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Myringoplasty

(A review of 365 operations)

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Introduction

THE repair of the tympanic membrane dates back for more than a century. In 1878 Berthold successfully closed a perforation with full thickness skin and introduced the term 'myringoplastik'. Reports of similar operations by Ely (1881) and Tangemann (1884) soon followed. However, enthusiasm subsequently waned and it was not until the 1950's that interest was rekindled as a direct consequence of the introduction of microsurgery together with the availability of antiobiotic drugs. In this era the pioneer work of Zöllner and Wullstein provided the main stimulus to the development of new tympanoplastic techniques in the reconstruction of ears damaged by otitis media. Although initially skin continued as the material of choice for tympanic membrane repair, it was not long before other tissues were introduced. Amniotic membrane (Schrimpf, 1954), autologous mucous membrane of cheek (Hall, 1956) and cornea (Holewinski, 1958) were all tried but were later abandoned as more suitable tissues were discovered. Periosteum (Claros-Domenech, 1959), vein (Shea, 1960), connective tissue (Portmann *et al.*, 1964), adipose tissue (Ringenberg, 1962) and perichondrium (Goodhill, 1963) all proved of value and have remained in current use in various centres until the present time. In 1959 Ortegren tried out fascia as a graft material and, following its introduction to the U.S.A. in the following year by Storrs, this tissue rapidly gained widespread acceptance so that, at the present time, over 20 years later, it remains the most popular grafting material. Allografts—dura mater (Preobrazkensky, 1961) and tympanic membrane (Chalat, 1964; Marquet, 1966; Betow, 1970)—also have their advocates and are currently used extensively in some centres.

As graft materials changed with the passage of time so also did operative techniques. Although the original 'onlay' method is still practised there has been a progressive swing, over the years, towards the 'underlay' technique introduced by Austin and Shea (1961) and later modified and improved by Hough (1970). Sandwich and plugging methods are employed in some centres, the latter being used mainly in the closure of small-sized perforations.

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Evaluation and comparison of different grafting techniques and materials have proved extremely difficult, as each surgeon, having discovered a successful method of repair, has quite naturally tended to stick to it, thus rendering a valid comparison of techniques by the same surgeon well nigh impossible. In the present survey the same problem applies to some extent for, although a variety of techniques was used, the numbers of cases in which some of these methods were applied were small, making comparison difficult.

Materials and Methods

The study set out to analyse 365 consecutive cases of tympanic membrane repair carried out by the same surgeon (A.G.G.) over a period of approximately 20 years. This period saw the evolution of myringoplasty from its early days. During the first decade several different techniques were tried out, but later on the underlay method of repair, using temporal fascia, became our standard procedure. The length of follow-up varied between one month and 13 years with a median of 7.3 months. This analysis covers not only simple repair of the tympanic membrane but also cases in which an additional procedure—ossicular reconstruction or mastoidectomy—was performed simultaneously.

The survey is divided accordingly into two parts. In the first part all cases of tympanic membrane grafting, irrespective of technique or the extent of the operative procedure, will be analysed. The investigation was designed to compare different grafting techniques and also to determine whether the introduction of an additional procedure, e.g. ossiculoplasty, at the same operation in any way compromised the success rate of the myringoplasty.

In the second part of the survey we proceed to a detailed analysis of the technique which we ultimately adopted as our standard procedure, namely: the fascia underlay method. This part of the survey comprises 206 operations, the results of which will be analysed in relation to take rate and hearing levels, and a special study will also be made of certain factors which we considered of possible importance in determining the outcome of the operation.

The parameters selected for this detailed study were as follows:

1. *Factors influencing graft take rate:*
   (a) Condition of the middle ear at operation.
   (b) Size of perforation.
   (c) Site of perforation.
   (d) State of hydration of graft.
   (e) Presence of tympanosclerosis in the tympanic membrane remnant.
2. *Antibiotic irrigation of the middle ear in relation to:*
   (a) Graft take rate.
   (b) Cochleo-toxic effects.

