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Main Article

Canalplasty for severe external auditory meatus exostoses

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Abstract
Exostoses of the external auditory meatus is a well known condition which infrequently requires surgical correction. However, the stenosis caused by severe exostosis can affect quality of life considerably and may require surgical intervention. Canalplasty, in such a situation, is a valid and effective management option. In our series the commonest indication for surgery was recurrent otitis externa. The detailed surgical technique is described and a retrospective analysis of 65 such procedures is presented. There were only two significant complications, both post-operative stenosis, requiring further corrective surgery. In conclusion, canalplasty for the exostosis of the external auditory meatus is a safe surgical option.

Key words: Exostoses; Ear Canal; Surgical Procedures, Operative

Introduction

Exostoses of the external auditory meatus (EAM) is not an uncommon condition. The majority of cases do not present to medical care. However, when the stenosis caused by this condition exceeds a certain limit it can give rise to problems such as recurrent wax retention, chronic inflammatory conditions and conductive hearing loss. This limit has been defined by Whitaker *et al.*[1] as greater than 80 per cent stenosis. In such cases surgery is indicated to restore normal physiology. Other less frequent but significant indications include conditions in which access medial to the exostosis is required, such as chronic suppurative otitis media and otosclerosis.

In this manuscript the technique used at Gruppo Otologico for canalplasty for exostosis is described and our long-term results are presented.

Materials and methods

A retrospective analysis was done from the charts of patients who underwent surgery for severe exostoses from January 1985 to January 2003. These charts where analysed for date of surgery, patient's age and sex, indication for surgical intervention, hearing assessment pre- and post-operatively, surgical outcome, and complications. A total of 65 canalplasty procedures were performed in 57 patients, with eight patients receiving bilateral interventions. Patients' ages ranged from 12 to 77 years. The left ear was involved in 38 procedures and the right ear in 27. The pure tone average was calculated using the mean of hearing level at 500, 1000, 2000 and 4000 Hz. for both air and bone conduction. The average follow-up was 34 months, ranging from 8 months to 10 years. The statistical test used for the analysis of results was the paired *t* test.

Surgical technique

Our technique has been published in detail elsewhere;[2] in this paper we present a review of the technique, stressing the key points for avoiding complications and side-effects.

The classical retroauricular skin incision is performed, followed by harvesting the superficial fascia of the temporalis muscle. The beaver knife is used to incise the posterior meatal skin, forming a flap which is held anteriorly together with the auricle using the retractor. In mild cases in which the tympanic membrane (TM) can be seen, the meatal skin is elevated medially towards it using the meatal knife and a small cottonoid while the flap is protected by a small piece of aluminium harvested from the packing of the surgical threads then drilling is commenced.

In severe exostoses the protrusion causes a bottle-neck constriction of the EAM, rendering the space available lateral to it too shallow to accommodate the meatal skin flap. Since the integrity of the meatal skin flap is of great importance for the success of the surgical procedure and the prevention of post-operative stenosis, an alternative technique of dissection is required to protect the flap. In these cases, instead of elevating the skin evenly and simultaneously from the canal walls, this part of the procedure is done in a stepwise manner. The skin overlying one protrusion is elevated up to the level of the constriction, and the elevated skin is laid over the opposite wall and protected by an aluminum sheet. Careful drilling of the bone is started and continued to just beyond the level of constriction (Figure 1). The skin is then reflected back over the drilled space and the opposite wall is dealt with in a similar manner.

This process is repeated until all the protrusions are

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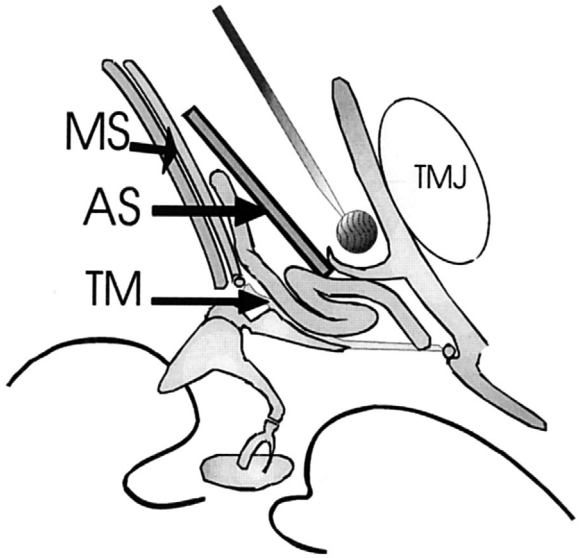

FIG. 1

Drilling to just beyond the level of constriction. AS = aluminium sheet; MS = meatal skin; E = exostoses; TM = tympanic membrane; M = malleus; I = incus; AN = annulus.

