 4 patients (5%) had increased tinnitus. 23 patients (29%) experienced dizziness, which decreased after the surgery.

The majority of patients (74.6%) reported recurrent acute otitis media since childhood. Only 5 patients (6.3%) had adenotomy, no patient had a cleft palate, which is a major risk factor for EMP. In 4 patients (5%) surgery was required in the case of otogenic meningitis.

Preoperative perforation of the tympanic membrane occurred in 77 patients (97.5%), but in long-term follow-up its presence was found in 17 patients (21.5%). Twenty-five subjects (31.6%) had retraction pockets in long-term follow-up. Otorrhea in the operated ear appeared in 13 patients (16.5%), on average 3 years after surgery.

79 otosurgeries were performed. The procedure limited to the tympanic cavity was performed in 38 patients, while in the remaining individuals (41 patients) it had to be extended to other middle ear spaces (Fig. 1.).

In 52 patients (66%) there were no pathological changes in the middle ear, while in the remaining 27 (34%) cholesteatoma masses or inflammatory granulomatous lesions were removed.

Perichondrium and/or fascia of temporal muscle were used for reconstruction of the tympanic membrane (Fig. 2.).

The analysis focused primarily on long-term hearing outcomes.

Patients were divided into groups depending on the tympanoplasty performed.

- Surgery no. 1 (n = 19): Austin-Kartush A [M+I-S+] / Type II tympanoplasty;
- Surgery no. 2 (n = 13): Austin-Kartush A [M-I-S+] / Type II tympanoplasty (using PORP);
- Surgery no. 3 (n = 20): Austin-Kartush O / Type I tympanoplasty;
- Surgery no. 4 (n = 27): Austin-Kartush C / Type III tympanoplasty.

Comparing pure-tone audiograms made before surgery and in long-term follow-up after tympanoplasty for surgeries no. 1, 2 and 4, statistically significant worse mean bone conduction was observed after many years' observation with comparable mean air conduction and significantly smaller air-bone gap (Tab. I.).

Analyzing the follow-up long-term audiogram for surgery no. 3, there is no substantial decline in bone conduction after many years, while air conduction decreases at p = 0.059, which is close to significance. After many years, the air-bone gap decreases significantly (Tab. II.).

No statistical difference was observed in preoperative audiograms between treatments, either in air conduction, bone conduction or air-bone gap. However, in long-term follow-up after surgery there was a significant difference in bone conduction for a frequency of 2000 Hz between surgery no. 3 (tympanoplasty type I) of 35.8 dB and surgery no. 4 (tympanoplasty type III) of 55.9 dB at p = 0.036. Additionally, for surgery no. 4 there was statistically significantly worse air conduction at each frequency compared to surgery no. 3, on average for surgery no. 3 it was 46.7 dB and for surgery no. 4 it was 69.1 dB, at p = 0.022.

In long-term follow-up, the average cochlear reserve after surgery no. 1 is statistically significantly smaller than after surgery no. 2 and 4 (Tab. III.).

The further phase of the research consisted in comparing early and distant treatment results, assessing their change over time (Tab. IV.).

The mean bone conduction before surgery was 31.8 dB, SD 16.3, it did not differ significantly (p = 0.355) 6 months after surgery (32.8 dB SD 17.3), but it increased significantly (p < 0.001) in long-term 10-year follow-up at 43.4 dB, SD 23. The mean air conduction before surgery was 57.6 dB, SD 18.2, it significantly improved in the early follow-up at 50.5 dB SD 19.5, at p < 0.001. In long-term follow-up it increased again to 61.3 dB SD 22.9 and was significantly different from the early postoperative period (p < 0.001). The air-bone gap before surgery averaged 26.4 dB SD 12.4, and it decreased significantly (p < 0.001) in the postoperative period at 17.6 dB SD 11.4. The air-bone gap level remained at a similar level in long-term follow-up.

Tab. I. Comparison of pure-tone audiograms taken before and at long-term follow-up after surgery no. 1 (tympanoplasty type II), no. 2 (tympanoplasty type II (using AfterRP) and 4 (tympanoplasty type III). SD – standard deviation.

