Title: Surgical management of troublesome mastoid cavities

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SURGICAL MANAGEMENT OF TROUBLESOME MASTOID CAVITIES

ABSTRACT

Objective: To examine the reasons for discharging mastoid cavities, the operative findings during revision surgery and the medium term outcome.
Study Design: Observational study on a cohort of revision mastoidectomies.
Setting: Tertiary referral center.
Patients: One hundred and forty (140) revision mastoidectomies in 131 patients were studied. There were 25 children and 106 adults. The follow up regime was at 3-months, 6-months, 1-year post-operation and yearly from then on. Cases requiring just meatoplasty or tympanoplasty without surgery on the mastoid bowl were not included in the cohort.
Intervention(s): A variety of techniques were performed on the troublesome mastoid cavities, with over 80% treated with mastoid obliteration. In the present cohort, two-thirds of the ears also had concomitant grafting or reinforcement of the tympanic membrane. Concomitant hearing restorative procedures were carried out in one-third of the ears at the same operation.
Main Outcome Measure(s): Percentage of ears still having otorrhoea, residual tympanic perforation, water intolerance at 1-year post-operation, and the residual cholesteatoma rate at 5-year post-operation were studied. The hearing outcome at 1-year post-surgery was analysed.
Results: The reasons for the troublesome mastoid cavities were large cavity size, bony overhang of the cavity, residual infected mastoid cells, presence of cholesteatoma or perforations, and inadequate meatoplasty. At 1 year following revision mastoidectomy, over 95% of the ears had become completely dry and water resistant. Overall, 36.6% of the ears had a hearing gain of 10 dB or more at 12 months, and 50.9% has a 12-month post-operative air-bone gap of 20 dB or less.
Conclusions: Revision mastoidectomy has a high success rate in converting troublesome mastoid cavities into dry and water resistant ears. However, hearing restoration may not be achievable in majority of the ears.

INTRODUCTION

Open cavity mastoidectomy or canal wall down mastoidectomy is one of the main techniques in cholesteatoma surgery. The perceived advantage is that it has a lower rate of recurrent and residual cholesteatoma compared to intact canal wall mastoidectomy.[1] The perceived disadvantage is that the open mastoid cavity accumulates cerumen that requires regular cleaning, and the cavity may be intolerant to water.[2] The surgical outcome of open cavity mastoidectomy is often influenced by the extent of the cholesteatoma and the skill of the surgeon. Many eminent otologists have written on the surgical principles of open cavity mastoidectomy, such as wide meatoplasty, low facial ridge, intact tympanic membrane, and smooth mastoid bowl.[3] The senior author (MWY) works in a tertiary referral centre and has the opportunity of managing a large number of long-standing troublesome mastoid cavities. The ones that failed conservative treatments were treated by surgery. The aim of the present study is to examine the reasons for the surgical failures of these troublesome mastoid cavities, the operative findings and the medium term outcome of revision mastoidectomy. The senior author (MY) has a policy of long-term follow-up of his patients following mastoid surgery on a yearly basis. It gives the opportunity of performing an observational study on a relatively large cohort of revision mastoidectomies.

MATERIALS AND METHOD

A. Ear Audit Clinic

The senior author (MWY) has had a policy of a yearly review of patients following mastoid surgery since 1988. A weekly ear audit clinic was set up with audiological support provided by 2 audiologists. The author personally evaluates all the patients at each post-operative follow-up. All the patients were advised to try water sports or hair washing without ear protection as part of the routine post-operative assessment. Air and bone conduction thresholds were also recorded on each patient. The clinical information was recorded in case notes as well as on a data proforma.

B. Patients

Between 1988 and 2008, 140 revision mastoidectomies were performed for troublesome mastoid cavities on 131 patients, aged between 8 and 79 years. There were 25 children (age 16 and below) and 106 adults. The follow up regime was at 3-months, 6-months, 1-year post-operation and yearly from then on. Nine (9) patients had revision mastoidectomies on both ears. The main indications for surgery were listed in Table 1. The commonest indication by far was ear discharge that cannot be controlled by conservative treatments, such as aural toilet and topical medications. Cases requiring just meatoplasty or tympanoplasty without surgery on the mastoid bowl were not included in the present cohort.