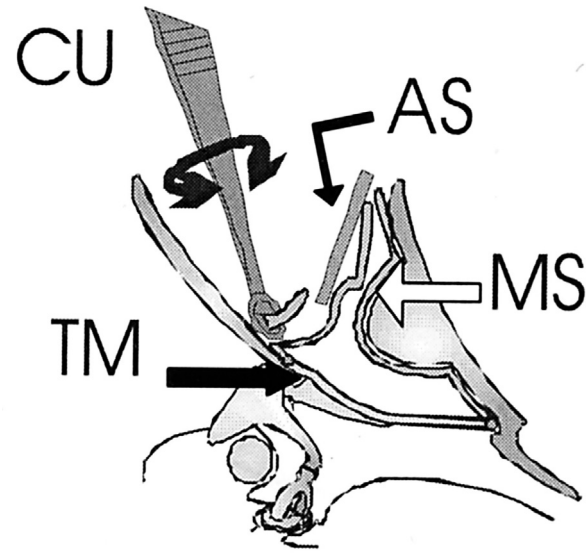

FIG. 3

Removal of the last bony remnant using a curette. AS = aluminium sheet, MS = meatal skin, TM = tympanic membrane, CU = curette

evenly drilled medial to the level of the constriction, resulting in its widening. Once this has been done, the meatal knife can be safely introduced medial to the constriction, allowing the elevation of the skin covering the medial aspect of the protrusions. Having done this, the entire meatal skin flap can now be tucked medial to the narrowing, covered by aluminum and drilling started again to eliminate what is left of the excessive bone (Figure 2). From time to time the meatal skin is draped back over the canal walls to assess progress and to check the position of the annulus, which serves as the main indicator for the adequacy of drilling.

Two important structures to be aware of while drilling the bony protrusions are the facial nerve and the temporomandibular joint. These lie in the posterior wall and the anterior wall, respectively, and every effort should be made not to disturb them. In cases of severe narrowing, facial nerve protection takes precedence. This objective is generally facilitated by restricting blind drilling of the posterior canal wall while the tympanic membrane is not visible, because of the relationship of the facial nerve to the annulus.[3–6] Thus the drilling can continue in the superior, inferior and anterior wall. When the TM position is verified, the posterior wall protrusion can be removed. In order to evaluate exactly how much bone is left to be drilled, the position of the annulus is assessed by using the right-angled meatal knife, insinuated between the repositioned flap and the TM to assess the thickness of the remaining bone yet to be removed. Drilling in the part lateral to the annulus is now safer, but the posterior wall should not be over-thinned in order not to expose the mastoid air cells.

During the process of drilling the direction of movement of the drill is of paramount importance. The surgeon should never drill from lateral to medial, so as not to touch the TM accidentally – this can result in an iatrogenic perforation or a sensory neural hearing loss as a result of the contact of the high speed burr with an intact ossicular chain. Instead, a medial-to-lateral direction is used in the narrow regions of the canal, the superior and inferior walls. While drilling the posterior and anterior walls the direction of drilling is parallel to the tympanic membrane.

The last bony remnant overlying the annulus should now be removed. If a drill is used for that purpose, drilling the anterosuperior wall should be left until last in order to avoid touching the short process of the malleus with the moving drill. Alternatively, a small curette could be used (Figure 3). In both cases, the direction of movement of the instrument should be parallel to the TM and an aluminum sheath should be used to cover both the flap and the TM.

