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Retrograde Mastoidectomy on Demand with Soft-Wall Reconstruction in Pediatric Cholesteatoma

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Running Head: Soft-wall reconstruction in children

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Objective: To evaluate surgical outcomes of retrograde mastoidectomy when using soft-wall reconstruction in pediatric cholesteatoma.

Study Design: Retrospective case review.

Setting: Tertiary referral center.

Patients: A total of 25 children underwent cholesteatoma removal surgery employing soft-wall reconstruction. Average follow-up time was 48.7 months.

Intervention: In order to fully expose and extirpate the disease, the bony canal wall was removed in association with a retrograde-type mastoidectomy in all cases. The posterior ear canal defect was then reconstructed using soft-tissue; i.e., temporal fascia and canal wall skin.

Main Outcome Measures: The incidence and localization of residual and recurrent cholesteatoma, preoperative and postoperative audiogram results, pure-tone average, and air-bone gap were assessed.

Results: Residual cholesteatoma was detected in 5 (20%) out of 25 ears. There were 4 small residual cholesteatomas that were located in the posterior tympanic sinus, on the stapedial tendon, on the stapes head, and in the epitympanum, respectively. As we found aggressive residual disease in 1 case, the total recurrent cholesteatoma was 1 (4%) out of 25 ears. The mean preoperative pure-tone average (PTA) of air conduction (AC) was 39.1 dB, while the preoperative PTA of the air-bone gaps (ABG) was 28.8 dB. At 6 months or more after the last surgical intervention, the mean postoperative PTA–AC and PTA-ABG were 20.9 dB and 11.7 dB, respectively. The mean hearing gain was 18.1 dB. The differences between the pre- and postoperative values were statistically significant ($p < 0.05$).

Conclusion: Retrograde mastoidectomy with soft-wall reconstruction is an effective

technique that can be used to lower the recurrence rate of cholesteatoma in the pediatric population.

Key Words:

retrograde mastoidectomy, soft-wall reconstruction, residual cholesteatoma, recurrent cholesteatoma, hearing

Abbreviations:

SWR, soft-wall reconstruction technique; CWU, canal wall-up technique; CWD, canal wall-down technique; EAC, external auditory canal; TF, temporalis fascia; PTA, pure-tone audiogram; AC, air conduction; BC, bone conduction; ABG, air-bone gaps.

Introduction

The primary goal of surgery for cholesteatoma is to render the affected ear clean and dry. Surgeries are also performed in order to prevent recurrence of the disease and to preserve or improve hearing. In order to avoid disadvantage of using the canal wall-down techniques (CWD) and to lower the recurrence rate in the pediatric population that occurs when using the canal wall-up technique (CWU), CWD has been modified to use soft-wall reconstruction techniques (SWR) of the external auditory canal (EAC). By preserving the canal wall during CWU surgery, this maintains the normal anatomy of the ear canal and ensures normal skin migration. Although this technique helps to reduce the healing time, the exposure of the epitympanum, facial recess and tympanic sinus is very limited during the surgery, which can lead to high residual rates of cholesteatoma recurrence. One alternative is to use the open method tympanoplasty in CWD surgeries, as this provides excellent exposure for cholesteatoma removal and thus leads to lower residual rates. When using this procedure, however, the cavity is incompletely cleaned and this can lead to subsequent bowl infections, or the so-called cavity problem. In an attempt to find a solution that does not lead to the above problems, a method that uses several graft materials during CWD tympanomastoidectomy to reconstruct the posterior wall of the EAC has been developed. The SWR method employs CWD tympanomastoidectomy and reconstructs the EAC wall using only soft tissues such as remnant EAC skin and a piece of the temporalis fascia (TF). This method is advantageous in that the procedure provides a wide and excellent surgical view, similar to the CWD procedure. One possible disadvantage of the procedure is that a large radical-like cavity sometimes appears after surgeries in which a large or complete mastoidectomy has been performed. However,

even when large radical-like cavity formations do occur after surgery, these cases do not exhibit any cavity problems, as the cavity is covered with intact canal skin that has normal skin migration. Depending upon the extent of the cholesteatoma and the pneumatization, we conducted retrograde-type mastoidectomies on demand, followed by SWR in almost all of our cholesteatoma cases, including pediatric cholesteatoma. In this report, we describe our surgical procedure and the advantages of using retrograde mastoidectomy on demand with SWR in a series of pediatric cholesteatoma cases. This is the first report to document the outcomes of this procedure in the pediatric population.