Of the 140 troublesome mastoid cavities in the present cohort, 126 (90%) were created originally by other surgeons, and 14 were created originally by the senior author himself (MY). Being a tertiary referral centre, 77 patients with 84 (60%) troublesome mastoid cavities in the present cohort were tertiary referrals from other institutions. In this cohort of 140 mastoid cavities, 99 had one mastoid operation, 32 had two mastoid operations and nine (9) had 3 or more mastoid operations performed previously.

C. Surgical intervention

The surgical technique of revision mastoidectomy used by the senior author (MY) has evolved since 1988, though the surgical principle remains the same. It involves reducing the bony overhang of the mastoid cavity, meticulous removal of the residual

mastoid cells, skeletonisation of the semicircular canals, dural and sinus plates, creating an adequate meatoplasty, reducing the size of the mastoid cavity, and repairing defects of the tympanic membrane. Before 1994, the size of the mastoid cavity was reduced by removing the mastoid tip or partial obliteration of the mastoid cavity using a Palva flap and/or bone paste. Since 1994, obliteration of the mastoid cavity was performed using hydroxyapatite granules. Initially, the hydroxyapatite (HA) granules were covered with an inferiorly based periosteal flap.[4] Since 1999, the HA granules were covered using cartilage sheets, an inferiorly based periosteal flap and a mid-temporal flap.[5] In the present cohort, two-thirds of the ears also had concomitant grafting or reinforcement of the tympanic membrane. The material of choice for the tympanoplasty was cartilage sheets or palisades to stiffen the tympanic membrane. Although the main purpose of the revision mastoidectomy was not to improve hearing, concomitant hearing restorative procedures were carried out in one-third of the ears at the same operation. Table 2 is a summary of the surgical interventions performed on the present cohort.

D. Data analysis

For the analysis on otorrhoea, intermittent discharge was not categorized in the present study as 'dry ear'. A cut-off analyses of the percentage of post-operative 'dry ear' and intact tympanic membrane at 6 months, 1year and 3 years were performed. For post-operative hearing outcome, the results at 1-year post-operation were presented. The 4-tone average of 0.5, 1, 2 and 3 KHz was used for the mean air conduction (AC) thresholds, following the recommendations from the Committee of Hearing and Equilibrium.[6]

In general, it takes longer for residual or recurrent cholesteatoma to manifest. Hence only a subset of ears operated on before 2004 were included for this analysis, as all the ears would have been given the chance of a 5-year follow-up. The recurrent and residual cholesteatoma rates were studied using cut-off analysis at 5 years. Residual cholesteatoma usually took the form of an epithelial pearl due to remnants of the cholesteatoma matrix left behind from the operation. Recurrent cholesteatoma was defined as a newly formed retraction pocket. To search for residual cholesteatoma underneath the HA granules, a 12-month interval CT-scan of the mastoid bone was performed on all mastoid cavities that had been obliterated with HA granules.[7]

RESULTS

Of the 140 mastoid cavities, 125 were still discharging at the time of the revision mastoidectomy. In these actively discharging ears, 60 were discharging from the mastoid segment, 8 were discharging from the tympanic segment, and 57 were discharging from both the mastoid and tympanic segments. The bony covering of many important structures were found to be missing at surgery, making the revision mastoidectomies hazardous. Many ears had exposed dura, sigmoid sinus, facial nerve, and some ears had labyrinthine fistulae. Almost one in five ears had exposed facial nerve. There were also eight (8) dead ears within the present cohort. Table 3 is a summary of the damage to important structures observed at the time of surgery. Only 7 ears out of 140 ears (5%) were found to have an intact ossicular chain.

At surgery, the senior author (MY) tried to identify the reasons for the surgical failure. Table 4 is a list of the perceived reasons for surgical failures in the present cohort of troublesome mastoid cavities. There were 5 cases of recurrent cholesteatoma, 4 of which were retraction pockets at the location of the attic cartilage graft from previous atticotomies or attico-antrostomies. There were also 34 cases of residual cholesteatoma within the middle ear or the residual mastoid cells. In total, about one quarter of the ears was harboring cholesteatoma.

