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MAIN ARTICLE

Postinflammatory medial meatal fibrosis: early and late surgical outcomes

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Abstract

Objectives: To evaluate the primary and long-term surgical outcomes of patients with postinflammatory medial meatal fibrosis.

Methods: A retrospective study was conducted of 14 ears (in 12 patients) with postinflammatory medial meatal fibrosis managed surgically. Outcome measures were primary (i.e. less than six months) and long-term (i.e. greater than five years) closure of the air–bone gap, and the incidence of otorrhoea and restenosis.

Results: At primary review, the mean air–bone gap ± standard deviation had decreased from 29.9 ± 11.6 dB to 12 ± 8.4 dB ($p < 0.0006$). Seven (50 per cent) ears had closure of the air–bone gap to within 10 dB. However, for the 9 ears receiving long-term review, the mean air–bone gap ± standard deviation increased to 19.3 ± 15.2 dB; there was no significant difference between this result and pre-operative values ($p = 0.06$). Of the 9 long-term review ears, 3 (33 per cent) showed closure of the air–bone gap to within 10 dB. Recurrent otorrhoea was the most common complication, occurring in 5 of the 9 long-term review ears (56 per cent); in addition, 3 (33 per cent) of these 9 ears developed restenosis.

Conclusion: Over time, the success of surgery for postinflammatory medial meatal fibrosis diminishes. This was demonstrated in the present study by progressive post-operative hearing decline and a high prevalence of otorrhoea and restenosis.

Key words: Ear Canal; Hearing Loss, Conductive; Ear Diseases; Otitis Externa; Fibrosis; Treatment Outcome

Introduction

Postinflammatory medial meatal fibrosis is an uncommon, acquired atresia of the external auditory canal. This entity has many synonyms, such as postinflammatory acquired atresia, medial meatal fibrosis, chronic stenosing external otitis and recurrent acquired atresia. In order to reduce the disarray of nomenclature, Tos introduced a classification system for acquired atresia.[1] Terms for subtypes of the condition are related to aetiology, and include post-traumatic, post-operative, neoplastic and postinflammatory. The focus of the current study is postinflammatory medial meatal fibrosis.

As the name suggests, postinflammatory medial meatal fibrosis involves an inflammatory process. However, due to the lack of any animal model there remain significant gaps in our understanding of this condition, firstly regarding the nature of the inflammation, and secondly regarding the precise steps involved in the development of atresia. On review of the literature, it is generally agreed that otitis externa or chronic suppurative otitis media is the initiating insult. In the primary stages of the disease, there is loss of the squamous epithelial lining of the lateral surface of the tympanic membrane and medial canal, exposing the fibrous layer. In the presence of persistent inflammation, healing occurs with the formation of granulation tissue. Granular myringitis is considered to constitute an important step in the formation of atresia, and was initially observed by Toynbee in 1860.[2] The granulations eventually undergo fibroid degeneration and epithelialisation. Recurrent episodes of infection lead to further spread of the atresia laterally, until a dense, circumferential, fibrous plug occupies the medial portion of the external auditory canal. This gradual progression from granular myringitis to fibrotic thickening was described by Bonding and Tos in one of their patients followed up over five years.[3]

Patients with postinflammatory medial meatal fibrosis undergo two distinct phases. In the primary or wet stage, episodic inflammation leads to frequent otorrhoea. Management generally involves regular aural microsuction and antibiotic-steroid drops. As the granulations

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heal and develop into a stenotic, fibrous plug, the external auditory canal enters the dry stage and patients are left with conductive hearing loss. In some cases, central areas of fibrosis can break down, leading to further discharge.[4]

When a circumferential fibrous plug has formed and the external auditory canal is dry, most authors recommend surgical intervention. The most commonly employed technique is complete excision of the fibrous tissue, with a careful attempt to preserve the fibrous layer of the tympanic membrane. The bony canal is then widened, with the exposed bone being covered with split thickness skin grafts. Some authors advocate the use of full thickness grafts, fascia or transposition flaps to line the created defect.

The overall aims of surgery are to create a wide and well-ventilated external auditory canal, and to improve the hearing disability. In the literature, surgical results in the short to mid-term (i.e. six months to two years) are reported to be very promising. However, there are many important issues that need further clarification. There still remains significant uncertainty concerning long-term outcomes (i.e. greater than five years) regarding hearing and the condition of the external auditory canal and tympanic membrane. Currently, there is no universal consensus concerning the optimal surgical approach. In addition, the timing of surgery also raises debate, with most authors advocating a completely dry external auditory canal as a prerequisite to surgery. There are no series reporting outcomes for patients with wet and granular postinflammatory medial meatal fibrosis who are still to develop a completely dry fibrous plug.