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The above factors will be studied in isolation, but attempts will also be made to correlate them as it seemed possible that in some cases two or more factors might combine to influence the take rate of the graft.

Results

(A) *General survey.* (All types and methods of operations included—365 cases).

The overall results according to the type of operation performed are classified in Table I. Group A comprises all cases of simple tympanic membrane repair. In this group a routine tympanotomy with inspection of the middle ear formed an integral part of the procedure in all but a few cases of central perforation, mainly in the early part of the survey, in which tympanotomy was omitted. There were also a few cases in the series in which disease, usually cholesteatoma, was present in the middle ear and was excised prior to repair. In Groups B, C and D tympanic membrane repair was combined with an additional surgical procedure such as ossiculoplasty, mastoidectomy or both.

This survey was carried out with a view to comparing the take rate in these different groups. The results showed no statistically significant difference in graft take rate in any of these, all categories varying between 81 per cent and 90.5 per cent ($\chi^2 = 1.33$, DF $= 3$, $p > 0.5$). Thus it would seem that the inclusion of some additional procedure during the operation has no significant effect on the success rate of the myringoplasty.

Table II is concerned with grafting materials used at operation. At the commencement of this study the use of skin as a graft material was already falling into disrepute, and only two such cases are included, both of which were failures. In the early part of the series vein was the material of choice but later on fascia was preferred. Fat, connective tissue, periosteum and perichondrium were also used but the numbers of cases in these categories were small and they have therefore been grouped together under the heading 'miscellaneous'. Comparison of success rates between individual groups within this miscellaneous category would be of no value because of the small numbers, but it is interesting that the overall success rate of this mixed group was similar to that achieved using vein and fascia.

TABLE I

TYPES OF OPERATIVE PROCEDURES – RESULTS

Group	Description	No. cases	Failed	Percentage take rate
A	Myringoplasty	257	34	86.7
B	Myringoplasty + ossiculoplasty	50	6	88.0
C	Myringoplasty as part of combined approach tympanoplasty	37	7	81.0
D	Myringoplasty + 'open' mastoidectomy operation	21	2	90.5

$p > 0.5$

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TABLE II
GRAFT MATERIALS

Type of graft	No. of cases	Failed	Percentage take rate
Fascia	313	37	88.2
Vein	27	6	77.8
Miscellaneous (fat, connective tissue, periosteum, perichondrium)	23	4	82.6
Skin	2	2	0.0

Comparison of fascia, vein and miscellaneous groups $p > 0.1$.
Comparison of skin to other groups $p > 0.05$ (Fisher-Irwin test).

Different operating techniques are compared in Table III. The results suggest that the underlay and sandwich techniques may be more successful than the onlay or plugging methods, but the numbers of cases are again too small to be significant. Unfortunately, the opportunity to obtain further evidence from a larger series of cases did not present itself as the small groups, for the most part, were composed of cases in which a particular technique was tried for a time and later abandoned.

The choice of grafting material and technique is not, of course, related to take rate alone. Many other factors have to be taken into account such as availability of graft tissue, ease of handling, graft acceptability, hearing results and surgical complications.

(B) *Detailed survey*—(Simple myringoplasty—primary and revision—fascial repair—underlay technique—206 cases.)

Technique of operation

The surgical technique used in our underlay fascia operation closely resembles that described by Hough (1970), the essential steps being as follows:

The standard approach is by way of the meatus but in narrow canals a post-auricular or endaural approach may be advantageous. The edges of the perforation are excised except in those areas where the defect extends up to the fibrous annulus, which is always retained. The medial surface of

TABLE III
GRAFTING TECHNIQUE

Graft placement	No. of cases	Failed	Percentage take rate
Underlay	319	40	87.5
Onlay	25	6	76.0
Sandwich	13	1	92.3
Plugging	8	2	75.0

