The use of total ossicular replacement prosthesis after radical tympanomastoidectomy

Upotreba totalne osikularne proteze nakon radikalne trepanacije temporalne kosti

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Abstract

Background/Aim. This paper presents our operative method for hearing recovery after the previous radical tympanomastoidectomy, radical trepanation of the temporal bone (trepanatio radicalis ossis temporalis – TROT) in eight patients submitted to operations for giant cholesteatoma.

Methods. All the patients were admitted to our clinic after TROT. There were no signs of cholesteatoma or infection. The patients refused any stent implantations or any hearing aids due to possible aesthetic problems. The described procedure developed in two steps. The first one was to restore the destroyed cavum tympany and to covert with chondroperichondral new membrane with a pin-like “guide” as columnela. The second step was to insert a TORP (total ossicular replacement prosthesis) after guide excision.

Results. After the first operation (stage one) there were no infections in the operated area nor chondroperichondral graft rejection. Postoperative audiometry (6 to 8 weeks) was done to demonstrate the improvement of air conduction. Three months following the first, the second (stage two) operation was performed and 2.5 to 3 months after this operation even greater audiometry revealed hearing improvement in air- and bone-conduction. The patients were dismissed from the hospital 2 days after each procedure without any complications. They did not experience any dizziness, vomiting nor a severe pain. Three months after the second operative stage, otoscopic findings were very good. The audiometry findings after a 3-months period (after stage one) and 3 months after final TORP insertion was done for each of the patients. After one year, the audiometric curve was the same. Clinical and audiometry follow up demonstrated a healing recovery and closure of air bone gap (ABG) to values of 5 to 15 dB. Conclusion. The use of TORP after radical tympanomastoidectomy is feasible. The first step of the procedure is the fixation of a neomembrane. A stabilized neomembrane is essential for light overpressure on the prosthesis and this is important for optimal or better conductivity. A better hearing recovery is confirmed with audiometric findings and ABG reduction to 5–15 dB. This method could be performed in all patients (with good bone-conduction) after radical tympanomastoidectomy for better hearing.

Key words: cholesteatoma; otologic surgical procedures; hearing loss, conductive; ossicular replacement; prostheses and implants; reconstructive surgical procedures.

Apstrakt


Rezultati. Posle prve operacije (faza 1) nije došlo do inficiranja u zoni operacije, niti do odbacivanja hondroperihondralnog grafa. Posleoperativna audiometrija (6–8 nedelja) pokazala je poboljšanje vazdušne provodljivosti. Tri meseca posle prve, urađena je druga operacija (faza 2), a 2,5–3 meseca posle nije još opsežnija audiometrija pokazala je popravljanje sluha i vazdušne i koštane pokretljivosti. Bolesnici su otopljeni iz bolnice bez iječne komplikacije, kao i vrtoglave, povraćanja niti bola. Tri meseca posle druge operativne faze, nalazi dobijeni otoskopijom bili su veoma dobr. Urađena je i audiometrija tri meseca posle faze 1, ko i tri meseca posle konačnog ubacivanja TORP-a kod svakog bolesnika. Audiometrijska kriva bila je ista i godinu dana kasnije. Klini-

**Ključne reči:**
- holesteatom; hirurgija, otološka, procedure; sluš, konduktivni gubitak; slušne košćice, proteze; protezi i implantati; hirurgija, rekonstruktivna, procedure.

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**Introduction**

By definition, radical trepanation of the temporal bone (trepanatio radicalis ossis temporalis – TROT) includes mastoidectomy, antrotomy, cleansing whole middle ear and closure of the Eustachian tube. This operation is also known as radical tympanomastoidectomy. This procedure is often indicated in patients with huge cholesteatoma processes or tumors in middle ear and mastoid region. After TROT the frequency of hearing impairment was high.

There are many attempts to improve hearing thereafter. In case of partial defects in ossicular chain, there are different types of tympanoossiculoplasty with partial or total prosthesis in use. If there is no ossicle, a total prosthesis must be used.

