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FUNCTIONAL RESULTS OF TYMPANOPLASTY WITH DIFFERENT VARIANTS OF THE SOUND CONDUCTING DEVICE RECONSTRUCTION OF THE MIDDLE EAR

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Presently the surgical treatment and rehabilitation of patients with chronic supputative middle ear otitis remains importantal in modern otiatry. The purpose of our work was to study the functional results of hearing improving operations with the use of artificial, biological and combined prostheses and assessment of the clinico–roetgenological conditions for their use in the patients with middle ear surgery pathology. An optimal length of the partial prosthesis has been established for reconstruction of the hearing bones depending on the timpanoplastia variant. After reconstructive operations performed in the patients with chronic suppurative otitis media there was an improvement of the hearing function in the sound–conducting apparatus in all study groups during the nearest 3–month period after surgery ($p<0.05$). During early post–operation period there was no statistically significant difference in the functional results in ocssiculoplastic operation using either PORP and TORP prostheses depending on the used ossicular prosthese material (bioautocartrillage, combined teflon or combined titan).

Key words: chronic suppurative otitis media, partial ossicular prosthesis, total ossicular prosthesis, timpanoplasty, chainlet of auditory ossicles.

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ФУНКЦІОНАЛЬНІ РЕЗУЛЬТАТИ ТИМПАНОПЛАСТИКИ З РІЗНИМИ ВАРІАНТАМИ РЕКОНСТРУКЦІЇ ЗВУКОПРОВІДНОГО АПАРАТА СЕРЕДНЬОГО ВУХА

Проблема хірургічного лікування та реабілітації пацієнтів з хронічним гнійним середнім отитом до теперішнього часу залишається актуальною у сучасній отіатрії. Метою нашої роботи було вивчити функціональні результати слухопокращуючих операцій з використанням штучних, біологічних та комбінованих протезів та визначити клініко–рентгенологічні умови для використання їх у пацієнтів з хірургічною патологією середнього вуха. Встановлено оптимальну довжину парціального протезу для реконструкції слухових кісточок в залежності від варіанту тимпанопластики. Після проведених реконструктивних операцій у пацієнтів з ХГСО різних груп у найближчому періоді після слухопокращуючого оперативного лікування відмічалося достовірне ($p<0,05$) покращення слухової функції з боку звукопровідного апарату. Не встановлено достовірної різниці функціональних результатів осикулопластики з використанням ПОРП та ТОРП протезів в залежності від матеріалу осикулярних протезів (біоаутохрящовий, біоаутокістковий, комбінований тефлоновий чи комбінований титановий).

Ключові слова: хронічний гнійний середній отит, парціальний осикулярний протез, тотальний осикулярний протез, тимпанопластика, ланцюг слухових кісточок.

The work is a fragment of the research "Rationale for the use of ossicular prostheses in patients with surgical pathology of the middle ear", state registration No. 0119U100617

The most important problem faced by patients with chronic purulent otitis media (CPOM) is hearing loss. This is mainly due to the violation of the sound system due to the purulent-destructive process. According to some authors, the destruction of the auditory ossicles is observed in 60–82% of patients with chronic purulent otitis media (CPOM) [2, 5, 7]. The problem of surgical treatment and rehabilitation of patients with chronic purulent otitis media still remains relevant in modern otiatry, because often there are unsatisfactory functional and morphological results of modern methods of reconstructive interventions on the middle ear [1, 2, 11, 12].

Despite the success of tympanoplasty, its results in terms of auditory function are not always satisfactory [2, 3, 8, 9]. This is due to the disadvantages of different types of transplantates used in surgical treatment, which leads to their resorption, dislocation and extrusion, etc. [1, 6]. This may be due to anatomical conditions in the middle ear, the patient's age, the condition of the ear canal and the peculiarities of the middle ear ventilation, the presence of concomitant chronic inflammatory process in the mucosa, recurrence of the main pathological process [1, 2]. Different types of oscillary prostheses are used to restore the sound-conducting apparatus of the middle ear. The choice of the prosthesis type and the material from which it is made of depends on the nature of the defect of the auditory ossicles, the experience and preferences of the surgeon. Thus, the problem of choosing the shape and type of prosthesis under different clinical and anatomical conditions in the course of the disease and improving the technique of surgical treatment remains relevant.