The objectives of the present study were to address these issues via presentation of our experience and review of the literature on postinflammatory medial meatal fibrosis. In the longest series follow up conducted to date, we report the primary and long-term functional hearing benefit, recurrence rates, persistence of chronic inflammation, and the state of the external auditory canal and tympanic membrane, following surgical intervention. We also present the surgical outcomes of a series of patients with wet postinflammatory medial meatal fibrosis. Our results are compared with those of other, similar published studies.

Method

Between January 2003 and September 2011, 14 ears in 12 patients were diagnosed with postinflammatory medial meatal fibrosis. All patients were assessed in the ENT clinic and a structured interview conducted. The following information was recorded: age, gender, presence of dermatological conditions, history of trauma, previous operations and current symptoms.

Otomicroscopy was performed by the senior author (MCFS). The diagnosis was based upon the characteristic findings of a fibrous plug causing complete occlusion and shortening of the external auditory canal. In some cases, the plug was wet and granular, in others it was a dry, skin-lined pit.

Pure tone audiometry and computed tomography were routinely performed pre-operatively.

Surgical technique

All patients were operated upon by a single surgeon (MCFS). The surgical approach was postauricular. A circumferential incision was then made in the skin of the external ear canal just lateral to the stenotic plug. The fibrous plug was carefully elevated from the bone down to the fibrous annulus. Further continuous elevation was performed along the outer surface of the tympanic membrane. The process was carefully completed, aiming to leave the lamina propria and lamina mucosa of the tympanic membrane intact. At this stage, if middle-ear disease was suspected a small tympanotomy was performed and the middle ear inspected for any abnormality. The bony external auditory canal was then widened until the whole of the fibrous annulus was clearly visible from one position under the microscope. The anterior tympanomeatal angle was laid open to at least 90°.

Once these steps had been completed, the bone in the medial meatus was mostly exposed and bare of skin. The denuded bone was then covered with split thickness skin grafts harvested from either the thigh or behind the pinna. Skin from the thigh was taken using an electric dermatome (Zimmer, Warsaw, Indiana, USA) at a thickness of 0.2 mm. The split thickness skin graft was then cut into a disc to cover the entire tympanic membrane. Strips were placed onto the exposed bone of the external auditory canal. In those cases in which post-aural skin grafts were used, pinch skin grafts were harvested then placed edge to edge as a patchwork to cover the tympanic membrane and exposed bone of the canal. If the meatus was considered to be inadequate, a soft tissue conchomeatoplasty was performed. In cases in which the tympanic membrane had perforated, repair was performed using standard myringoplasty techniques with temporalis fascia underlay grafting.

At the end of the procedure, the external auditory canal was packed with moistened Gelfoam pieces (Pfizer, New York, New York, USA) soaked in ciprofloxacin, and ribbon gauze soaked with bismuth iodine paraffin paste. This was left in situ for two weeks.

Audiometry

Pure tone audiometry was conducted in accordance with the recommendations of the British Society of Audiology. An Aurical system with audit base (Aurical, San Mateo, California, USA) was used. The frequencies tested for air conduction were 0.25, 0.5, 1, 2, 4 and 8 kHz; those for bone conduction were 0.5, 1, 2 and 4 kHz. Masking was performed during all bone conduction testing regardless of the threshold difference for interaural bone conduction. Air conduction masking was used when air conduction thresholds

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in the affected ear were worse than the bone conduction thresholds in the contralateral ear by 40 dB or more. Pure tone averages for air conduction and bone conduction, and the air–bone gap, were determined at 0.5, 1, 2 and 4 kHz.

Outcome measures

Patients were followed up in clinic on a regular basis. The first (primary) follow-up appointment took place within 6 months; thereafter, patients were followed up at 6- to 12-month intervals. The outcome of surgery was recorded in relation to the impact on hearing, the long-term patency of the external auditory canal, and the condition of the external auditory canal and the tympanic membrane. These outcomes were assessed during clinic visits, using a combination of history-taking, otomicroscopy examination and pure tone audiometry.