The cost of these procedures is very high in developing countries and young individuals experience some aesthetic problems in accepting hearing aids.

The aim of this study was to present our original two-step operative method that can help in hearing recovery in patients who refused a hearing aids, and to demonstrate functional results using this method which is a combination of the known methods in otosurgery.

**Method**

All the 8 patients were admitted to the University Hospital with poor hearing in the previously operated ear.

The 8 patients were of both sexes, different age (from 13 to 57 years). All the patients had previously been operated on for cholesteatoma and everyone had made radical tympanomastoidectomy, with the epitelized postoperative cavity, and no signs of infection and recurrence of cholesteatoma. All the patients had preserved bone conductivity and conductivity air significantly decreased (about 45 dB air-bone gap-ABG). The studied group of patients refused visible hearing aids or implants, and accepted the proposed surgical treatment, although they had been submitted to radical tympanomastoidectomy 3–9 years ago.

Including factors for this type of surgery were: already underwent radical tympanomastoidectomy; no signs of infection and recurrence of cholesteatoma in the postoperative period; good (preserved) bone conductivity (15–20 dB), ABG greater than 40 dB and the wish to improve hearing without visible hearing aids (for aesthetic reasons). The patients with radical tympanomastoidectomy who wanted total assicular replacement prosthesis (TORP) implantation were not treated due to (excluding factors): suspected infection or recurrence of cholesteatoma, the lack of preserved bone conduction and small ABG and/or the existence of sensorineural hypacusis.

Our patients were followed clinically and audiometrically prior to surgery, after the first phase (about 3 months) and after the set TORP prosthesis (3 months and a year later).

Clinical findings were very good in the years following radical operation. Mastoid CT showed no signs of rest/residual cholesteatoma. There were no recidives of cholesteatoma and no signs of infection. Pure tone audiometric examination showed insufficient air conduction. Audiometric examination showed a reduction in air conduction. The patients and their families refused any surgical procedure along with the use of visible hearing aids.

At admission otoscopic findings revealed a wide postoperative cavity after radical mastoidectomy with good epithelization. There were no signs of infection, nor residual cholesteatoma. Audiometrical findings showed a satisfied bone-conduction (BC) (approx. 25–30 dB in whole frequencies) and poor air-conduction (AC) (approx. 45–55 dB) in the same range.

Inclusion criteria for this method was good postoperative bone-conduction (BC) (less than 40 dB) and poor air conduction (AC) (more than 65 dB),

After preoperative planning, the operation was performed in two steps. Both operations were performed in general endotracheal anesthesia.

After local infiltration, through retroauricular incision, the whole epithelized cavity was exposed. The first step of operation was performed through several phases.

At the beginning of operation, de-epithelization of the common cavity after radical trepanation of the temporal bone was performed (Figure 1). Special attention was paid not to...
injure the footplate of stapes, promontorium (the first turn of the cochlea) and the facial nerve. The identification and reopening of the Eustachian tube was of great importance (Figure 2). The aspiration or probe of the Eustachian tube was necessary. Identification of sticky, transparent secret confirmed the right and proper tube position (Figure 3).

It was important to secure an adequate positioning of the neomembrane with the cartilaginous “guide”. Two marks should be followed: interiorly, above the tubal orificium and posteriorly, on the facial ridge of temporal bone. The “guide” was positioned in such a way to touch the base of stapes (Figure 5). This “guide” enabled sound conduction and prevented collapsing of the neomembrane. The “guide” will facilitate the identification of the stapes footplate and easy application of a prosthesis.

Creating a neomembrane was the next step of the procedure to prepare a chondro-peri-chondrial graft from tragus tissue. After the incision on the external ridge of tragus and the exposure of cartilage, a semilunar excision was performed. The excised cartilage was separated in the shape of butterfly wings to be used as a neomembrane. One half of the cartilage was trimmed in order to reduce volume and thickness. On another part a triangular semiexcision was performed where the base of the triangle was fixed to the cartilage. This triangular cartilage part was seen as a “guide” (Figure 4).