$p > 0.25$

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the tympanic membrane remnant in the vicinity of the perforation is then scarified using a Hough scraper. In areas where the remnant is almost non-existent, the lateral bony tympanic wall adjacent to the annulus is also scarified. A tympanomeatal flap is then elevated, as in the standard stapedectomy operation, and the middle ear and ossicular chain are thoroughly inspected. A temporal fascia graft is removed through a separate incision and trimmed to an oblong shape. It is then inserted so as to lie partly against the medial aspect of the tympanic membrane remnant and handle of the malleus, and partly on the posterior meatal wall. If the graft is not dried, that part which lies in the middle ear is usually backed with a disc of Gelfoam to facilitate insertion and provide support. Further support with additional Gelfoam is sometimes required, especially in the deeper anterior part of the tympanic cavity. The meatal section of the graft is covered by the tympanomeatal flap. A graft overlap of around 2 mm. is considered the acceptable minimum at the margins of the perforation but a much bigger overlap is usually aimed at, especially if the ear is wet. In suitable cases the graft is fixed in position by pulling small tucks through stab incisions of the tympanic membrane 2-3 mm. peripheral to the margin of the perforation. The meatus is then packed with Gelfoam soaked in an antibiotic solution.

Overall results (1) *Graft take rate:*

The criterion of success applied was the restoration of an intact functional tympanic membrane with no evidence of residual middle ear disease. This was achieved in 89.3 per cent of all cases (Table IV), and both primary and revision procedures gave similar success rates (Table V). It

TABLE IV
FASCIA UNDERLAY GRAFTING – RESULTS

Group	No. of cases	Failed	Percentage take rate
Dry	164	14	91.4
Wet	42	8	80.9
Total	206	21	89.3

Comparison of wet and dry ears $p < 0.05$.

TABLE V
PRIMARY AND REVISION OPERATIONS – RESULTS

Description	No. of cases	Failed	Percentage take rate
Primary	151	15	90.0
Revision	55	5	90.0

In revision procedures all primary operations except 4 were carried out by the original surgeon.

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should be noted that the above figure represents the average take rate for both dry and wet ears, the success rate being slightly higher if dry ears only are included. The results of these individual groups will be considered in the subsequent discussion.

Factors influencing graft take rate:

A. *Condition of middle ear at operation.*

It is generally accepted that the state of the middle ear at the time of operation has a direct bearing on the graft take rate, and the ear should ideally be completely dry and free from infection at the time of operation.

Dry ears. Two groups of cases were included in the 'dry' category. The larger group consisted of cases in which the ear was dry and free from infection at the time of the initial examination. In the other group discharge was present in varying degrees when the patient was first seen, but subsequently dried up as a result of conservative treatment. A period of three months of freedom from infection was then generally aimed at before operating. The combined graft take rate for both of these groups was 91.4 per cent.

Wet ears. In this category infection was present in the middle ear in varying degree at the time of surgery. This infection had either not been treated or had persisted despite intensive conservative therapy. In this group of cases the graft take was significantly lower, 80.9 per cent (Table IV). Despite this lower success rate the operation often contributed greatly to the patient's welfare since in a number of cases an ear previously discharging was rendered dry, while in others recurrent episodes of discharge were eliminated.

B. *Size of perforation.*

For the purpose of this survey 'large' perforations were designated as those occupying one half or more of the surface area of the tympanic membrane, perforations covering a lesser area being categorized as 'small'. The size of the perforation was considered to be a factor which might well influence the success of the operation or the technique selected. Indeed, we have encountered otologists who considered the underlay technique unsuitable for the repair of large anterior or subtotal perforations.

Table VI illustrates the breakdown of the various categories with their

TABLE VI
SIZE OF PERFORATION

Description	No. of cases	Failed	Percentage take rate
Large perforation	113	15	87
Small perforation	93	7	92.4

$p > 0.10$

N.B. Of the 113 large perforations, 17 were 'subtotal' perforations with only 1 failure (take rate 94.2 per cent).