The main purposes of the revision mastoidectomy were in the present cohort were to stop ear discharge, make the ear water proof while preserving hearing. The post-operative parameters of success are listed in Table 5, including dry ear, intact tympanic membrane and water resistance. At 12-month post-operation, only 6 out of 140 ears (4.3%) were still intolerant to water. Hearing preservation in this study was defined as ‘deterioration of air conduction threshold of no more than 10dB following surgery’. This parameter is also included in Table 5. The hearing results and water resistant property at 12-month post surgery were chosen for presentation in the present study,. The other properties of dry ear and intact tympanic membrane at 6-months, 12-months and 3-years were presented. There was no facial palsy or dead ear as a result of the revision mastoidectomy.

In the present cohort, the mean pre-operative hearing level before surgery was 53.3 dB (SD: 20.4; 95% CI: 13.4, 93.2), and the mean pre-operative air-bone gap was 29.1 dB (SD: 13.6; 95% CI: 3.4, 54.8). At 12 months after surgery, the mean hearing level was 47.6 dB (SD: 21.6; 95% CI: 5.3, 89.9), and the mean air-bone gap was 22.2 dB (SD: 12.2; 95% CI: -1.8, 46.2). The mean hearing gain at 12-months was 6.5dB (SD: 16.0; 95% CI: -24.9, 37.9). Amongst the 140 revision mastoidectomies, concomitant hearing restorative procedures were carried out in 44 cases (one in three cases) (se Table 2). Table 6 is a summary of the hearing gains and post-operative air-bone gaps for the present cohort. Data on post-operative air-bone gaps were not available in some ears because of difficulty in obtaining a reliable masked bone conduction threshold, e.g. ears with severe sensori-neural hearing loss. Overall, 36.6% of the ears had a hearing gain of 10 dB or more at 12 months. On the ears where air-bone gap data were available, 50.9% has a 12-month post-operative air-bone gap of 20 dB or less.

For the 5-year data on recurrent or residual cholesteatoma, 100 ears (operated between 1988 and 2004) were eligible for the study. Out of these, 18 ears were not available for the 5-year follow up. Of the remaining 82 ears, there were 2 residual cholesteatoma manifested at 2- and 6-year following surgery. Another ear developed a false membrane in the attic area 3 years after surgery. It trapped keratin behind the membrane and was regarded as a recurrent cholesteatoma. Hence the 5-year cholesteatoma rate using the cut-off analysis was 3.7%.

In this observational study, further surgical interventions following the revision mastoidectomies were also recorded. Table 7 is a list of subsequent surgery on the ears. Amongst these, 17 ears (12.1%) had further surgical procedures that were felt to be necessary. Other procedures were regarded as non-essential but desirable such as ossiculoplasty or bone anchored hearing aid operations.

DISCUSSION

Open cavity mastoidectomy is a commonly performed operation for cholesteatoma. However, the resultant mastoid cavities may create problems for some patients. The cavities need to be cleaned regularly to avoid excessive build-up of cerumen. Some cavities are intolerant to water because of the caloric effect. Occasionally the cavity may become infected and cause otorrhoea when the lining breaks down. In a study on the outpatient attendance pattern of the open cavity mastoidectomy patients over a 3-year period, Khalil et al noted an average of 13.3 visits per patients. The majority of the visits were for chronic cavity inflammation.[2]

Otorrhoea and clinician-dependence were the main indications for revision mastoidectomies in the present cohort. It is also interesting that almost one-quarter of the patients wished to have treatment to make their ears water resistant. Pre-operatively, cholesteatoma was noted in only 11 out of the 140 ears, yet in reality 39 ears (around one-quarter of cases) had cholesteatoma discovered at the time of surgery. Many of these cholesteatoma were hidden behind intact tympanic membrane or within residual mastoid cells. Therefore the possibility of hidden cholesteatoma must be considered in a non-stop discharging mastoid cavity.