Patients and Methods

We retrospectively evaluated a series of 25 consecutive children who were all 16 years old or younger. All children underwent cholesteatoma surgery at the Department of Otolaryngology, Kanazawa University Hospital between October 2002 and August 2008. All surgeries were performed by the same surgeon (M.I.). All patients were operated under general anesthesia, and retrograde mastoidectomy with widening the EAC was carried out on demand for the bone work, as modified technique which described by Tos (1). The mastoidectomy procedure performed was dependent upon the extent of the cholesteatoma and the pneumatization. If the cholesteatoma extended to the sinus tympani, we performed a large otosclerosis drilling over an expanded area in order to inspect the extension of the cholesteatoma. Depending upon the extent of the disease, we sometimes performed an atticotomy and an aditotomy (Figure 1). In addition, when the cholesteatoma extended beyond the antrum, we performed a small to large CWD mastoidectomy (Figure 2). After the retrograde mastoidectomy was

completed, the cholesteatoma was removed. The incus along with the head of the malleus, and on occasion, the whole malleus were removed in order to facilitate eradication of the disease and to make it possible to examine the anterior attic. In suitable cases, we performed ossicular chain reconstructions at the same time. If this proved not to be possible, we performed a staged reconstruction. To ensure that SWR could be completed, temporal muscle fascia was used for the tympanic membrane (TM) reconstruction in addition to providing support for the posterior wall skin of the EAC. In all planned surgery cases, a silicone sheet was inserted into the tympanum. Less than half of the planned surgeries required a simultaneous ventilation tube insertion. At a minimum of 6 months after the initial surgery, a second surgery was conducted to evaluate each patient. Depending upon the extent of the recurrent cholesteatoma, some cases also required revision mastoidectomies. For reconstruction of the ossicular chain, we used autologous ossicle as the graft material of first choice, with alloplastic graft materials (hydroxyapatite cement) used as the second choice.

The following parameters were analyzed: age at the time of presentation for surgery, sex, type of cholesteatoma, surgical findings noted at the first operation, rates of recurrent or residual disease, pure-tone audiogram (PTA) results with preoperative and postoperative air conduction (AC), bone conduction (BC), air-bone gaps (ABG), and the hearing gain and pure-tone averages at 3 different frequencies (500, 1000, and 2000 Hz) that were obtained at 6 months or more after the last surgical intervention. If the surgery was staged, the total number of surgical procedures performed was also recorded. Operative findings, particularly the status of the ossicular chain, were noted as well as the type of ossicular reconstruction. The postoperative status of the EAC and the TM was examined microscopically at regular intervals. To determine the presence of

residual or recurrent cholesteatoma, patients were visually evaluated during the planned second-stage surgery or, in some cases, visually evaluated in conjunction with examinations using high-resolution computed tomography. Residual cholesteatoma was defined as regrowth of keratinizing squamous epithelium that was visually identifiable as cholesteatoma. Recurrent cholesteatoma was defined as a new cholesteatoma developing from a postoperative retraction pocket. In the current study, both residual and recurrent cholesteatoma were designated as cholesteatoma recidivism. Results were examined using the Student's *t*-test, with $p<0.05$ considered to be significant.

Results

Of the 25 patients for whom data were available, there were 22 males and 3 females, with a mean age at the time of surgical intervention of 9 years (range, 4-15 years). The mean postoperative follow-up period after initial surgery was 48.7 months (range, 12-96 months). At the initial surgery, 16 patients (64%) had congenital cholesteatoma while 9 patients (36%) had acquired cholesteatoma. Surgical findings are reported in Figure 3. During the initial surgery, the disease was limited to the tympanum in 10 patients (40%), while it extended to the mastoid in 15 patients (60%). The disease extended to the eustachian tube in 6 patients (24%) and to the tympanic sinus in 16 patients (64%). Destruction of the ossicular chain was noted in 19 cases (76%) at the initial surgery. The incus and the stapes were frequently involved in the primary cholesteatoma, with the incus destroyed in 18 cases (72%), and the stapes superstructure either absent or destroyed in 13 cases (52%). In 1 case (4%), the malleus head was completely destroyed. No fixed footplate was found in any of the cases. Congenital ossicular malformation was noted in 1 patient. Labyrinthine fistula was detected in 2

patients, and 1 patient complained of dizziness prior to the surgery. Exposure of the sigmoid sinus was found in 2 patients (8%), while 1 patient (4%) had exposure of the posterior fossa dura. At the latest follow-up, the graft was dry and trouble-free in all children. One patient had a small perforation that was due to insertion of a tympanic ventilation tube 6 years prior to the initial surgery.