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success rates. Within the 'large' group, subtotal perforations were analysed separately. We had expected some differences in the results because of the greater technical problem in dealing with large perforations, but the statistical analysis showed no significant differences between the 'large' and 'small' groups ($p > 0.10$).

Also, the single failure which occurred amongst the 17 subtotal perforations was not significantly different from the 15 failures out of the 113 large perforations in that group. The results suggest that, provided a careful technique is used, the success rate in repairing perforations is not affected by the size of the defect.

Combination factors—size of perforation/condition of middle ear—were also analysed in relation to take rate. In our experience low grade disease, manifesting itself as minimal or recurrent discharge, is more common in conjunction with small perforations than with larger ones, and we wondered if this would affect the results. Statistically the comparative success rates of closure of small and larger perforations remained the same irrespective of the state of the middle ear. However, it seems possible that the greater technical ease of closing small perforations, which might be expected to lead to better results, may be off-set by the increased liability to infection so that these factors cancel out and the final result is the same.

C. *Site of perforation.*

The ease with which a perforation is repaired is also related to the site, as technical problems occasionally arise with anterior perforations reaching the annulus. Although these problems have largely been overcome with improved techniques, it was felt that in a retrospective survey such as this an analysis of the perforation site would be worth while. In addition we considered that the association of different types of middle ear pathology with varying sites of perforation could also influence the results.

For the purpose of the analysis the sites are categorized as follows:

(i) 'Central' perforation: this is conventionally accepted as a perforation occupying the pars tensa, the margins of which are formed by the tympanic membrane remnant. We have included within this category large anterior perforations which invariably reach, but do not destroy, the fibrous annulus.

(ii) The term 'marginal' is applied only when destruction of the annulus occurs.

Table VII shows the cross tabulations indicating the rates of success with perforations at different sites.

It will be evident that marginal perforations, which in this series all occurred posteriorly, and central defects were repaired with equal success.

The technical problems related to closure of anterior perforations did not appear to affect the final results, as there was no increase in the failure rate in this anterior central perforation category. These results concur with our clinical impression that, provided the annulus is clearly exposed at

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TABLE VII
SITE OF PERFORATION

Description	No. of cases	Failed	Percentage take rate
Central	183	20	89
Marginal	23	2	91.3

$p > 0.50$

operation, thus enabling accurate placement of the graft, the take rate is not compromised by perforations reaching, or even destroying, the annulus.

D. *Condition of the graft.*

There are considerable differences of opinion as to whether or not a graft should be dried prior to use, and whether drying affects its viability or immunological status. In this series of cases most of the grafts implanted were fresh and moist. This was usually achieved by removing the graft from the donor area immediately prior to the actual placement in the prepared site. In a few cases the graft was removed early on in the operation and kept moist in Ringer's solution or normal saline. In some instances, some degree of spontaneous drying of the material occurred because of slight delay between removal and insertion. Cases in this category were included under the heading 'partially dried'. In other instances the graft was deliberately dried, or allowed to dry, until it resembled parchment.

Table VIII categorizes the degree of dehydration of the graft under the above groups. (The number of cases analysed is reduced since, in a considerable proportion, the physical state of the implanted materials was not recorded). The overall analysis showed that the take rate was not influenced significantly by the state of hydration of the graft material.

E. *Tympanosclerosis in tympanic membrane remnant.*

Over one-third of the series had tympanosclerotic involvement of the tympanic membrane remnant. All the results were analysed to try to determine if the take rate was influenced by the presence of tympanosclerosis. Histologically tympanosclerotic plaques are shown to have a very poor blood supply and we considered this to be of potential significance. In

TABLE VIII
CONDITION OF FASCIAL GRAFT

Description	No. of cases	Failed	Percentage take rate
Not dried or fresh	117	13	88.8
Partially dried	35	3	91.4
Completely dried	20	2	90
Unknown	34	4	88.2