After finishing the bone work, the resultant canal is usually wider than the meatal flap. Therefore the latter may require longitudinal cuts from lateral to medial in order to ensure intimate contact of the skin with the bone. If any significant amount of bone remains bare after this manoeuvre, the fascia harvested at the beginning of the operation is now used to cover it. The new canal is now packed partially with gel foam to allow inspection of the cartilaginous part of the meatus, which could be narrower

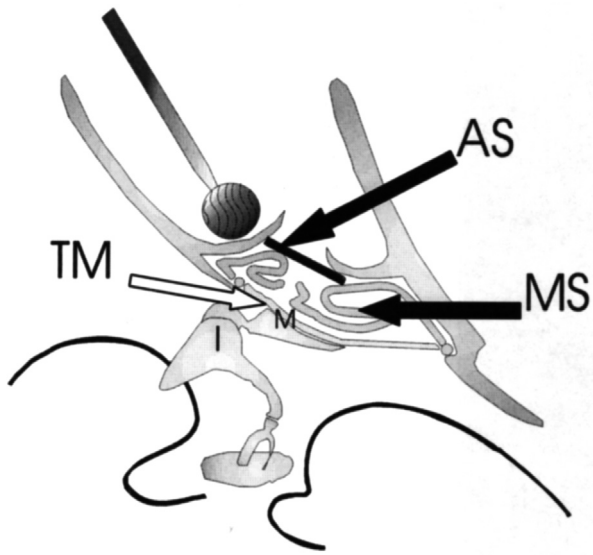

FIG. 2

Tucking the meatal skin flap medial to the constriction. AS = aluminium sheet; MS = meatal skin; M = malleus; I = incus; TM = tympanic membrane.

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TABLE I
INDICATIONS FOR CANALPLASTY (65 PROCEDURES)

Indication	n	%
Otitis externa	34	52
Conductive hearing loss	10	15.4
Hearing aid fitting	5	7.7
Stapedotomy	6	9.2
Myringoplasty	8	12.3
Ossiculoplasty	2	3

than the enlarged bony part. If this is the case, conchoplasty is indicated; a longitudinal incision is made in the posterior wall of the cartilaginous canal and sufficient cartilage removed. Finally, the incision is sutured in layers.

Results

Using this technique at Gruppo Otologico, a total of 65 canalplasty procedures were performed in 57 patients. The indications are listed in Table I. The commonest indication was excessive wax accumulation and retention with resulting frequent otitis externa (52 per cent). Providing surgical access in order to perform other middle ear surgery was the indication for 24.4 per cent of the procedures. In 15.4 per cent the indication was to correct the conductive hearing loss caused by the narrowing.

Audiometric follow-up was available for 57 out of the 65 procedures performed. When all the cases were considered together, the post-operative air–bone gap was improved by more than 10 dB. compared with the pre-operative level in 15 patients, 34 patients maintained their air–bone gap within 10 dB. of the pre-operative level, and in eight patients the air–bone gap worsened by more than 10 dB. In four out of the eight cases in which the air–bone gap worsened, the post-operative level fell by less than 15 dB. compared with the pre-operative level, and in the remaining four cases the difference was less than 20 dB. The bone conduction average deteriorated from 12 dB. pre-operatively to 22 dB. post-operatively in one case; this was the only case in the series in which a deterioration of bone conduction occurred. When these changes were tested statistically, the change in the air–bone gap was not significant ($p = 0.06$, paired t test). When the 10 cases operated upon for reduction of air–bone gap were considered alone, the post-operative gap was improved by more than 10 dB. compared with the pre-operative level in five patients, three patients maintained their air–bone gap within 10 dB. of the pre-operative level, and in two patients the air–bone gap worsened by more than 10 dB. In one of these two patients the post-operative air–bone gap deteriorated by 18 dB. The second case was the only one in the series in which a deterioration in the bone conduction level occurred. As mentioned previously the post-operative bone conduction average deteriorated by 10 dB and the air–bone gap by 14 dB. The average pre-operative air-bone gap for the 10 patients operated on for conductive defect was 35 dB; post-operatively, it averaged 20.3 dB. Although in one case the bone conduction level worsened post-operatively, the difference between the post-operative and pre-operative bone conduction levels was not statistically significant, neither when the group was considered as a whole ($p = 0.1$, paired t test) nor when the cases operated upon for reduction of air–bone gap were considered separately ($p = 0.29$, paired t test).

There were complications in three cases in our series. In one case the mastoid air cells in the posterior canal wall were inadvertently opened, necessitating covering with fascia. The patient was kept under close observation, and there have been no adverse effects over seven years of follow-up.

Two patients developed post-operative canal stenosis as a consequence of post-operative infection, both of whom needed surgical correction. One had a fibrous stenosis which required excision of the scar and relining of the external auditory meatus with a split thickness skin graft, followed by packing the canal. At the time of writing this patient has been under follow-up for 18 months and the stenosis has not recurred. The second is the same patient who experienced post-operative deterioration of the bone conduction level and the air–bone gap. In this patient fibrous as well as bony stenosis were encountered, requiring the use of a drill for excision and the lining of the canal with a split thickness skin graft. At the time of writing, after a one-year follow-up, there has been no evidence of any further stenosis.