In 5 patients, the revision surgery was not required, as it was possible to entirely and easily remove the cholesteatoma without having to open the matrix during the primary surgery. In addition, none of these 5 patients required any further surgeries. Primary ossiculoplasty was done in 3 out of these 5 patients, while the other 2 patients required no ossiculoplasty and were able to receive type 1 tympanoplasty as a result of their limited disease.

A total of 20 patients received staged tympanoplasty with delayed ossiculoplasty. In order to achieve a good surgical view, revision mastoidectomy was performed to remove the cortical bone outgrowth in almost all patients. Residual cholesteatoma was detected in 5 (20%) out of 25 ears while recurrent cholesteatoma occurred in 1 (4%) out of 25 ears. Within these 6 recurrences, only 1 residual case proved to be congenital cholesteatoma. The other 5 recurrences were diagnosed as acquired cholesteatoma, as TM perforation was observed during their initial surgeries.

Within the 5 residual cholesteatoma cases, only a small pearl was detected in 4 cases (4 out of the total 25 cases, 16.7%). These were located in the posterior tympanic sinus, on the stapedial tendon, on the stapes head, and in the epitympanum, respectively. On the other hand, extensive re-growth of the cholesteatoma into the antrum was detected in 2 cases during the second-look surgeries, with 1 case each of residual cholesteatoma and recurrent disease. Both of these patients underwent a retrograde

mastoidectomy on demand in order to remove the disease, which was followed by ossiculoplasty. During the second-look surgeries, development of healthy mucosa was found in all but 2 patients. Furthermore, 6 years after the second surgery, the patient with residual disease required a third surgery for the epithelial pearl on the TM. In this particular case, it was possible to remove the cholesteatoma without destroying the reconstructed ossicular chain. There were no patients that required the use of the open technique during the CWD mastoidectomy for the disease.

Ossicular reconstruction was performed in 22 cases (19 staged-tympanoplasty and 3 non-staged) using a remodeled incus (n = 11), malleus (n = 3), cartilage (n = 1), malleus with incus (n = 3) or TORP with cartilage (n = 4) (Figure 4). The mean preoperative PTA–AC was 39.1 dB with a preoperative PTA–ABG of 28.8 dB. The postoperative hearing results were assessed 6 months or more after the ossicular reconstruction. The mean postoperative PTA–AC was 20.9 dB with a postoperative PTA-ABG of 11.7 dB. The mean hearing gain was 18.1 dB. The differences between the pre and postoperative values were significant in both the AC ($p = 0.005$) and ABG ($p = 0.044$) groups. No statistically significant difference was found between pre and postoperative BC values ($p = 0.053$).

Discussion

The issue of how to manage the posterior canal wall during cholesteatoma surgery is controversial. Preservation of the canal wall during CWU surgery preserves the normal anatomy of the ear canal, which leads to a reduced healing time and the avoidance of subsequent bowl infections, the so-called cavity problem (2). However, since use of this technique limits the surgical exposure, this can cause difficulties during

the operative procedures, resulting in higher residual rates. Therefore, this technique ultimately leads to more frequent second-stage surgeries. On the other hand, the open method tympanoplasty in CWD mastoidectomy provides excellent exposure for cholesteatoma removal. Even so, the cavity problem still exists. One method that has been shown to achieve complete eradication of the cholesteatoma and control the inflammation is a procedure that first removes the posterior canal wall and then reconstructs the wall. As per the technique described by Tos, we determined the extent of the cholesteatoma sac, and then carried out the retrograde mastoidectomy on demand, with expansion of the EAC dependent upon the extent of the disease actually present (1). Subsequently, the canal wall defect was repaired via the use of soft tissue. Retrograde mastoidectomy on demand has been proposed as a way to drill the mastoid bone for the purpose of removal of the cholesteatoma. This limited mastoid surgery is variable, with a transmeatal atticotomy performed through a canal-wall down mastoidectomy.