Fig. 1 Autoosseous simulated oscillary prosthesis for the reconstruction of the damaged by the pathological process oscillary mechanism of the middle ear.

Fig. 2. Combined titanium-cartilage PORP for the reconstruction of the ossicular mechanism of the middle ear destroyed by the pathological process.

The purpose of the work was to study the functional results of hearing-improving operations using artificial, biological and combined prostheses and to determine the clinical and radiological conditions for their use in patients with surgical pathology of the middle ear.

Materials and methods. We have examined 65 patients with chronic purulent otitis media who were treated in the Department of Ear Microsurgery of the State Institution "OS Kolomiychenko Institute of Otolaryngology, NAMSU" and which in the process of reconstructive (auditory) surgery installed ossicular prostheses of different types in order to reconstruct the sound-conducting apparatus of the middle ear. The age of patients ranged from 18 to 61 years, including 43 women and 22 men. Preliminary selection of patients included history taking, ENT examination, otomicroscopic examination and audiometric examination of auditory function. All patients underwent computed tomography (CT) of the temporal bones to determine the volume of the air cavities.

All patients were operated on in the department of ear microsurgery and otoneurosurgery. Patients underwent different types of tympanoplasty: open and closed options.

At the first stage, patients with CPOM underwent remediation of the chronic focus of infection, at the second – reconstruction of the sound-conducting apparatus of the middle ear, i.e. tympanoplasty and osiculoplasty. Osiculoplasty in these patients was performed simultaneously (25 patients) or delayed (40 patients) (from 6 to 12 months after stage 1 of tympanoplasty, the second stage was performed, i.e. asiculoplasty).

In the process of reconstructive surgery, 33 patients underwent partial oscillatory reconstructive prostheses (PORP). Varieties of PORP are presented in fig. 1–2.

Total ossicular reconstructive prostheses (TORP) were installed in 32 patients with CPOM. Varieties of TORP are presented in Fig. 3–4.

Determination of hearing acuity, the degree and nature of its disorders was carried out according to audiometry. Itera audiometer (Denmark), phonetically balanced articulation language tests were used for audiometric examination. Assessment of efficacy was performed in the early period (within 1 month) after surgery according to audiometry.

Fig. 3 Combined titanium-cartilage prosthesis with a cartilaginous plate in the area of the prosthesis base.

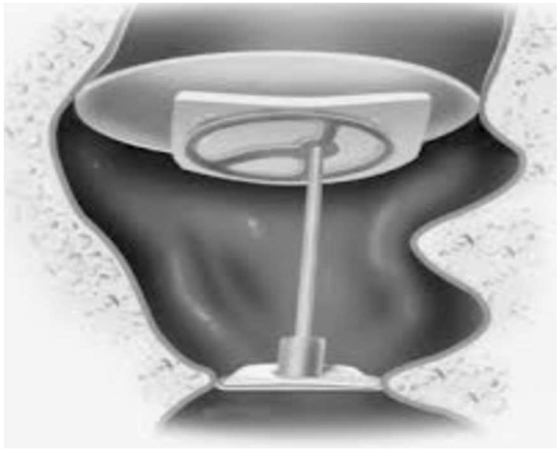

Fig. 4 Combined titanium-cartilage prosthesis with a cartilaginous plate in the site of the neotympanic membrane.

Assessment of the osiculoplasty efficacy using a variety of prostheses was performed in the early period (3 months) after surgery according to audiometry.

Statistical processing of the study results was performed using a personal computer by means of Microsoft Office Excel software. Student's t-test was used to determine the statistical significance of differences and to compare the mean sample values. The difference was considered statistically significant at $p<0.05$.

Results of the study and their discussion. Patients with chronic purulent otitis media (CPOM) were divided into 6 groups depending on the ossicular prosthesis type, which was installed in the middle ear during surgery:

Group 1 – patients with the installed bioautocartilage PORP (12 patients);

Group 2 – patients who have been installed a combined Teflon prosthesis (Teflon PORP and autocartilage protective plate inserted between the prosthesis and the eardrum) (15 patients);

Group 3 – patients who have installed a combined titanium prosthesis (titanium PORP and autocartilage protective plate inserted between the prosthesis and the eardrum) (6 patients);

Group 4 – patients who have been installed a biological simulated cartilage prosthesis - Columella TORP (8 patients);

Group 5 – patients who have been istalled a combined Teflon-cartilage prosthesis (Teflon TORP and autocartilage plate inserted between the prosthesis and the eardrum) (15 patients);

Group 6 – patients who have been intalled a combined titanium-cartilage prosthesis (titanium TOPP and autocartilage plate inserted between the prosthesis and the neotympanic membrane) (9 patients).