At the end of the first step we performed the closure of a neocavum tympani and tamponade of the external auditory canal. The closure was very delicate. The peripheral part of the chondro-perichondrial flap must be fixed under the planned excision during deepithelization and the posterior part must lie on the facial ridge on the anterior part (Figure 6). Good fixation of this kind of graft insured a good aeration and good neomembrane elasticity.

At the end of this procedure the postoperative course was uneventful. Bandages were changed on the third postoperative day. The patients were dismissed from hospital after 6 days.

Three months postoperatively, audiometry showed better air- and bone-conduction.

Three months after the first step, the second step was performed. Using the transmeatal approach, the neomembrane was identified and opened like a tympanomeatal flap. The cavity below the neomembrane was epithelized with respiratory epithelium. This respiratory-epithelium invasion
probably originates from the Eustachian tube. Also the tip of the “guide” was epithelialized at the footplate of stapes. A proximal part of “guide”, fixed to the neomembrane, was cut with micro-scissors and totally removed. A small scratch on the stapes footplate was made. A TORP, model Aerial-Vario by “Kurz” (Germany) was used. The TORP was subsequently placed in standard manner.

The second step of the proposed operation was shortly performed in three parts.

The first part comprised of preparing a tympanomeatal flap 5 mm from the fixed neomembrane border which was very slightly pushed up until the “guide” was exposed. The second part was the removal of the “guide” (Figures 7 and 8). The trapezoid space which remained after removing the „guide“ was very suitable for the placement of the upper part of TORP. The third part was the insertion of TORP in its place.

The statistical methods used in the study were the ANOVA to the chosen significance level and the Dunnett’s test to compare the mean values of the groups. Regression analysis and the significance of differences in the level of air and bone conductivity was performed by ANOVA followed by Dunnett post hoc multiple comparison tests using SPSS software Version 11.5.

**Results**

After the first operation (stage one) there were no infections in the operated area nor chondroperichondral graft rejection. Postoperative audiometry (6 to 8 weeks) was done to demonstrate the improvement of air conduction.

Three months following the first, the second (stage two) operation was performed and 2.5 to 3 months after this operation even greater audiometry revealed hearing improvement in AC and BC (Table 1).

<table>
<thead>
<tr>
<th>Conductivity</th>
<th>Pre OP (dB)</th>
<th>After TORP (dB)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>68.93 ± 10.21</td>
<td>45.6 ± 8.71</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>BC</td>
<td>40.07 ± 8.16</td>
<td>34.28 ± 7.85</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>

The patients were dismissed from the hospital 2 days after each procedure without any complications. They did not experience any dizziness, vomiting nor a severe pain.

Three months after the second operative stage, otoscopic findings were very good. The audiometry findings after period a 3-months (after stage one) and 3 months after final TORP insertion was done for each of the patients (Figures 9–11).

Fig. 9 – Puretone audiometry preoperatively (PreOP), after stage one (“cavum parvum” – “CP”) and 3 months after the total ossicular replacement prosthesis (TORP) insertion.

After one year, the audiometric curve was the same.

**Discussion**

For the presented patients, the use of this operative modality was based on their wish to improve their hearing, but specifically without the use of any visible hearing aid. This method was developed out of the need to recover hearing in patients with hearing impairment after radical trepanation of temporal bone. It should not be forgotten that for a patient with childhood cholesteatoma this process has some special characteristics. A different type of prosthesis is used to improve the loss of hearing after tympano-ossiculoplasty. A partid ossicular replacement prosthesis (PORP) and TORP are indicated for patients with chronical otitis and damaged ossicular chain. A TORP is currently used in tympanoossiculoplasty as the last resort to preserve hearing abilities. In this study TORP was used after radical trepanation of temporal bone. There is no sufficient data describing the use of TORP in this indication.
Considering different types of tympanoplasty and reported success,8,12,13 with different ossicular prosthesis14,15 the right question is: Who are the suitable candidates and why to use this prosthesis? The patients had good BC but poor AC.