Although the technique for hard-tissue reconstruction of the posterior canal wall includes the use of autologous materials such as cartilage, mastoid bone, mastoid bone pate and alloplastic graft materials (hydroxyapatite cement), hard-tissue reconstructions have a tendency to create a retraction pocket that can lead to high rates of recurrent cholesteatoma formation (3,4). Dornhoffer has reported performing retrograde mastoidectomy that leaves the lower third of the posterior canal wall bone, which makes it possible to facilitate the reconstruction of the posterior canal wall using cartilage (5,6). Because the lower third of the posterior canal wall is necessary for hard-tissue reconstruction, this restricts the surgical view of the posterior tympanum. Furthermore, there is a risk that this method eventually leads to recurrence of cholesteatoma from the epitympanic retraction. Smith et al. first reported using SWR

with a Palva flap and a large piece of fascia in conjunction with packing the middle ear and mastoid cavity with moistened Gelfoam (7). In the current study, after the removal of the posterior EAC bony wall, we reconstructed the posterior canal wall by simultaneously performing myringoplasty using a large piece of fascia and retrograde mastoidectomy. The advantages of this procedure are the excellent surgical exposure of the posterior tympanum, the simplicity of the reconstructive technique of the canal wall and the quick healing period. Since the surface area of the skin defect is as small as that found for the CWU technique, this leads to early wound healing.

Cholesteatoma recidivism in our study was 24% for the retrograde mastoidectomy with soft-wall reconstruction. Rates of cholesteatoma recidivism in children have been reported to range from 26 to 45% for CWU, and from 12 to 43% for CWD procedures (8-13). As compared to previously published studies, the recidivism rate for our procedure was lower than that reported for the CWU procedure, but similar to that for the CWD procedure.

There were more cases of residual cholesteatomas detected in acquired cholesteatoma (4 out of 5 cases) as compared to the congenital cholesteatoma (1 out of 5 cases) in our study. Despite this result, we do not think that residual lesions are more common in acquired cholesteatoma versus congenital disease. This is because diseases with TM perforation were diagnosed as acquired cholesteatoma while all of the residual recurrent diseases tended to have greater amounts of extension to the mastoid (100%), the Eustachian tube (50%), and the tympanic sinus (80%) as compared to the non-residual recurrent diseases. Similar to that reported by Darrouzet et al., we do not believe there is a better prognosis for congenital cholesteatoma versus acquired cholesteatoma, unless the congenital cholesteatoma is both limited and directly

accessible (14). Thus, the residual cholesteatoma recidivism rate really depends upon the initial extension of the lesions. When the disease involves the facial recess, the tympanic sinus or the mesotympanum, it is surgically more difficult to remove the disease when using CWU mastoidectomy. In such cases, removal of the canal wall improves the exposure and makes it easier to remove the cholesteatoma in these areas, thereby leading to a lower incidence of residual cholesteatoma in single stage approaches such as CWD surgery. However, staged surgery is fundamentally necessary in pediatric cholesteatoma due to the possibility of residual disease. Thus, we performed a systematic second-look operation in 80% of the cases in our current study. Because of the aggressiveness of pediatric cholesteatoma, we prefer to use a short delay interval, and thus we only waited 5 to 12 months before performing our second-look surgeries.

In this patient group, there are preoperative concerns that can dictate using an open method in CWD. These concerns include operating on the only hearing ear, poor follow-up, requirement of a single-stage procedure, sclerotic mastoid, and labyrinthine fistula (11,15).

A second important outcome measure is hearing restoration and/or preservation of hearing. Several authors have reported that the status of the canal wall has little effect on the hearing outcome (11,13,16). Our data support this contention, even though our canal wall was reconstructed with a soft wall. In our study, socially acceptable hearing (30 dB HL or better) was achieved in 88% of the cases. Hearing results are reported to be satisfactory if patients have an intact stapes superstructure (type 3) and poor when they lack the stapes superstructure (type 4) (17,18). We found that 93.3% of the cases in which ossicular reconstruction was done in the presence of the stapes superstructure had acceptable social hearing levels as compared to only 80%

of the cases where the stapes superstructure did not exist. Success is also usually defined as a postoperative AB gap of less than 20 dB. In our study, 80% of the cases had an AB gap that was less than 20 dB.