Statistical analysis

The statistical analysis was performed using Johns Macintosh Project (also termed JMP) version 6 software (SAS, Marlow, UK). Data are presented in simple descriptive format and in tables. Categorical variables are presented as percentages and continuous variables as mean ± standard deviation (SD). Statistical significance was assessed using a paired *t*-test; *p* values of less than 0.05 were considered to be significant. The Glasgow benefit plot was used to assess binaural hearing.

Results

Fourteen ears in 12 patients were operated upon for postinflammatory medial meatal fibrosis. Two patients had bilateral disease, and one was operated upon for restenosis. The patient cohort consisted of 7 males (58 per cent) and 5 females (42 per cent), with an average age of 51 years (range, 16–75 years).

Nine patients had a history of chronic otitis externa and three had a history of chronic suppurative otitis media. The right ear was involved in 8 (57 per cent) cases and the left in 6 (43 per cent). Dermatological conditions were present in 5 (42 per cent) patients. Three patients had psoriasis, one had eczema and one had atopic dermatitis. The duration of symptoms prior to presentation ranged from 2 to 45 years, with a mean duration of 14 years and 2 months.

Otomicroscopy examination showed the external auditory canal to be shortened and obliterated, ending in a false tympanic membrane, in all ears. Five (36 per cent) ears had wet external auditory canals, despite maximal medical management at the time of operative intervention.

A pre-operative computed tomography scan was performed for all patients, and characteristically demonstrated a circumferential core of dense soft tissue in the medial portion of the external auditory canal. In one patient, cholesteatoma was suspected on radiology and later confirmed during surgery.

Surgery was successfully performed in all ears, with no intra-operative complications. The fibrous tissue was detached with relative ease from the tympanic membrane. Three ears (21 per cent) had small perforations in the fibrous lamina of the tympanic membrane, which were repaired with standard myringoplasty techniques. One patient was found to have cholesteatoma in the bony external auditory canal, medial to the fibrosis. Twelve ears (86 per cent) required split thickness skin grafts, and two (15 per cent) received conchal bowl skin flaps in addition to split thickness skin grafts. The primary site of graft harvesting was the postauricular skin in 5 (36 per cent) ears, thigh skin in 4 (29 per cent) ears, a combination of pinna and thigh skin in 2 (15 per cent) ears, and a combination of pinna skin and temporalis fascia in 3 (21 per cent) ears.

Histopathological analysis was performed on all excised specimens. This showed fibrous connective tissue with varying degrees of inflammatory cell infiltration.

Primary follow up was performed within 6 months of surgery, for all 14 ears. Of these 14 ears, 9 underwent long-term follow up, that is, for a minimum of 5 years; these 9 ears had a mean follow up duration of 7.6 years (range, 6.3–9 years).

Hearing alteration

At initial presentation, all patients complained of hearing loss. Pre-operatively, the mean absolute air conduction threshold was 14 ± 54 dB (range, 31–71 dB), with a mean air–bone gap of 29.9 dB ± 11.6 dB (range, 15–52 dB). At the primary follow-up appointment, the mean air conduction had improved to 35 ± 11.6 dB (range, 14–54 dB), with a mean air–bone gap of 12 ± 8.4 dB (range, 2–34 dB). These improvements were statistically significant, for both absolute hearing ($p < 0.0024$) and air–bone gap ($p < 0.0006$). The air–bone gap was closed to within 10 dB in 7 (50 per cent) ears and to within 20 dB in 13 (93 per cent) ears. Seven (50 per cent) of the ears had social hearing (0–30 dB). Application of the Glasgow benefit plot indicated that 8 (57 per cent) ears had binaural hearing at primary follow up.

At long-term follow up, the mean air conduction threshold was 38.9 ± 20.2 dB (range, 16–72 dB) with an air–bone gap of 19.3 ± 15.2 dB (range, 3–55 dB). There was no statistically significant change between these results and pre-operative values, for either absolute hearing ($p = 0.22$) or air–bone gap ($p = 0.06$). The air–bone gap was closed to within 10 dB in 3 (33 per cent) ears and to within 20 dB in 5 (55 per cent) ears. Four (44 per cent) ears had social hearing (0–30 dB) and 3 (33 per cent) ears maintained binaural hearing.

State of the external auditory canal

At the time of surgery, the external auditory canal was dry in nine ears and wet in five ears.