Two patients were fitted with a combined titanium-cartilage prosthesis with a cartilaginous plate in the area of the foot plate of the stirrup.

All patients underwent CT of the temporal bones to determine the volume of the air cavities, pneumatization of the papillary process, the depth of the tympanic cavity and the presence of cholesteatoma in the tympanic cavity and papillary process of cholesteatoma (with delayed ossiculoplasty – recurrent or residual cholestema).

At the same time pneumatization of a papillary process indirectly testified to sufficient ventilating function of an auditory tube. If no air was detected in the germ cells according to the CT, this allowed to think about the insufficient function of the ear canal and the reduction of the volume of the air cavities. In such patients, the reconstruction of the damaged ossicular apparatus was performed delayed - tympanoplasty with ossiculoplasty was performed in 2 stages. At the first stage, the tympanic membrane was restored and a ventilating subanular tube was installed for the purpose of prolonged ventilation of the tympanic cavity and formation of a ventilated tympanic cavity. The second stage of tympanoplasty (osiculoplasty with a partial prosthesis) was postponed for 6–12 months. Prostheses of different types were installed between the head of the movable stirrup and the epidermal neotympanic membrane.

The length of the prosthesis was determined by CT of the temporal bones to determine the depth of the tympanic cavity, by measuring the distance from the protrusion of the promontory wall and from the head of the stirrup to the level of the neotympanic membrane. The defined indices differed in patients at various options of a tympanoplasty. At the closed variant of a tympanoplasty the big depth of a tympanic cavity was noted, and length of a partial prosthesis made 4.6±0.2 mm. In the open version of tympanoplasty, respectively, the depth of the tympanic cavity was less, the length of the partial prosthesis was 2.6±0.4 mm.

The thickness of the cartilaginous plate installed between the TORP oscillary prosthesis and the neotympanic membrane differed depending on the pneumatization of the middle ear and the ventilation function of the ear canal. With satisfactory function of the ear canal and normal pneumatization of thepapillary process, its thickness was 0.1–0.2 mm. In cases of insufficient ventilation of the tympanic cavity, it was necessary to increase the thickness of the plate to 0.4–0.5 mm in order to prevent extrusion of the prosthesis in the remote postoperative period. The length of TORP, which was installed in a patient with chronic purulent otitis media to obtain a positive functional result, differed depending on the type of tympanoplasty: in the closed version of tympanoplasty it was 5.2±0.2 mm, in the open version, respectively 3.4±0.4 mm.

The thickness of the cartilaginous plate installed between the oscillary prosthesis and the neotympanic membrane differed depending on the pneumatization of the middle ear and the ventilation function of the ear canal. With satisfactory function of the ear canal and normal pneumatization of the joint venture, its thickness was 0.2–0.3 mm. In cases of insufficient ventilation of the tympanic cavity, it was necessary to increase the thickness of the plate to 0.4–0.5 mm.

During the examination of patients of group 1 according to the results of subjective audiometry before treatment, the following was found (table 1). Dysfunction of the sound-conducting apparatus of the II – III severity degree was noted (mean hearing loss was 51.7±7.7 dB). Whispered speech was perceived from a distance of 0.8±0.1 m, colloquial - 2.5±0.1 m.

After treatment, patients in group 1 showed significant ($p<0.05$) improvement in tonal hearing. There was a decrease in the thresholds of air-conducted tones on average from 51.7±7.7 dB to 28.0±6.7 dB, i.e. by 23.7±7.2 dB (table 1).