The postoperative anatomical structure of the EAC in cases with SWR depends upon middle ear pressure regulation. There have only been a few reports on the occurrence of epitympanic retraction pocket formation (19). It is known that the Eustachian tube and the gas exchange functions of the mucosa in the mastoid air cells have important roles. Therefore, wasteful mastoidectomy should never be done. If there is a limited extension of the cholesteatoma, we prefer to use a transmeatal approach to expose the tympanic cavity. In our study, a healthy mucosa was seen in almost all cases during the second-look surgeries. By virtue of the acquisition of a better gas exchange function after the first surgery, this made it possible for the development of the mastoid air cells that we observed during the second-look surgeries. However, there were no cases of the open-like formation found, and there was 1 recurrent cholesteatoma detected in the current study. Therefore, ventilation tube insertion is probably necessary in certain cases, even after second-look surgeries.

In the current method that we report here, there is a single philosophy that is applicable to all cholesteatomas, including pediatric cases. Surgeons need to individualize the mastoidectomy by considering the location and extent of the cholesteatoma along with the states of infection. Only then should they reconstruct the canal wall using a soft wall. The cholesteatoma recidivism rate found in the current study was comparable to other reports that have used the CWD method. In addition, the postoperative hearing levels in patients in this study were found to be satisfying overall. Therefore, we believe that this SWR technique provides a good option for almost all

pediatric cholesteatomas.

Conclusion

Retrograde mastoidectomy with SWR is a beneficial technique that can be used to manage pediatric cholesteatoma. Although we are currently using this surgical technique in the majority of our adult and pediatric cholesteatoma cases, the possibility of recidivism could still pose a problem. However, if residual cholesteatoma does occur, this can be safely dealt with provided there are careful stagings and postoperative follow-ups.

Figure legends

Figure 1

Case 1: 5-year-old male with congenital cholesteatoma in his left ear.

Cholesteatoma (star) was found in the attic and the tympanic sinus during the first surgery. Otosclerosis drilling was performed to inspect the extension of the sinus cholesteatoma (A). Atticotomy and aditotomy were additionally performed in the patient (B). MH, malleus head; CT, chorda tympani nerve; RWN, round window niche; SF, stapes foot plate; FC, fallopian canal.

Figure 2

Case 2: 5-year-old male with congenital cholesteatoma in his right ear.

After removal of the incus body and the malleus and cleaning of the entire tympanic sinus, the cholesteatoma mass was then removed from the stapes (A). This case was representative of the CWD mastoidectomies that were performed for cholesteatomas

that occupied the entire antrum (B).

S, stapes superstructure; PE, pyramidal eminence; CT, chorda tympani nerve.

Figure 3

Surgical findings.

Figure 4

Types of ossicular chain reconstructions.

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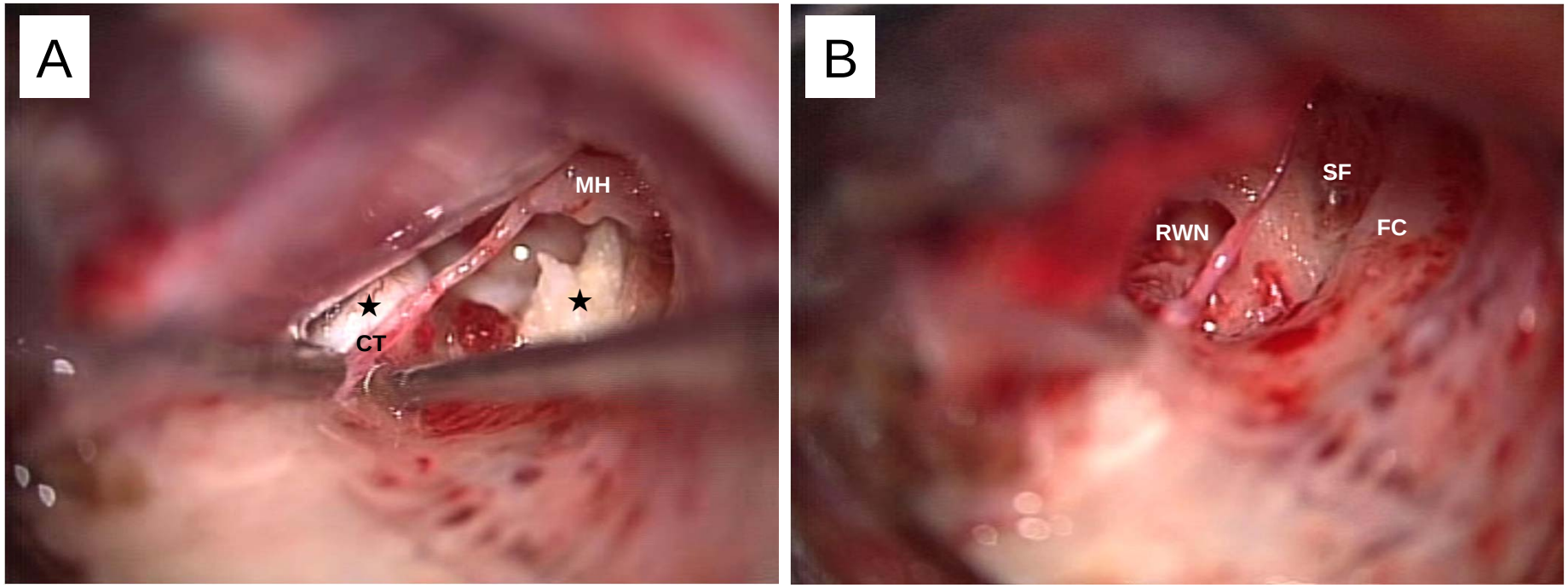