$p > 0.50$

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some cases plaques were removed prior to grafting: in other instances they were left *in situ*. In either event, grafting was performed by the standard technique. The decision regarding removal was dependent on the effect of the plaque on sound transmission—if the plaque was mobile and causing no deafness it was left undisturbed. If plaques were retained the graft was placed directly against them. The analysis of results showed no significant difference in the graft take rate between the tympanosclerotic and non-tympanosclerotic groups (Table IX). These findings accord with our clinical impression, held for many years, that the graft take rate appears to be little affected by tympanosclerosis even if grafts are applied directly over avascular plaques.

TABLE IX
TYMPANOSCLEROSIS IN TYMPANIC MEMBRANE REMNANT

Description	No. of cases	Failed	Percentage take rate
Present	86	5	94.1
Absent	120	17	85.8

$p > 0.50$

(2) *Antibiotic irrigation of the middle ear.*

A. Effect on graft take rate.

Our results have already shown that local infection in the ear tends to affect the success rate in myringoplasty. The infection may be severe or of low grade, and in the latter instance may not always be easily recognized. It may be present pre-operatively, arise at the time of operation, or develop during the recovery period.

In an effort to control actual or potential infection the middle ear was irrigated with an antibiotic solution during the course of the operation. A topical preparation of framycetin* was chosen for this purpose for reasons given later. The cases were not selected, the antibiotic being given at random in both wet and dry ears. The influence of this procedure on the graft take rate was determined by comparing the results with a control group in which no antibiotic was used (Table X).

TABLE X
ANTIBIOTIC IRRIGATION OF MIDDLE EAR AT OPERATION

Description	No. of cases	Failed	Percentage take rate
Irrigated	164	20	87.8
Not irrigated	42	2	95.2

$p > 0.10$

*Framygen (Fisons).

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It will be seen that in this series of cases the application of a topical antibiotic did not significantly alter the graft take rate.

B. *Cochleotoxic effects.*

It is well established that a number of antibiotics have cochleotoxic effects. While these belong mainly to the aminoglycoside group of drugs, cases have been reported where other antibiotics have been incriminated. Ototoxicity has been reported after systemic or topical application. As far as is known framycetin is relatively free from ototoxic complications, although it has been suspected as the cause of deafness in rare instances (Ballantyne, 1981). Because of its relative freedom from ototoxic effects, together with its anti-bacterial spectrum, it was selected as the antibiotic of choice for local use. Great care was taken after irrigation to aspirate any excess antibiotic from both round and oval window areas because of the risk of permeation of the drug into the inner ear, especially by way of the round window membrane. Irrigation was carried out in 164 cases and a close watch was kept for possible ototoxic effects. Pre- and post-operative audiograms were compared in these cases but no evidence could be found of post-operative cochlear deterioration.

Hearing results.

Routine audiometry was carried out pre-operatively and also at one month and six months post-operatively.

We had hoped to present a detailed analysis of the hearing results but it soon became obvious that in this survey these were subject to too many variables to be useful. For example, in a considerable number of cases the hearing deficit was partly or even chiefly the result of ossicular disease, so that potential hearing improvement was essentially dependent on ossicular reconstruction which in most of the earlier cases was delayed to a second stage operation; thus, no improvement was recorded following the primary myringoplasty procedure. Furthermore, in some cases with a well-marked sensori-neural deficit, myringoplasty was undertaken merely to seal off the middle ear, e.g. for swimming or to prevent recurrent infection. In these cases no hearing improvement was anticipated nor did it occur.

We did, however, consider it important to find out if there were any instances of hearing deterioration following the operation, since a conductive deafness could result from damage to the ossicular chain while sensorineural hearing loss could follow excessive commotion of the ossicular chain or the use of cochleotoxic drugs. Some of these problems will be discussed in greater detail later. Our analysis failed to reveal any evidence of post-operative hearing deterioration of either type throughout the entire series. The 55 revision operations were examined separately, as it was felt that there might be an increased liability to cochlear problems in these. However, it was reassuring to find no evidence of cochlear degeneration in any case in this group.