For the 9 ears with dry external auditory canals, the mean pre-operative air conduction threshold was

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53.7 ± 13 dB and the mean air–bone gap was 34 ± 10 dB. At primary follow up, the mean air conduction threshold improved to 38 ± 16 dB, with a mean air–bone gap of 10.7 ± 10.5 dB. These changes represented a statistically significant difference for both air conduction ($p = 0.0460$) and air–bone gap ($p = 0.0073$). The air–bone gap was within 10 dB in 5 ears and within 20 dB in 9. At primary post-operative review, four of the pre-operatively dry ears had otorrhoea.

Of the 9 pre-operatively dry ears, 5 received long-term follow up (mean duration, 7.5 years; range, 7.3–7.9 years). For these ears, the mean long-term air conduction was 42 ± 20 dB and the mean long-term air–bone gap was 18.8 ± 12 dB. These results did not differ significantly from pre-operative values, for either air conduction ($p = 0.30$) or air–bone gap ($p = 0.107$). In the long term, the air–bone gap was within 10 dB in 2 ears and within 20 dB in 3 ears. Four of the pre-operatively dry ears continued to have persistent otorrhoea over long-term follow up; two of these four ears developed restenosis, two years after surgery. A further pre-operatively dry ear developed otorrhoea six months after surgery.

For the 5 ears with a wet external auditory canal at the time of surgery, the mean pre-operative air conduction was 46.4 ± 10 dB and the mean air–bone gap was 26.3 ± 12 dB. At primary follow up, these ears showed a significantly improved mean air conduction (31 ± 18.7 dB; $p = 0.25$) and mean air–bone gap (14.2 ± 3.27 dB; $p = 0.043$). The air–bone gap was within 10 dB in 2 ears and within 20 dB in 4 ears. At the primary post-operative review, one (pre-operatively wet) ear had otorrhoea.

Of the 5 pre-operatively wet ears, 4 received long-term follow up (mean duration, 7.5 years; range, 6.3–9 years). For these 4 ears, the mean long-term air conduction was 34 ± 22 dB and the mean long-term air–bone gap was 20 ± 20 dB. These results did not differ significantly from pre-operative values, for either air conduction ($p = 0.39$) or air–bone gap ($p = 0.22$). The long-term air–bone gap was within 10 dB in 1 patient and within 20 dB in 2 patients. All the pre-operatively wet ears had dry external auditory canals at final review. One pre-operatively wet ear developed restenosis, four years after surgery.

Post-operative otorrhoea and tympanic membrane state

At primary follow up, 5 ears (36 per cent) had otorrhoea. Of these 5 ears, 4 (80 per cent) occurred in pre-operatively dry ears and 1 (20 per cent) in a pre-operatively wet ear. Of the 9 ears which were dry pre-operatively, 5 (56 per cent) were noted at long-term follow up to have persistent otorrhoea requiring regular microsuction. None of the pre-operatively wet ears developed persistent otorrhoea.

All ears (100 per cent) had an intact tympanic membrane post-operatively, at both primary and long-term review.

Restenosis

Table I gives information on post-operative restenosis. Of the 14 ears studied, 3 (21 per cent) developed restenosis, with 1 ear requiring further surgery. Recurrence occurred two years after surgery in two ears and four years after surgery in one ear. In two of the ears, restenosis occurred secondary to otitis externa.

Discussion

Postinflammatory medial meatal fibrosis is a relatively rare entity; however, most otolaryngologists will be required to manage it at some stage during their career. The initiating insult is most commonly infective and frequently attributed to chronic otitis externa. Patients most typically present with significant conductive hearing loss and frequent otorrhoea.

Once a mature fibrous plug has formed, the recommended management is surgical removal. The evidence for this approach is supplied by a relatively small number of studies, of which the majority are retrospective case series. Most authors have reported good post-operative outcomes in the short and mid-term, particularly in relation to hearing improvement. Advocates of surgery also argue that operative intervention is indicated in case there is trapped squamous epithelium within the fibrous plug lateral to the tympanic membrane. We encountered one such case in our study, with cholesteatoma suspected pre-operatively on the basis of computed tomography. However, before surgery becomes the accepted standard management there are many issues that need further clarification, including: consensus on surgical technique; the audiology criteria representing a good result; and the longer-term surgical outcome (i.e. more than five years). Additionally, surgery is associated with significant

TABLE I
FOLLOW UP AND RESTENOSIS

Ear (no)	FU (mth)	Restenosis	
		Occurred?	Time* (mth)
1	21	No	
2	22	No	
3	23	No	
4	23	No	
5	23	No	
6	76	No	
7	87	Yes	24
8	88	Yes	24
9	90	No	
10	92	No	
11	93	No	
12	94	Yes	48
13	95	No	
14	108	No	

*Time between primary operation and restenosis. No = number; mth = months

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complications, including frequent episodes of otorrhoea requiring regular and long-term aural microsuction, late tympanic membrane perforation, and relatively high rates of recurrence.