The operation of revision mastoidectomy could be quite harzardous as normal anatomy is often distorted by infection and previous surgery. It is slightly surprising that only 3% of the ears in the present cohort had labyrinthine fistula, taken into consideration that there were 8 dead ears in this cohort. Many ears have exposed facial nerve, dura of the tegmen and sigmoid sinus. Therefore revision mastoidectomy should be performed by experienced otologists or in tertiary referral centers. Although ossicular damage was found in the majority of cases, the senior author chose to perform single stage ossiculoplasty in only 23 out of 140 ears.

The three commonest causes for troublesome mastoid cavities were residual bony overhang, large mastoid cavities and presence of residual mastoid cells. The presence of bony overhang over a large and deep mastoid cavity hinders self cleaning of the mastoid cavity, and makes aural toilet difficult. Residual mastoid cells harbor chronic inflammation or cholesteatoma. In the present cohort, it was found that 65 ears had

discharge coming from the tympanic segment. Some were due to perforation of the tympanic membrane, but some were due to active chronic otitis media existing behind an intact tympanic membrane. Often, the difficult part of the operation was to remove the granulation within the middle ear rather than from the mastoid cavity.

This current study is not designed to find out whether one particular operation is better than the others. The senior author (MY) tried to individualize the operation. As most ears in the present cohort had big mastoid cavities, the senior author favored eliminating the mastoid cavity using the obliteration technique. All but 16 cavities in the present cohort were treated with mastoid obliteration, in the majority with HA granules and the mid-temporal flap. Before obliterating the mastoid cavity, the mastoid cells were meticulously removed, especially around the labyrinthine block, the supra-facial area, sinu-dural angle and mastoid tip. The senior author prefers using HA granules for obliteration because they maintain their volume over time.[4] The mid-temporal flap is a pedicled flap based on the mid-temporal artery.[5] In the experience of the senior author, the outcome is predictably good, with the mid-temporal flap re-epithelialised within weeks following surgery. Patient can usually allow water in the ear within 3 months of surgery. In the last 20 years, the senior author (MY) has not experienced major problems, such as undetected cholesteatoma hidden behind the HA granules resulting in intracranial complications. In cases where the eardrum was atrophic or retracted, it was stiffened using cartilage plates or palisades to prevent pars tensa retraction. Considering that 93.6% of the mastoid cavities had otorrhoea before surgery, the medium term results of the revision mastoidectomies were excellent. Almost all the cavities became dry and 95% were water resistant at 12 months. Furthermore, around 50% had an air-bone gap of 20dB or less.

One difficulty in reporting the rates of recurrent or residual cholesteatoma is that they take many years to manifest.[8] Many patients may not comply with the follow-up regime. In this study, the 5-year follow-up rate for the 100 eligible ears was 82%. Using the cut-off analysis, the rate of residual and recurrent cholesteatoma combined was 3.7%.

In the present study, the outcome of revision mastoidectomy appears to be excellent, with high rates of post-operative dry ear, intact tympanic membrane and water resistance. However, 25 out of the 140 ears (17.9%) required further operations afterwards. Excluding second look procedures and second stage hearing restorative procedures, 17 ears (12.1%) had problems requiring further surgical corrections. The main problems were residual cholesteatoma and retracted tympanic membrane.

There are relatively few reports in the literature on the outcome of revision mastoid surgery. Table 8 is a summary of the case mix and outcome of some of these reports. It is not easy to make direct comparison of these studies because of different case mix and follow-up periods amongst these reports.

In conclusion, this study shows that in general revision mastoidectomy has a high success rate in converting troublesome mastoid cavities into dry and water resistant ears. However, around 10% of the ears will eventually need further surgical procedures. Also, hearing restoration may not be achievable in majority of the ears.

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Table 1. Indications for revision mastoid surgery for 140 mastoid cavities.

Indications	**Number of ears / total (%)**
Persistent or intermittent discharge	131/140 (93.6%)
Intolerance to water	24/140 (17.1%)
Excessive building up of cerumen	25/140 (17.9%)
Dizziness	11/140 (7.9%)
Presence of cholesteatoma	11/140 (7.9%)