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Discussion

Graft take failure

The use of free grafts to repair tympanic membrane perforations is surprisingly successful despite the existence of a number of problems specific to this operation which prevent the implementation of many of the standard principles of free grafting applying to other sites of the body. These special problems relate partly to the relative inaccessibility of the middle ear site and partly to the fact that, in large perforations in particular, the graft is draped across a wide air-containing space where it has no support or nourishment from contiguous tissue. Thus, in large perforations, the area of contact between the graft and the host tympanic membrane may be reduced to a small rim at the periphery and, if this contact is lost at any point, a defect will develop in the reconstructed membrane. The chances of this happening are increased if (a) overlap of the graft is minimal, (b) the bed for the graft is poorly prepared, (c) the graft is not adequately supported or fixed in position, (d) the operative exposure is poor, (e) excessive bleeding occurs at operation, (f) infection or mucoid secretions are present at the graft site, or (g) the blood supply to the graft is poor.

While these potential causes of failure are listed separately, it should be realized that several or even all may to some extent contribute in the same case. Thus it is often difficult to determine which factor or factors are primarily responsible in any particular case.

(a) *Graft overlap*

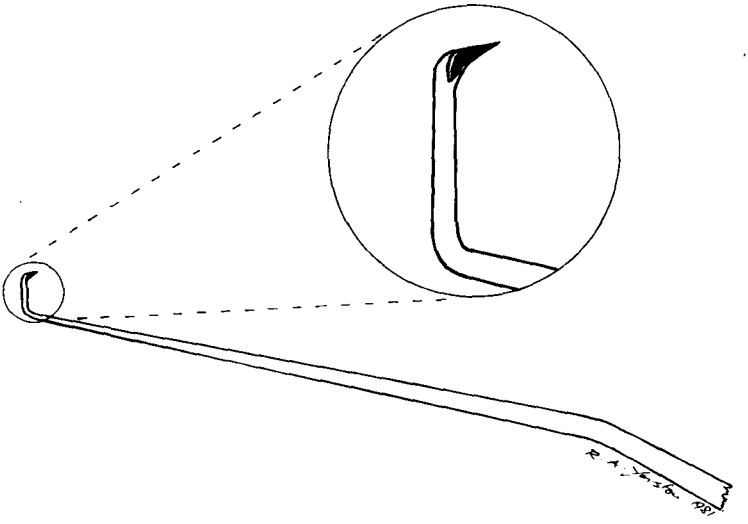
An adequate area of contact between the graft and the prepared recipient site is relatively easy to achieve in small perforations, and no problem of graft overlap should arise. The situation, however, alters significantly with larger perforations, especially if these are subtotal or occupy the anterior half of the tympanic membrane. In these circumstances the contact between the tympanic membrane remnant and the graft may be minimal and, if overlap is to be improved, it is essential to spread the graft over the adjacent bone and thus increase the contact area. The same problem does not occur with posterior perforations, where overlap is always ensured, since the graft is spread out along the posterior meatal wall where it lies in direct contact with the tympanomeatal flap. The commonest sites in which problems arise from limited overlap are the anterior margin of the perforation and, to a lesser extent, the inferior margin, especially a limited area postero-inferiorly, close to where the lower margin of the graft passes under the fibrous annulus to reach the posterior meatal wall.

The above observations refer only to underlay grafting. With the onlay technique the problem of achieving overlap with anterior perforations may be even greater, as 'blunting' is certain to occur if the graft is carried on to the anterior meatal wall. The graft is therefore placed on the annular rim only and the area of contact with the host tissues is thus very limited.