In 1966, Parparella and Kukjian were the first to report the basic principles of the management of post-inflammatory medial meatal fibrosis.[5] These principles remain largely unaltered and have been cited in the majority of major published series (Table II). The basic surgical steps involve complete removal of the fibrous plug whilst maintaining an intact fibrous layer of the tympanic membrane, widening of the bony canal, recreating an epithelial layer for the external auditory canal, and firm post-operative packing to aid graft uptake and long-term patency. Over time, some authors have applied various modifications to these basic principles in order to achieve better outcomes. There is general agreement that the fibrous plug should be completely excised.

One exception has been Soliman *et al.*, who proposed wedge excision of the fibrous plug from the floor of the external auditory canal and insertion of a rubber tube for six weeks. These authors studied a total of 16 surgical cases, 13 of which resulted in a satisfactory external auditory canal with epithelialisation. The follow-up period was 18 months and the restenosis rate was reported as 20 per cent. However, no audiology results were available.[16]

The majority of authors report widening of the bony canal. In a few series, meatoplasty was also considered an important component. Generous but careful widening is required to achieve visualisation of the whole tympanic annulus. More specifically, the surgeon should obtain a clear view of the tympanomeatal angle, which should be laid open to at least 90°. Incomplete removal in this respect is believed to be a cause of restenosis. This was noted in El-Sayed's series, in which blunting of the angle was considered to be an early form of restenosis.[13] Similarly, Tos and Balle note the tympanomeatal angle as an important anatomical point from which fibrous tissue should be thoroughly removed in order to prevent restenosis.[1]

Complete removal of the fibrous tissue inevitably results in large areas of denuded bone. It is at this stage that the greatest variation in surgical technique exists. The exposed bone can be covered using a variety of skin flaps, full thickness grafts and split thickness grafts. Most surgeons will also place split thickness grafts over the tympanic membrane as well as the external auditory canal.

The main argument for the use of skin flaps is that the properties of the external auditory canal skin are unique. The lateral external auditory canal contains many apocrine and sebaceous glands, important for self-cleaning and prevention of infection. It is important to preserve these functions, especially if portions of the skin lining the lateral external auditory canal have been removed during the surgical procedure. However, this must be weighed against the fact that skin flaps can be bulky and inadequate for the coverage of more medial defects. Another important method of coverage for the denuded bone is the use of full thickness grafts. Proponents of full thickness grafts cite better durability, lower rates of contracture and the presence of glandular elements that aid lubrication.[17] However, the most commonly applied strategy for resurfacing the external auditory canal is split thickness grafting. The most common sites from which the grafts are harvested include the postauricular region and the upper arm; other, rarer donor sites include the thigh and abdomen. The main benefit of split thickness grafts is their excellent acceptance rate. Studies using split thickness grafts have the most comprehensive outcome data available. There remains no consensus on ideal graft thickness.

The final stage of the procedure is adequate packing. Once all the fibrotic tissue has been removed, the primary aim of packing is to establish firm contact between the graft and the bone in order to encourage acceptance. Surgeons' packing preferences vary widely, with a range of materials being used. The most common are Silastic® sheeting and gelatin sponge (Gelfoam) soaked with antibiotic drops. Other materials used to pack the external auditory canal include bismuth iodine paraffin paste, and gauze covered with antibiotics and steroids. Packing is commonly removed between two and four weeks post-operatively.

An important aim of surgical intervention is functional correction of the patient's hearing disability. Improvement in hearing is an important criterion against which the success of surgery is determined. In the literature, 11 series (including the present study) involving a minimum of 10 ears each have reported operative effects on hearing (Table III; Jacobsen and Mills' study[15] is excluded as no follow-up time was specified). The mean follow-up duration in these studies was 21 months (range, 5–43.2 months). The exact criteria used to assess the impact on hearing varied between studies. With no direct consensus on what constitutes a good post-operative result, making a firm comparative analysis remains challenging. The most commonly used criterion was the number of patients with air–bone gap closure to within 20 dB. Outcomes were reported for 196 ears (including ears from the present study), 84 per cent of which (n =165) achieved an air–bone gap of less than 20 dB; results for individual studies ranged from 64 to 100 per cent. Our early post-operative results are consistent with the current literature, with 93 per cent of ears achieving an air–bone gap of less than 20 dB. However, closure of the air–bone gap to within 20 dB still leaves patients with a significant conductive hearing loss. A more appropriate criterion for success may be closure of the air–bone gap to within 10 dB.