SURGERY	MEAN CONDUCTION FOR FREQUENCIES 500, 1000, 2000 HZ	STUDY	AUDIOGRAM		WILCOXON TEST
			MEAN	SD	
No. 1 (n = 19)	bone	Before	30.0	12.0	**p = 0.002**
		After	42.8	23.3	
	air	Before	56.3	18.1	p = 0.396
		After	58.5	25.4	
	air-bone gap	Before	27.9	8.4	**p = 0.007**
		after	15.7	14.5	
No. 2 (n = 13)	bone	before	31.9	7.6	**p = 0.005**
		after	41.3	10.2	
	air	before	62.8	15.5	p = 0.889
		after	62.8	16.3	
	air-bone gap	before	30.9	16.4	**p = 0.05**
		after	21.5	12.5	
No. 4 (n = 27)	bone	before	36.5	23.7	**p = 0.003**
		after	49.1	27.0	
	air	before	61.2	22.9	p = 0.048
		after	69.1	25.5	
	air-bone gap	before	27.7	13.1	**p = 0.025**
		after	19.9	13.8	

Tab. II. Comparison of pure-tone audiograms taken before and at long-term follow-up after surgery no. 3 (tympanoplasty type I). SD – standard deviation.

SURGERY	MEAN CONDUCTIVITY AT 500, 1000, 2000 HZ	STUDY	AUDIOGRAM		WILCOXON TEST
			MEAN	SD	
No. 3 (n = 20)	Bone	before	32.1	15.8	p = 0.370
		After	34.3	18.8	
	Air	before	50.7	19.9	p = 0.059
		After	46.7	25.5	
	air-bone gap	before	19.1	10.9	**p < 0.001**
		after	7.8	8.7	

Tab. III. Mean air-bone gap in long-term postoperative follow-up depending on the conducted procedure. N – number of patients.

SURGERY	N	AVERAGE AIR-BONE GAP FOR 500, 1000 AND 2000 HZ		ANOVA KRUSKAL-WALLIS	MULTIPLE COMPARISON TEST
		MEAN	DEVIATION		
1	19	15.7	14.5		**2#3 p = 0.019**
2	13	21.5	12.5	**p = 0.008**	
3	20	7.8	8.7		**3#4 p = 0.021**
4	27	19.9	13.8		

Further evaluation examined whether pathological masses within the middle ear have an impact on audiometric results. No significantly worse results were observed in bone or air conduction, or the air-bone gap level in patients with cholesteatoma and/or granulation tissue compared to patients without a diseased middle ear mucosa in long-term follow-up. No advantage of the material

Tab. IV. Comparison of early and long-term otosurgical treatment results in patients with chronic otitis media. SD – standard deviation.

CONDUCTIVITY	FREQUENCY	STUDY	MEAN	SD	FRIEDMAN ANOVA	0–10 L	6 M-10 L	0–6 M
bone	Mean (500, 1000 and 2000 Hz)	before	31.8	16.3	**p < 0.001**	**p < 0.001**	**p < 0.001**	p = 0.355
		6 months after	32.8	17.3				
		10 years after	43.4	23.0				
air	Mean (500, 1000 and 2000 Hz)	before	57.6	18.2	**p < 0.001**	p = 0.334	**p < 0.001**	**p < 0.001**
		6 months after	50.5	19.5				
		10 years after	61.3	22.9				
air-bone gap (mean)		before	26.4	12.4	**p < 0.001**	**p < 0.001**	p = 0.385	**p < 0.001**
		6 months after	17.6	11.4				
		10 years after	15.9	12.9				

Tab. V. Comparison of the impact of reoperation on audiogram outcomes in long-term follow-up. SD – standard deviation; N – number of patients.

CONDUCTIVITY	FREQUENCY	REOPERATIONS	N	AUDIOGRAM		WILCOXON TEST
				MEAN	SD	
bone	Mean for 500, 1000 and 2000 Hz	no reoperation	57	40.6	21.1	p = 0.212
		reoperation/s	22	47.8	25.2	
air	Mean for 500, 1000 and 2000 Hz	no reoperation	57	55.6	24.6	**p = 0.015**
		reoperation/s	22	70.8	24.4	
air-bone gap (mean)		no reoperation	57	13.4	11.6	**p = 0.014**
		reoperation/s	22	23.0	15.6	

used for reconstruction of the tympanic membrane was observed. Both the fascia of temporal muscle and perichondrium yielded comparable results of hearing tests in the conducted study.

The next part of the study compared the effects of reoperation on hearing outcomes. 22 patients (27.8%) required reoperation. The number of repeated treatments ranged from 1 to 5 in a single patient. The average bone conduction in the non-reoperated group and in the reoperated group did not differ statistically. In contrast, air conduction was statistically significantly worse in the reoperated group and equaled 70.8 dB compared to 55.6 dB in the non-reoperated group, p = 0.015. Therefore, the air-bone gap was significantly higher in the reoperated group (p = 0.014) (Tab. V.).

DISCUSSION

In otosurgical procedures, in addition to removing lesions and restoring proper ventilation of the middle ear, it is also important to obtain the best possible hearing in the operated ear. The development of new operating techniques and increasingly modern equipment allow for better functional results.