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(b) *Preparation of graft site*

The bed for the graft must be thoroughly prepared by careful scarification of the lining mucosa, so that a raw surface is ensured. For this purpose a Hough scraper is employed which enables the surgeon to scarify the medial surface of the tympanic membrane remnant via the perforation. In areas where graft overlap is likely to be limited, it is essential to scarify the tympanic membrane remnant very thoroughly, and to extend this procedure on to the adjacent bony lateral tympanic wall peripheral to the annulus, so that graft will adhere over a wider area. In some cases the drum remnant is extremely thin and scraping would inevitably cause tearing. In these circumstances it is usually better to excise the thin areas, thereby enlarging the perforation, before proceeding with the usual grafting technique. If the tympanic membrane remnant is thickened, thorough scraping is easy, but a thick membrane may have to be thinned out or even excised prior to grafting if mobility is seriously impaired.



(c) *Supporting the graft in position*

Post-operative defects occasionally result from the graft falling inwards. In such an event there has clearly been a failure of adherence between the graft and the host tissues. This may be related to a number of factors—minimal overlap, inaccurate placement, poor preparation of graft bed, infection—but in most instances it is probable that the graft has been inadequately supported or fixed in position. It has been our routine practice to insert the graft with a disc of compressed Gelfoam applied to its medial surface. This not only facilitates insertion but the Gelfoam swells and provides support over the area of the promontory. However, this support is usually inadequate where the tympanic cavity deepens anteriorly and inferiorly, and additional Gelfoam support is essential in perforations

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involving these areas. Collapse of the graft is unlikely posteriorly, as the tail of the graft is supported by the posterior canal wall but, in the event of such a possibility, additional Gelfoam should be inserted there also. An alternative method of fixing the graft, by tucking the edge through small incisions in the tympanic membrane remnant, has already been described in the section on technique. However, this method is suitable only for central perforations.

(d) *Operation exposure*

Clear exposure of all the margins of the perforation is essential for accurate grafting and, if this is not achieved, occasional technical failures are inevitable.

If a meatal approach is employed, access to the middle ear may at times be difficult on account of a narrow or angulated meatus or a bony overhang of the anterior meatal wall. In most of these cases adequate exposure can be obtained by enlarging the meatus. Bony overhang affecting the anterior meatal wall is readily removed by elevating a rectangular skin flap based medially or laterally, according to choice. The obstructing bone is then removed after which the skin is replaced. However, if access is likely to be a problem, we now advise a post-auricular approach to by-pass the outer part of the meatus and thus gain better access to the middle ear.

(e) *Excessive bleeding at operation*

A dry blood-free field is of great importance, particularly during the positioning of the graft. Bleeding tends to obscure the operation field, necessitates excessive suction, and generally causes frustration to the surgeon, often leading to inaccurate placement of the graft. These problems are multiplied in the transcanal approach, especially if the meatus is narrow. Despite improvements in anaesthesia it is inevitable that this type of problem will occur from time to time, especially in cases where the operation is difficult and the operating time is prolonged.

(f) *Presence of infection or mucoid secretion*

Analysis of the results in this survey showed that discharge from the middle ear has a significant effect on the graft take rate. The percentage success was closely related to the nature of the infection and amount of discharge, ears which were only slightly damp faring significantly better than those discharging profusely. Every effort was made to dry up damp or discharging ears by conservative or surgical methods prior to grafting; those cases in which the ear was wet at the time of operation comprise the group in which these measures failed or were likely to be unavailing. Despite the higher failure rate, grafting in wet ears was considered well worth while, as no effective alternative treatment appeared to exist, and in many cases the ear was rendered trouble free as a result of the operation.

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(g) *Vascular supply to graft*

Obvious break-down of a tympanic membrane graft due to inadequate blood supply is relatively rare. This is surprising in view of the fact that in many cases a large area of the graft lies unsupported in space and the surface area from which the blood supply is derived is relatively small. Furthermore, the bed for the graft may have a poor blood supply, especially in cases where tympanosclerosis is present. It is possible that some of the primary graft failures may be related to poor blood supply. On the other hand grafts placed on tympanosclerotic plaques which are relatively avascular usually take satisfactorily.