Table 1

Mean statistical indices of sounds perception thresholds on air conductivity in patients of groups 1 and 2

Terms of examination	Tonal hearing thresholds, dB			
	500 hz	1000 hz	2000 hz	4000 hz
Before the surgery, group 1	48.2±6.6	42.8±7.6	50.3±7.4	55.3±8.7
After the surgery, group 1	26.7±7.2*	25.3±6.4*	28.7±6.9*	29.7±7.1*
Increase in patients of group 1, dB	21.5±6.8	17.5±6.4	21.6±7.1	25.6±7.5
Before the surgery, group 2	50.4±5.9	65.1±8.2	58.4±7.9	49.8±6.6
After the surgery, group 2	25.9±8.1*	28.9±7.4*	29.2±6.6*	23.7±7.8*
Increase, group 2, dB	24.5±7.1	36.2±7.8	29.2±7.5	26.1±7.2

Note: * - indices of auditory function in groups 1 and 2 patients before treatment significantly differ from the respective values after treatment ($p<0.05$).

Examination of patients in group 2 according to the results of subjective audiometry before treatment revealed dysfunction of the sound-conducting apparatus of the II-III severity degree (mean hearing loss was 51.3±6.3 dB). Whispered speech was perceived from a distance of 0.7±0.1 m, colloquial - 2.6±0.1 m.

After surgical treatment in patients of group 2 there was a significant ($p<0.05$) improvement in tonal hearing, as evidenced by a decrease in airborne tonal signals on average from 51.3±6.3 dB to 25.3±7.1 dB , i.e. at 26.0±6.7 dB (table 1).

In patients with chronic purulent otitis media of group 3, the results of subjective audiometry before treatment revealed an impairment of the sound-conducting apparatus of the II-III severity degree (mean hearing loss was 50.9±7.3 dB). The mean distance of perception of whispered speech was 0.9±0.2 m, conversational, respectively, 2.8±0.3 m.

After treatment, patients in group 3 showed significant ($p<0.05$) improvement in tonal hearing. There was a decrease in air-conducted tones on average from 50.9±7.3 dB to 25.6±7.6 dB, i.e. by 25.3±7.5 dB (table 2).

During the examination of patients of group 4 according to the results of subjective and tonal threshold audiometry, the following audiometry was detected before the operation (table 2). Dysfunction of the sound-conducting apparatus of the II–III severity degree was noted (mean hearing loss was 53.4±5.5 dB). Whispered speech was perceived from a distance of up to 0.2 m, colloquial - 1.5±0.1 m.

After treatment, patients in group 4 showed significant ($p<0.05$) improvement in tonal hearing. There was a decrease in air-conducted tones on average from 53.4±5.5 dB to 26.8±4.6 dB, i.e. by 26.6±5.1 dB (table 2).

Table 2

Mean statistical indices of sound perception thresholds on air conductivity in patients of groups 3 and 4

Terms of examination	Tonal hearing thresholds, dB			
	500 hz	1000 hz	2000 hz	4000 hz
Before the surgery, group 3	46.7±6.2	56.4±8.5	59.3±6.9	51.9±8.6
After the surgery, group 3	21.9±8.8*	26.3±6.8*	32.2±7.9*	28.7±8.1*
Increase in patients of group 3, dB	24.8±7.6	30.1±7.7	27.1±7.4	23.2±8.4
Before the surgery, group 4	50.2±4.6	52.8±4.8	54.2±6.2	56.2±6.2
After the surgery, group 4	28.7±5.6*	24.3±3.8*	24.6±3.9*	29.6±5.2*
Increase in patients of group 4, dB	21.5±5.2	28.5±4.4	29.6±5.1	26.6±5.8

Note: * - indices of auditory function in groups 3 and 4 before treatment differ significantly from the respective values after treatment ($p<0.05$).

Examination of patients of group 5 according to the results of subjective audiometry before treatment revealed dysfunction of the sound-conducting apparatus of the II-III severity degree (mean hearing loss was 51.3±4.9 dB). Whispered speech was perceived from a distance of 0.4±0.2 m, colloquial - 1.2±0.1 m.

After surgical treatment in patients of group 5 there was a significant ($p<0.05$) improvement in tonal hearing, as evidenced by a decrease in airborne tonal signals on average from 51.3±4.9 dB to 24.7±5.3 dB , i.e. 28.6±4.5 dB (table 3).