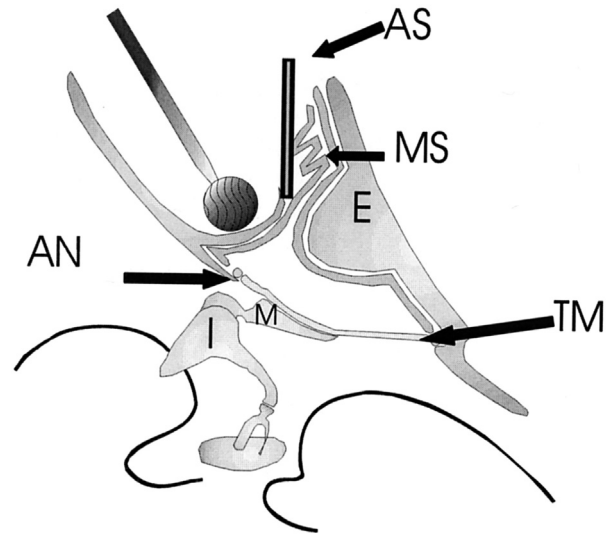

FIG. 4
Severe narrowing obliterating tympanic membrane. AN = annulus; TM = tympanic membrane; E = exostoses; MS = meatal skin.

Discussion

Physicians tend to distinguish between osteomas, which are true bone tumours occurring unilaterally, and exostoses, a bilateral condition thought to be secondary to repeated cold-water exposure or recurrent inflammation of the external ear.[7–9] Another difference between the two conditions is the relatively high incidence of exostoses (0.6 per cent) in the patients examined in otolaryngology clinics, compared with the rarity of osteomas.[10,11] Nevertheless when the lesion is severe enough to cause obstruction of the external auditory canal the clinical picture of the two conditions does not differ, indicating a similar surgical strategy.

Canalplasty is generally perceived as a simple task. However when the stenosis is severe the procedure can be demanding, especially given the absence of adequate landmarks (Figure 4).[6] For this reason we prefer the retroauricular approach for all but the mildest narrowing (which can be dealt with via a transcanal approach, thus reducing the complications rate).[12] An additional advantage of the retroauricular approach is that temporalis fascia can be harvested, which can prove useful when grafting small bare areas of the EAM.

After establishing access dissection of the meatal skin in begun, creating a medially based skin flap. This part of the operation must be carried out with extreme care, since the integrity of healthy meatal skin is a key factor in the success of the operation. Loss of an unacceptable amount of meatal skin can lead to formation of granulation tissue, fibrous

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stenosis and membranous atresia with complete closure of the ear canal.[13] On the other hand if the meatal skin is unhealthy it should be removed and replaced at the end of the operation by a skin graft harvested from the wound edge.

Before drilling is commenced the dissected meatal skin should be protected, as mentioned previously. For this purpose a sheet of aluminum trimmed to the appropriate size is used to cover the skin while using the drill. This sheet also allows the use of a cutting burr, which serves to speed up the operation. Longridge[14] has described a technique in which a laterally based meatal skin flap is created. Such a flap is at risk of damage from the rotating burr of the shaft because of the difficulty of covering it. In our series we had two cases of post-operative stenosis, both of which were the result of post-operative infection of the EAM and in our opinion were not related to skin loss.

- **Severe exostosis of the external auditory meatus can affect quality of life and may require surgical intervention by canalplasty**
- **In this series the commonest indication for surgery was recurrent otitis externa**
- **The authors describe their technique and retrospectively analyse 65 procedures; there were only two complications of restenosis**

The direction of drilling is of extreme importance. In their report Rodrigues *et al.*[15] stressed the importance of lateral-to-medial removal of bone so that the process could proceed under direct vision. In our technique the bony protrusion is divided into blocks which are progressively removed from lateral to medial. The difference is that while removing each block the drill is moved either parallel to the tympanic membrane or in a medial-to-lateral direction, never from lateral to medial. Hence in addition to working under direct vision we avoid the risk of accidental slipping of the drill, injuring the middle ear structures.