In surgery no. 1 (type II tympanoplasty) where at least 2 bone elements were preserved, surgery no. 2 (type II tympanoplasty using PORP) and surgery no. 4 (type III tympanoplasty), deterioration of bone conduction at all frequencies was observed in long-term follow-up. This stems from the adverse impact of toxic factors of inflammation on the inner ear, the possible effect of noise on the organ of Corti during lifting of the temporal bone, and the effect of impaired air conduction on the inner ear. Numerous authors have pointed out that surgical treatment of conductive hearing loss can result in damage to the inner ear secondary to stapes manipulation and damage due to noise emitted by the drill [2–4]. There are rare reports of total deafness during otosurgeries, estimated at 0.2% to 1% of cases [4, 5]. In our study, intraoperative deafness was at about 1%.

Edfeldt et al. believe that the only factors worsening postoperative hearing prognosis are reoperation and stapes injury requiring the use of a TORP prosthesis [6]. This is also confirmed by our view.

In long-term follow-up, as a result of a worsened bone conduction in the course of the illness and the passage of years, and thus damage to the inner ear, a decrease in cochlear reserve is observed with slightly altered air conduction. Many researchers consider that the most crucial factors affecting the long-term outcome of ossiculoplasty are persistent middle ear disease such as cholesteatoma, atelectasis, and Eustachian tube dysfunction. Such factors are often indications for reoperation and, as a consequence, worse hearing results [7, 8].

In surgery no. 3, where only myringoplasty was performed while the ossicular chain was preserved, the adverse impact of inflammation on the inner ear was minor, and the improvement in hearing expressed after the postoperative reduction of the air-bone gap was the largest and stable over time. The preserved ossicular chain and, above all, the lack of active inflammation, affects the maintenance of normal inner ear function. It allows to maintain the physiological sound amplification provided by the lever system that forms the chain of auditory ossicles.

No significant statistical differences were observed in preoperative audiograms in bone and air conduction, and air-bone gap. On average,

after 10 years of follow-up, bone conduction for 2000 Hz for surgery no. 4, in which the conduction element is most damaged, is statistically significantly worse compared to surgery no. 3, where it is completely preserved. 2000 Hz is the resonance frequency of the ossicular chain and its restoration is visible for myringoplasty itself. The difference also stems from the extent of the procedure, an active inflammatory process affecting the inner ear that occurs in the most locally advanced chronic middle ear inflammation [9]. Pareschi et al. noticed a reduced sense of hearing in long-term follow-up after surgery in the course of chronic granulomatous otitis media. After an initial improvement in the 6-month follow-up, if the stapes were preserved during surgery, there was a deterioration in pure-tone audiometry. In the absence of stapes, there was no significant difference in the audiogram after 6 months and 10 years [10, 11]. Our analysis did not involve any worse audiometry results depending on the pathological tissue within the middle ear, but only on damage within the ossicular chain and the reconstruction used. However, the preservation of stapes is a major prognostic factor for hearing improvement. According to other reports, the most important factor in postoperative hearing improvement beside the stapes is the presence of the handle of the malleus [12]. This is supported by our results.

An adverse prognostic factor for postoperative hearing improvement is any subsequent surgical intervention. The most common cause of reoperation is recurrence or persistent cholesteatoma. In literature, recurrence of cholesteatoma is estimated between 2% and 18% [10, 13, 14], while in our study, the recurrence of cholesteatoma was 15%. There are two ways to treat recurrence: as incomplete removal in the course of a single procedure or creating a new cholesteatoma from a retraction pocket [10]. Other risk factors include poor condition of the middle ear mucosa, the patient's age, and a lack of hearing improvement after previous operations [6, 10, 15, 16].

The mean cochlear reserve after surgery is subject to the greatest closure at surgery no. 3 (myringoplasty) and is 7.8 dB; it is statistically significantly smaller than in surgery no. 2 – 21.5 dB and surgery no. 4 – 19.9 dB. After surgery no. 1, the reserve is 15.7 dB. On this basis, it can be concluded that a completely preserved ossicular chain or such with damage to only one bone element guarantees a smaller auditory reserve that is stable over time.

CONCLUSIONS

1. A completely preserved ossicular chain in the absence of active chronic otitis media is the best prognosis for stable hearing improvement over the years with preserved normal ear function;

2. Reoperation worsens the long-term results of a hearing test compared to the first operation;

3. In long-term follow-up, as a result of the progressive deterioration of bone conduction in the course of the disease, a decrease in air-bone gap is observed with slightly changed air conduction;

4. There was no worse prognosis for hearing improvement in cholesteatoma and/or granulation tissue in the middle ear compared to normal mucosa.

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