Table 3

Mean statistical indices of sound perception thresholds on air conductivity in patients of groups 5 and 6

Terms of examination	Tonal hearing thresholds, dB			
	500 hz	1000 hz	2000 hz	4000 hz
Before the surgery, group 5	48.4±4.2	52.2±4.8	54.4±5.2	58.2±5.4
After the surgery, group 5	22.9±4.0*	24.6±4.2*	26.4±4.8*	26.6±5.0*
Increase in patients of group 5, dB	25.5±3.1	27.6±4.2	28.0±4.8	31.6±5.8
Before the surgery, group 6	49.6±6.2	52.4±7.5	58.2±7.8	60.2±8.2
Before the surgery, group 6	26.7±6.8*	28.3±7.2*	32.4±7.8*	32.8±8.1*
Increase in patients of group 6, dB	22.9±6.4	24.1±6.8	25.8±7.2	27.4±7.8

Note: * - indices of auditory function in groups 5 and 6 before treatment differ significantly from the respective values after treatment ($p<0.05$).

In patients with chronic purulent otitis media of group 6, the results of subjective audiometry before treatment revealed an impairment of the sound-conducting apparatus of the II-III severity degree (mean hearing loss was 50.9±7.3 dB). The mean distance of perception of whispered speech was (0.5±0.2) m, spoken respectively 1.5±0.3 m.

After treatment, patients in group 6 showed significant ($p<0.05$) improvement in tonal hearing. There was a decrease in air-conducted tones on average from 55.1±7.4 dB to 30.05±7.5 dB, i.e. by 25.1±7.1 dB (table 3).

Some authors [3] studied the functional results of ossiculoplasty using ossicular middle ear prostheses depending on the material of the ossicular prostheses. Materials such as autobone, autonails and titanium were studied.

In our work the comparison of functional results of hearing-improving operations with the use of bioautocartilage, bioautoosseous, combined Teflon and combined titanium prostheses is carried out. In contrast to the data of the authors [3], we did not establish a significant difference in the functional results of osiculoplasty using PORP and TORP prostheses depending on the material of ossicular prostheses. Dysfunction of the Eustachian tube and disturbances in gas exchange through the mucous membrane of the middle ear can cause negative pressure and retraction of pockets, adhesions, atelectasis and cholesteatoma. If this problem is present after surgery, it can again lead to retraction, reperforation and/or extrusion of the restored bone chain. This is especially true if conventional autologous materials such as fascia and cartilage are used to reconstruct the eardrum. In the works of foreign authors [10] the indications, surgical technique and functional results of 23 tympanoplastics using cartilage and titanium prostheses with a range of 20-55 months and, on average, 30 months are considered. In the study, a satisfactory functional result was obtained in all patients regardless of the type of prosthesis material.

In the performed study, we studied the dependence of the cartilaginous plate thickness, which was established between the ossicular prosthesis and the neotympanic membrane depending on the pneumatization of the middle ear and the ventilation function of the ear canal. Also, the length of PORP and TORP prosthesis was established in the variant of tympanoplasty using CT of the temporal bones to determine the depth of the tympanic cavity.

In the early postoperative period in patients of different groups there was no significant difference in the functional results of osiculoplasty using PORP and TORP prostheses depending on the material of ossicular prostheses.

Further studies of the functional results of hearing-improving operations on the middle ear with the use of different types of ossicular prostheses in the long term after surgery (12-24 months) are needed.

Conclusions

1. After reconstructive surgery in patients with CPOM of different groups (1, 2, 3, 4, 5 and 6) in the near future after hearing-improving surgical treatment (within 3 months) there was a significant ($p<0.05$) improvement in auditory function with side of the sound-conducting apparatus, as evidenced by a significant decrease in the thresholds of air-conducted sounds and a decrease in the bone-air interval.

2. In the presence of a pneumatized ossicular prosthesis (OP), sufficient function of the ear canal and intact mucous membrane of the medial wall of the tympanic cavity, a one-stage reconstructive operation with simultaneous restoration of the tympanic membrane and the ossicular apparatus of the middle ear is indicated.

3. The optimal length of the partial prosthesis for the reconstruction of the auditory ossicles depending on the variant of tympanoplasty has been established. Thus, in the closed version of tympanoplasty, the length of PORP was 4.6±0.2 mm, and TORP, respectively, 5.2±0.2 mm; in the open version for PORP 2.6±0.4 mm and for TORP 3.4±0.4 mm, respectively.