All the studies reported a degree of hearing improvement, with the air conduction threshold improving by a mean of 23.42 dB and the air–bone gap decreasing by

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TABLE II
REPORTED SURGICAL TECHNIQUES FOR POSTINFLAMMATORY MEDIAL MEATAL FIBROSIS

Study	Approach	Full FT excision?	Any skin preserved?	Full FA visualisation?	TA opened ≥90°?*	CP?	MP?	Graft type	Graft site	EAC packing	Pack time (wk)	Other post-op care
Macdonald *et al.*[6]	Postauricular	Yes	No	NS	NS	Yes	No	STG	Thigh, upper arm, lower abdominal wall	2 strips of medium-light Silastic sheeting + Cortisporin-soaked iodoform packs	4	Cortisporin Otic drops for 1 wk after pack removal
Tos & Balle[1]	Endaural	Yes	NS	Yes	Yes	Yes	NS	STG	NS	Silastic film + Gelfoam + hydrocortisone tetracycline gauze	4	
Cremers & Smeets[7]	Postauricular	Yes	NS	Yes	NS	Yes	Yes	Ped skin flap + STG	NS	Antibiotic-soaked sterile foam rubber balls	NS	
Keohane *et al.*[8]	Transcanal	Yes	Yes	NS	NS	Yes	NS	Ant canal flap + STG	NS	NS	NS	
Magliulo *et al.*[9]	Endaural	Yes	NS	Yes	NS	Yes	NS	STG	NS	Gelfoam + thin Silastic sheet	NS	Weekly review for 1 mth
Birman & Fagan[10]	Postauricular	Yes	Yes	Yes	Yes	Yes	NS	STG	Upper arm	Gelfoam + Celestone-gentamicin ointment	1	
Slattery & Saadat[11]	Postauricular	Yes	NS	NS	NS	NS	NS	5 of 14 ears grafted (type NS)	Pinna (n=4), abdomen (n = 1)	NS	NS	
Becker & Tos[12]	Transcanal	Yes	No	Yes	Yes	Yes	Yes	STG	NS	Gelfoam balls with antibiotic + gauze with hydrocortisone & Terramycin ointment	3	
El-Sayed[13]	Postauricular	Yes	NS	NS	NS	Yes	Yes	STG	Medial upper arm	NS	NS	
Lin *et al.*[14]	Endaural	Yes	No	Yes	NS	Yes	Yes	STG	NS	Thin Gelfilm strips + Gelfoam	2	Oral ciprofloxacin
Jacobsen & Mills[15]	Postauricular	Yes	No	NS	NS	Yes	Yes	STG	Upper arm	'Swiss roll' of Silastic sheet + ribbon gauze + bismuth iodoform paste	2	
Present	Postauricular	Yes	Yes	Yes	Yes	Yes	Yes	STG	Pinna, thigh	Ciprofloxacin-soaked Gelfoam balls + ribbon gauze with bismuth iodoform paraffin paste	2	

*Tympanomeatal angle (TA) laid open to at least 90°. FT = fibrous tissue; FA = fibrous annulus; CP = canalplasty; MP = meatoplasty; EAC = external auditory canal; wk = weeks; post-op = post-operative; NS = not specified; STG = split thickness graft; Ped = pedunculated; Ant = anterior; mth = months