Fig. 1

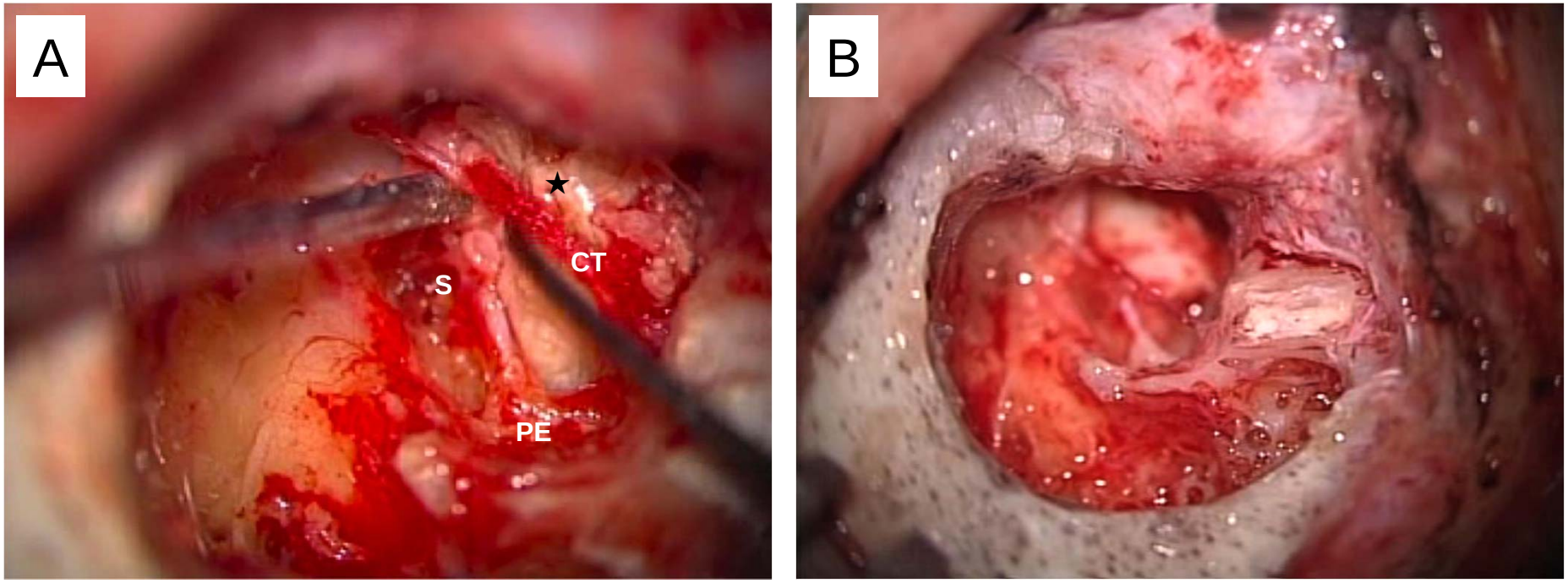

Fig. 2

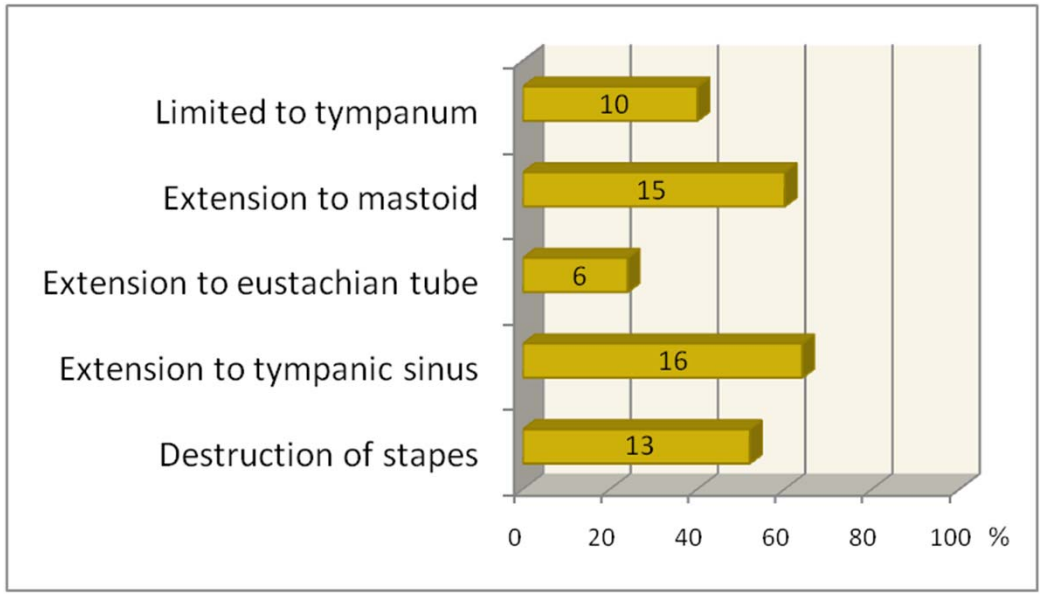
Limited to tympanum
10
Extension to mastoid
15
Extension to eustachian tube
6