4. The thickness of the cartilaginous plate installed between the ossicullar prosthesis and the neotympanic membrane differed depending on the pneumatization of the middle ear and the ventilation function of the ear canal. With satisfactory function of the ear canal and normal pneumatization of the joint venture, its thickness was 0.1–0.2 mm. In cases of insufficient ventilation of the tympanic cavity, it was necessary to increase the thickness of the plate to 0.4–0.5 mm.

5. In the early postoperative period (within 3 months after ossiculoplasty surgery) in patients of groups 1, 2, 3, 4, 5 and 6 there was no significant difference in the functional results of ossiculoplasty using PORP and TORP prostheses depending on the material of the ossicular prostheses (bioautocartilage, bioautoosseous, combined Teflon or combined titanium).

References

1. Bodrova IV, Rusetskiy YuYu, Kulakova LA, Lopatin AS, Ternovoy SK. Funktsionalnaya multispiralnaya kompyuternaya tomografiya zvukoprovodyashchikh struktur srednego ukha. Vestn. otorinolaringologii. 2011; 3: 36–40. [in Russian]

2. Kosyakov SYA. Izbrannyye voprosy prakticheskoy otokhirurgii. Moskva: MTSFER; 2012. 224 s. [in Russian]

3. Sitnikov VP, Anikin IA, Chernushevich II, Zavarzin BA, Anikin MI. Ispolzovaniye autotransplantatov i implantov pri ossikuloplastike. Vestn. otorinolaringologii. 2006; 2: 38–41. [in Russian]

4. Albera R, Canale A, PiumettoE, Lacilla M, DagnaF. Ossicular chain lesions in cholesteatoma. Acta otorhinolaryngologicaItalica: organoufficiale della Societaitaliana di otorinolaringologia e chirurgiacervico – facciale. 2012; 32 (5):309–13.

5. Berenholz L, Burkey J, Lippy W. Short– and long–term results of ossicular reconstruction using partial and total plastipore prostheses. OtolNeurotol.2013 Jul; 34(5):884–9. doi: 10.1097/MAO.0b013e31827
de491.

6. Demir UL, Karaca S, Ozmen OA, Kasapoglu F, Coskun HH, Basut O. Is it the middle ear disease or the reconstruction material that determines the functional outcome in ossicular chain reconstruction? OtolNeurotol. 2012 Jun; 33(4): 580–5. doi: 10.1097/MAO.0b013e31824b774c.

7. Faramarzi M, Jahangiri R, Roosta S. Comparison of titanium vs. polycell total ossicular replacement prosthesis. Iranian J Otorhinol. 2016 Mar; 28(85):89–97.

8. Kaplankıran H, Ceylan ME, Yıldırım GA, Ceylan G, Dalğıç A, Olgun L. Audiological results of total ossicular replacement prosthesis with cartilage shoe technique. Turk Arch Otorhinolaryngol. 2018 Jun;56(2):95–101. doi: 10.5152/tao.2018.3200.

9. Mardassi A, Deveze A, Sanjuan M, ParikhJ, Elbedeiwy A. Titanium ossicular chain replacement prostheses: prognostic factors and preliminary functional results. – Eur Ann Otorhinolaryngol Head Neck Dis 2011 Apr; 128(2):53–8. doi: 10.1016/j.anorl.2010.11.005.

10. Menéndez-Colino LM, Bernal M, Sprekelsen. Tympanic-ossicular reconstruction. Functional results using cartilage palisades and titanium prostheses. Acta Otorrinolaringol Esp. 2002 Dec; 53(10):718-24. doi: 10.1016/s0001-6519(02)78368-4.

11. Mostafa BE, Fiky LE, Hassan O.Functional results in ossiculoplasty with different titanium prostheses. Egyptian Journal of Ear, Nose, Throat and Allied Sciences. 2013; 14 (2): 79 – 84.

12. Yung M, Smith P. Titanium versus nontitanium ossicular prostheses – a randomized controlled study of the mediumoterm outcome. J OtolNeurotol. 2010 Jul; 31(5):752–8. doi: 10.1097/MAO.0b013e3181de4937.

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