The “Aerial-Vario” prosthesis, in comparison with other prosthesis16 has two characteristics which are very important considering its application in this case. First, the usable length (from the footplate up to a neomembrane) can be easily defined by rolling the upper plate up and down intraoperatively in 0.25 mm increments. Second, the elasticity of a neomembrane (chondroperichondral graft) allows better conductivity.

There are several issues that should be resolved in order to perform this procedure. The problem of a closed tube with a small diameter should be solved by using a diamond burr to make it wider. Finding of a “sticky” tubal secret is a proof that the tubal lumen was found. Curettage of tympanal part of tube should support microvascular and epithelial invasion in „cavum parvum“ (it is expected after 3 months which is the reason why the second step should be delayed for this period).

Neomembrane creation differs from other cartilage and/or perichondral grafts17–20. It uses a tragal cartilage-perichondral “butterfly-like” graft21. Its surface and shape are large enough to cover a future neocavum15. One half of the cartilage that was orientated posteriorly was of full thickness, and that was orientated interiorly was trimmed to the half of its full thickness. One half of the cartilage had been removed to enable better elasticity due to the weight and volume of the graft.

Considering that patients with chronic otitis could have a tubal dysfunction, the cartilage “guide” (triangular pin-like cartilage part) was used for two reasons. First, to prevent collapsing of the neomembrane and second, for sound conducting effect (columella effect). In case that auditory tube is blocked (mucous, edema, infection) the pin-like guide preserves a constant distance between a neomembrane and the footplate of stapes, preventing neomembrane collapse in case of negative pressure. Additionally pin-like “guide” serves as a columella to established/reestablish renewed cochlear activity to sound stimulation.

“Cavum parvum” is not the same as the one Wullstein reported on tympanoplasty type IV1. In this case it is a space under the neomembrane bordered anteriorly, superiorly and inferiorly on the new ridges (made with 0.5 mm diamond bur), and which lies on the facial ridge posteriorly.
The mastoid cavity was not filled or closed because of the ability to view a mastoid part. Of course, filling of mastoid cavity is possible with bone dust or commercial preparations, as in any “wall-down” tympanoplasty.

The second stage is simple – to cut out the “guide”, remove it and position a TORP in its place. It is very useful to make a small incision on the stapes footplate to prevent dislocation or migration of the prosthesis. For this reason, the upper part of a prosthesis was placed in an empty triangular space inside of a neomembrane.

Before the first stage, the audiometrical findings showed 25–39 dB of BC and 55 dB of AC. The air-bone conduction gap was 30 dB. Two months after the first stage ABG was 10–20 dB (depending of frequencies). It showed a better value range between 250 Hz and 2 kHz. At this time, BC also showed increased values from 5 dB. It could have been a sign that the cochlear activity was getting better. After 3 months, the second stage was performed. Three months after the second stage, audiometry showed BC of 20–25 dB; and AC of 30–35 dB; ABG was 5–15 dB.

With the use of TORP, ABG closure was expected. A surprising fact was that the bone conduction was improving. This study sheds a new light on recovery processes in the cochlea. The reason for it may be found in a better and more permanent stimulation of the cochlea. This is a very good procedure for hearing recovery for patients with good bone-conduction. Compared to other implantable systems it is cheaper and it is followed by good audimetrical findings.

In this case no visible hearing aids were used that was a very significant fact. The cost of the procedure (cheaper than other methods) should not be neglected either.

**Conclusion**

The use of TORP after radical tympanomastoidectomy is feasible. The first step of the procedure is fixation of a neomembrane. A stabilized neomembrane is essential for light overpressure on the prosthesis and this is important for optimal or better conductivity.

A better hearing recovery is confirmed with audimetric findings and ABG reduction to 5–15 dB.

This method could be performed in all patients (with good bone-conduction) after radical tympanomastoidectomy for better hearing.

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**REFERENCES**