Extension to tympanic sinus
16
Destruction of stapes
13
0
20
40
60
80
100
%

Fig. 3

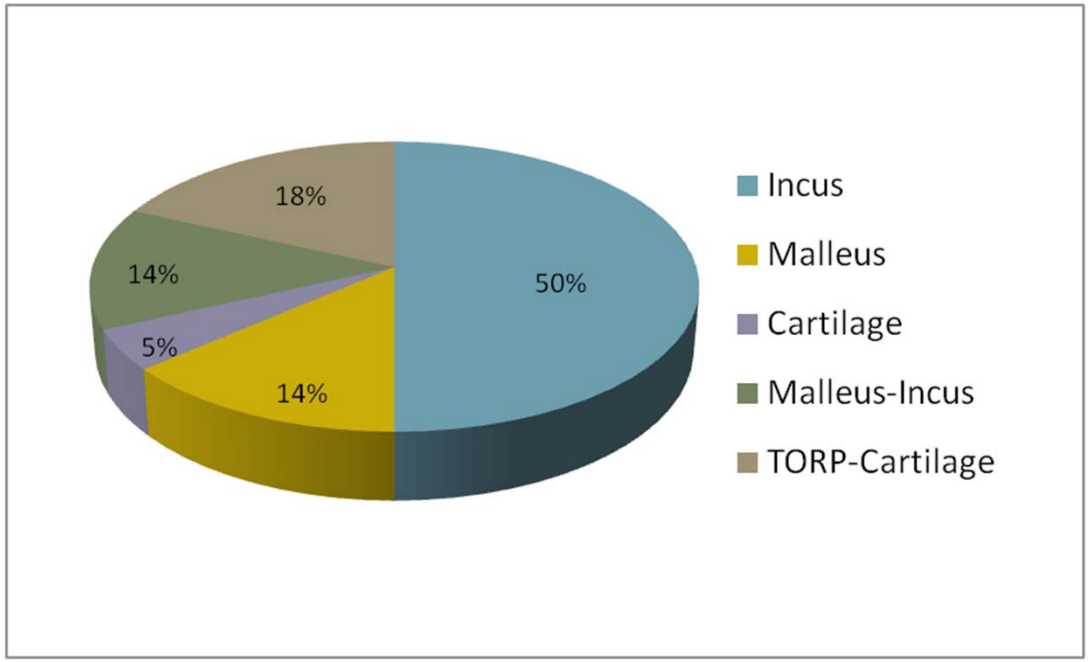
18%
14%
5%
14%
50%
Incus
Malleus
Cartilage
Malleus-Incus
TORP-Cartilage

Fig. 4