TABLE III
REPORTED SHORT TO MID-TERM* POST-OPERATIVE OUTCOMES FOR POSTINFLAMMATORY MEDIAL MEATAL FIBROSIS

Study	Ears (*n*)	FU (mean (range); mth)	ABG closure (*n* (%))		Pre-op:post-op ratio (means; dB)		Binaural hearing (*n* (%))	Restenosis (*n* (%))	Wet EAC (*n* (%))	TM perf (*n* (%))	Chol (*n* (%))
			<10 dB	<20 dB	AC	ABG					
Becker & Tos[12]	53	6	32 (60)	48 (90)	NS	NS	NS	3 (6)	9 (17)	2 (4)	5 (9.4)
Tos & Balle[1]	22	6	10 (45)	18 (80)	NS	NS	NS	3 (13.6)	2 (9)	0	4 (18.2)
Macdonald *et al.*[6]	22	40.8	NS	15 (68)	NS	NS	NS	4 (18.2)	NS	NS	0
Cremers & Smeets[7]	17	12	8 (47)	16 (94)	NS	NS	NS	0	2 (11.8)	0	2 (11.8)
Keohane *et al.*[8]	15	24	15 (100)	15 (100)	NS	NS	NS	1 (6.7)	1 (6.7)	1 (6.7)	0
Magliulo *et al.*[9]	13	27.6	NS	NS	NS	NS	9 (69)	4 (30.8)	NS	1 (7.6)	0
Birman & Fagan[10]	12	5	NS	NS	20	NS	NS	2 (16.7)	NS	1 (8)	0
Slattery & Saadat[11]	14	43.2	3 (25)	11 (77)	37.6:26.1	24.8:15.1	NS	3 (21.4)	1 (7)	1 (7)	0
El-Sayed[13]	12	30	NS	NS	NS:20	NS	NS	2 (16.7)	NS	NS	2 (16.7)
Lin *et al.*[14]	26	25.5	14 (54)	21 (81)	46.5:16.6†	28.7:12.50†	NS	3 (11.5)	13 (50)	2 (8)	0
Jacobsen & Mills[15]	13	NS	4 (31)	8 (64)	NS	29:17	6 (46)	4 (29)	NS	NS	0
Present	14	<6	7 (50)	13 (93)	50.4:35‡	29.9:12**	8 (57)	0§	5 (36)	0	1 (7)
Total	233	20.5 (5–43.2)	93/174 (53)	165/196 (84)	44.8:25.9	28.1:14.15	23/40 (58)	29/233 (12)	33/161 (20)	8/172 (5)	14/233 (6)

n (%) values refer to ears. *Five years or less. †$p < 0.001$; ‡$p = 0.0024$; **$p < 0.0006$. §All ears assessed less than 6 months post-surgery. FU = follow up; mth = months; ABG = air–bone gap; Pre-op = pre-operative; post-op = post-operative; EAC = external auditory canal; TM perf = tympanic membrane perforation; Chol = cholesteatoma; AC = air conduction; NS = not specified

TABLE IV
REPORTED LONG-TERM* POST-OPERATIVE OUTCOMES FOR POSTINFLAMMATORY MEDIAL MEATAL FIBROSIS

Study	Ears (*n*)	ABG closure (*n* (%))		FU (mean; mth)	Restenosis (*n* (%))	Wet EAC (*n* (%))	TM perf (*n* (%))
		<10 dB	<20 dB				
Becker & Tos[12]	38	12 (32)	23 (61)	60	1 (3)	3 (8)	2 (5)
Present	9	3 (33)	5 (56)	91.2	3 (33)	5 (56)	0
Total	47	15 (32)	28 (60)	75.6	4 (8)	8 (17)	2 (4)

n (%) values refer to ears. *More than 5 years. ABG = air–bone gap; FU = follow up; EAC =external auditory canal; TM perf = tympanic membrane perforation

a mean of 14.15 dB. However, only one previous study observed a statistically significant improvement.[14] Two studies assessed the post-operative effects on binaural hearing.[8,14] Of a total of 40 treated ears, 58 per cent ($n = 23$) achieved bilateral, symmetrical hearing. In conclusion, more than half of patients may potentially achieve a degree of functional benefit.

The long-term outcome of surgery (i.e. after more than five years) raises further debate. There is only one major series reporting long-term post-operative outcomes, published by Becker and Tos (Table IV). These authors found that the number of ears with a post-operative air–bone gap of less than 20 dB declined from 90 per cent at primary follow up to 61 per cent at 5 years.[12] The present series, smaller in size but representing the longest follow-up period reported to date, found a similar outcome: the proportion of ears benefitting from surgery (i.e. having an air–bone gap of less than 20 dB) progressively declined from 93 per cent to 55 per cent over a mean period of 5 years 5 months. Postinflammatory medial meatal fibrosis renders the external auditory canal unstable and can result in a protracted post-operative course. Over a period of time, the benefits of surgery progressively diminish.