However, very occasionally, late grafting failures do occur where a poor blood supply appears to be responsible. In rare instances tympanic membranes have healed only to reperforate after a variable interval—sometimes of several months or years. These perforations have sometimes been multiple and have even occurred in both ears after bilateral grafting. This picture has invariably been seen after the repair of large perforations and, in the absence of any obvious metabolic defect, strongly suggests that the blood supply to the grafted tympanic membrane has been inadequate. In these cases revision operations have been fraught with the same problems, and thicker grafts are now being tried in the hope of providing a solution.

Deafness

Residual deafness following myringoplasty may be conductive or sensori-neural. A persistent conductive hearing loss may result from the well recognized complications of 'blunting' of the anterior angle between tympanic membrane and canal wall, and of 'lateralization' of the graft. However, these complications are mainly related to onlay grafting and are virtually unknown with the underlay technique as previously described; they were not encountered in this survey.

However, the underlay technique is not entirely free from problems. If the handle of the malleus is severely retracted, especially if it is touching or adherent to the promontory, difficulties arise because of possible reduction in the depth of the tympanic cavity if the graft is placed medial to the malleus handle. In these cases the problem is easy to resolve if the ossicular chain is non-functional, as the malleus can then be divided at the neck and the handle lifted into the desired position; this manoeuvre is generally combined with an ossiculoplastic procedure. The real problem arises if the ossicular chain is intact and the hearing is good. In these cases the malleus handle cannot be lifted laterally without fracturing or dislocating it from the incus. We therefore leave it in its original retracted position and introduce one of the following modifications; either we use a split graft pulled up on each side of the malleus handle and tucked behind its upper part; or we amputate 2-3 mm. from the tip of the handle before proceeding with our standard technique. We do not claim that either of these methods is a satis-

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factory answer to what to us has proved a difficult problem. We are opposed to interference with the ossicular chain if the hearing is good.

Sensori-neural deafness appearing for the first time post-operatively is generally iatrogenic and the result of some technical error at operation. Thus it is essential to exercise extreme care throughout the operation to avoid undue commotion of the ossicular chain which might cause cochlear damage. If underlay grafting is employed special care should be taken to avoid touching the incus or stapes when scarifying the postero-superior area of the tympanic membrane remnant. If due care is not taken in this procedure it is possible to hook up the ossicles or incudo-stapedial joint with the scraper. It is also important to exercise extreme care when tucking the graft into position in this area; at this stage of the operation the ossicles are often obscured by the graft itself. In either event the stapes may be shaken and, if the trauma is severe, the footplate may even be cracked. Severe or even total sensori-neural deafness may result.

The introduction of toxic solutions in the middle ear at the time of operation is another possible cause of sensori-neural deafness; as already reported, we found no evidence of deafness in this series of cases after irrigation with framycetin solution at operation.

Cholesteatoma

No case of iatrogenic middle ear cholesteatoma occurred in this series.

In a few cases cholesteatoma was encountered in the mesotympanum at the time of operation. If it was well-defined and limited in extent, the cholesteatoma was excised and the perforation was then grafted. In several of these cases, however, cholesteatoma re-appeared at follow-up and further excision was necessary.

Epithelial pearls were encountered on the posterior meatal wall in a small number of cases and, less frequently, on the surface of the tympanic membrane. They caused no problem to the patient and were easily excised under the microscope.

Summary

A series of 365 cases of tympanic membrane repair by the same surgeon is analysed, comparing the results of different techniques and grafting materials.

A detailed study of 206 of these cases employing the underlay technique with temporal fascia is reported. In this group a graft take rate of 91.4 per cent in dry ears, and of 89.3 per cent in all cases, was achieved. Various factors liable to influence the success rate are analysed and discussed.

No cases of conductive or sensori-neural hearing loss resulting from the operation were encountered.

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