When operating on a severely narrowed canal it is important to restrict drilling in the posterior part of the canal until the TM is visible. The mastoid segment of the facial nerve lies 2–3 mm lateral to the TM in the inferior part of the posterior wall, where it can be exposed or even receive thermal injury from the heat of nearby drilling.[16] It is therefore wise to start drilling elsewhere until the TM is visible. On the other hand excessive drilling in the anterior wall would jeopardize the temporo-mandibular joint (Figure 5), the opening of which not only would cause masticatory problems and chronic pain[17] but would also lead to unnecessary movement in the canal, disrupting the healing process and leading to post-operative stenosis. Another dangerous area is the medial part of the anterosuperior wall. The distance between this part of the canal and the short process of the malleus is so small that an inattentive touch to the latter by the spinning burr could lead to sensorineural hearing loss. To avoid such a mishap the size of the burr should be small enough to fit in the interval between that wall and the short process without touching the latter.

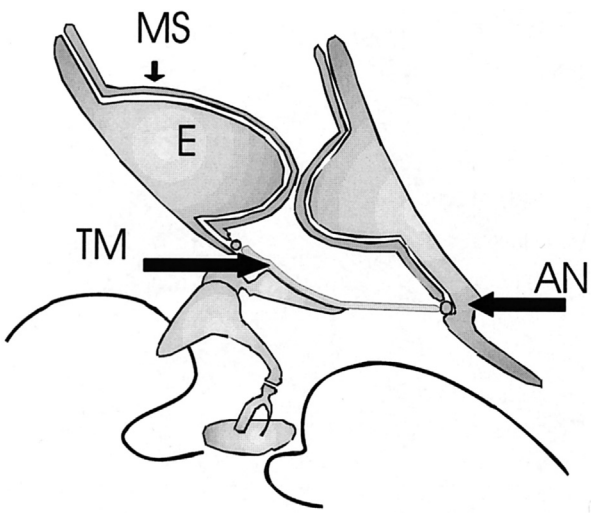

FIG. 5

Temporomandibular joint relationship to the anterior wall of the external auditory meatus. TMJ = temporomandibular joint, TM = tympanic membrane, AS = aluminium sheet, MS = meatal skin.

When the drilling is finished, and before returning the meatal skin, the posterior wall should be checked for any opened mastoid air cells. If any are found, these should be closed using bone dust or a piece of cartilage and the wall then covered with a piece of temporalis fascia. Failure to close such air cells would eventually lead to an iatrogenic cholesteatoma. The meatal skin is draped back over the canal walls, and if not sufficient to cover the now widened canal longitudinal cuts are made to allow for adaptation. Any significant bare areas of bone should be covered with fascia as this allows for faster healing and re-epithelialization.

Regarding post-operative hearing levels, the air–bone gap worsened in eight out of 57 patients. In six of these eight patients there was other pathology medial to the tympanic membrane, the progression of which could account for the worsening air–bone gap. Concerning the two cases operated on for correction of the air–bone gap in which deterioration of hearing level occurred, in one of these the pre-operative air–bone gap deteriorated from 42 dB pre-operatively to 60 dB post-operatively, ossicular chain disconnection or complete fixation of the stapes due to severe otosclerosis. Neither of these pathologies could be ruled out since the patient refused any further interventions. In the other case, in addition to deterioration of both the bone conduction level and the air–bone gap, a post-operative fibrous as well as bony stenosis was encountered. The deterioration of the bone conduction level from 12 dB pre-operatively to 22 dB post-operatively may be explained by the test/retest variation. Failure to bridge the air–bone gap in this patient is probably due to the recurrent stenosis that was encountered post-operatively.

Post-operative stenosis was encountered in another case. Here the stenosis was only fibrous and was due to post-operative infection.

The last complication we encountered in this series was the opening of the mastoid air cells while drilling the posterior canal wall. This case emphasizes the need to be careful while drilling in this area as the mastoid air cells can be encountered more anteriorly than usual. Obliteration of the opened air cells using fascia, as in this case, or a combination of cartilage and fascia for wider openings would markedly reduce the risk of developing a subsequent iatrogenic cholesteatoma.

Conclusion

Canalplasty of the EAM, despite being a relatively simple surgical task, has the potential to give rise to major complications if a meticulous and safe surgical technique is not adopted. We have detailed the surgical steps of this procedure, as performed in our centre over much of the past two decades. Our results demonstrate it to be a safe and effective manoeuvre, provided appropriate attention to detail is paid.

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