Other clinically significant post-operative complications include the development of persistent otorrhoea, tympanic membrane perforations and restenosis. Only a few studies have reported the post-operative condition of the external auditory canal. In a total of 7 studies reporting outcomes for 161 treated ears, 23 per cent ($n = 33$) developed a wet external auditory canal. The incidence in our study was higher, at 36 per cent and 56 per cent for primary and long-term follow up, respectively. In a recent study, Lin *et al.* reported a similar incidence of 50 per cent.[14] Our technique did not significantly differ from that of the majority of previously reported series. In all our patients, we performed a canaloplasty and meatoplasty where indicated, with the aim of creating a wide, well ventilated external auditory canal. Non-involved skin lateral to the fibrosis was preserved in all patients. However, several of our patients had dermatological conditions that may have mitigated against good skin healing, and may also have been part of the underlying aetiology of the condition.

Interestingly, we observed that all the ears with long-term post-operative otorrhoea had a dry external auditory canal pre-operatively. In contrast, all the ears with a wet external auditory canal pre-operatively had a completely dry post-operative external auditory canal in the long term. As granulations undergo fibrosis, the stenotic plug becomes thicker and extends laterally. The dry stage of postinflammatory medial meatal fibrosis represents advanced disease involving the entire medial portion of the external auditory canal. Surgery at this later stage is generally more extensive, and the proportion of remaining canal skin lateral to the fibrosis diminishes. Several authors have recommended that surgery should only be performed once the external auditory canal has become completely dry.[8,11] The present study findings indicate that this is generally unnecessary. Performing surgery at an earlier stage can reduce patient discomfort associated with a chronically discharging ear that will often require frequent out-patient visits for medical therapy over a period of many years. Such surgery may also enable a less extensive procedure and allow preservation of disease-free skin, which may be important for maintenance of the natural function of the external auditory canal.

The literature indicates that perforation of the tympanic membrane appears to be a relatively uncommon complication. Reported rates vary between 1 and 8 per cent, with a mean of 4.3 per cent. In our series, no tympanic membrane perforations were reported.

- **Surgery for postinflammatory medial meatal fibrosis improves hearing in the short term but benefits diminish over time**
- **Long-term hearing gain is very variable**
- **Long-term prevalence of otorrhoea and restenosis is high**
- **Early surgery may be beneficial for dense, wet, granular atresia, preventing chronic discharge**
- **Alternative management (e.g. bone-anchored hearing aid) should be carefully considered for all patients**

Restenosis is the most commonly described surgical complication, and the only reported complication for many authors. Stenosis, as opposed to recurrent atresia, may not be a problem if canal depth remains

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good and the skin dry. However, in many cases stenosis progresses to atresia over time. The time from surgery to recurrence can vary: it can be as short as six months or as long as nine years after surgery.[11] Early restenosis is particularly common when the denuded bone is not grafted. Restenosis has been reported in most series regardless of the surgical technique employed. One exception is the series reported by Cremer and Smeets, who used a combination of a pedunculated conchal skin flap and a split thickness graft to cover the exposed bone; no episodes of recurrence were observed, after a mean review period of 12 months.[7] Similarly, Keohane *et al.* used a combination of an anteriorly based canal flap and a split thickness graft, and also reported very low restenosis rates, at 6.1 per cent ($n = 1$).[8] Despite these results, it remains difficult to draw any definitive conclusions due to the small number involved and the lack of data on long-term outcomes.

The best management of postinflammatory medial meatal fibrosis is often argued to be surgical. However, in view of the potential long-term complications and significant variability in hearing gain and patient satisfaction, alternative options need to be considered carefully. The biggest disability for patients with postinflammatory medial meatal fibrosis remains the conductive hearing loss. The use of traditional hearing aids is extremely difficult in view of the occluded external auditory canal and resultant predisposition to otitis externa. More recently, the widespread availability of bone-anchored hearing aids has provided an alternative option for improving hearing without the need for extensive surgery. Those patients offered surgery should be carefully selected and given a realistic picture of post-operative outcomes.

Conclusion

Long-term surgical outcomes for postinflammatory medial meatal fibrosis is generally poor. Hearing gains can be variable, with a high prevalence of otorrhoea and restenosis. From the present study findings, we conclude that early surgery is appropriate for ears with dense, wet, granular atresia, because it can often result in a dry ear with no prolonged discharge. Hearing often improves, at least in the shorter term. Those ears which have established a dry false fundus, often after many years of otorrhoea, may be best treated by avoiding external auditory canal surgery, because the ear may return to a state of wet otorrhoea and the early hearing gains are often lost over time.

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