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Homograft ossicular reconstruction*

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SINCE Hall and Rytzner in 1957 reported the successful use of the autologous incus in the treatment of patients with otosclerosis and interruption of the ossicular chain, and House, Patterson and Linthicum in 1966 showed that the alcohol-preserved homologous incus could be used without rejection, ossicles have had wide acceptance in attempting to restore ossicular chain function.

With Steinbach and Hildmann's demonstration in 1972 of residual cholesteatoma, when using autografts affected by chronic infection or cholesteatoma, there has been a tendency to use more stored homologous ossicles in reconstruction procedures.

As these ossicles are accepted without rejection by the middle ear because it may be 'a favoured site' (Cornich and Scott, 1968), as they are replaced by a creeping substitution of new bone and as they become quickly covered by mucous membrane when not in contact with bone, they should function indefinitely. Thus they propose good long-term function in two out of the three main reconstructive problems facing the surgeon.

1. *Absence of long process of incus*

Very satisfactory results can be obtained by:

(a) Placing homologous bone between the stapes and malleus (Fig. 1), or

(b) Keying a modified ossicle between these structures either by the two hole technique of Marquet (Fig. 2), or by drilling a recess to take the head of the stapes and a groove to receive the handle of the malleus (Fig. 3).

2. *Absence of superstructure of the stapes and long process*

A stored incus or malleus can be readily modified so that the most suitable process, depending on the depth of the oval window niche, can be placed on the footplate and the remainder positioned under the handle (Fig. 4).

3. *Absence of handle of malleus*

Rarely in this circumstance is there an intact long process, and in only 7·8 per cent of cases, according to Austin (1971), is there even a super-

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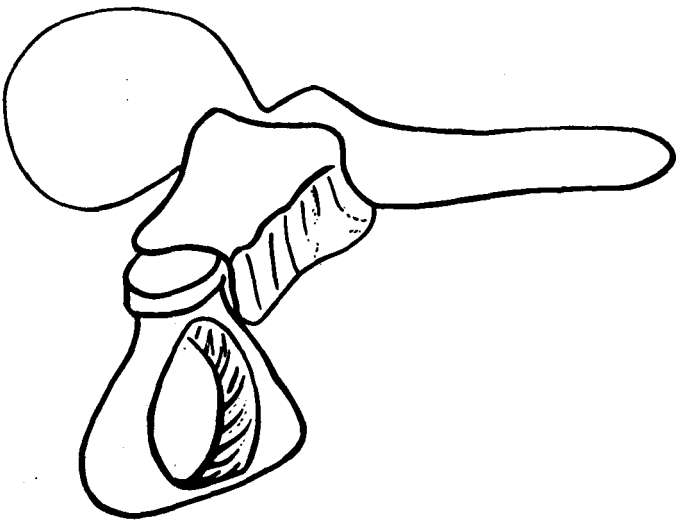


FIG. 1

HOMOLOGOUS bone between stapes and handle in the absence of the incus long process.

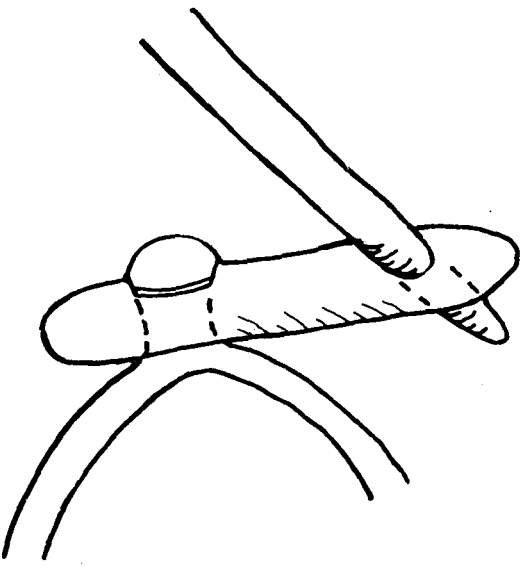


FIG. 2

HOMOLOGOUS bone keyed between stapes and handle in the absence of the incus long process (Marquet).

structure of the stapes. Furthermore there tends to be a large, if not total, perforation of the tympanic membrane. The long-term results obtained by using a stored ossicle or any prosthesis between the stapes head or footplate and fascia-grafted tympanic membrane are disappointing.

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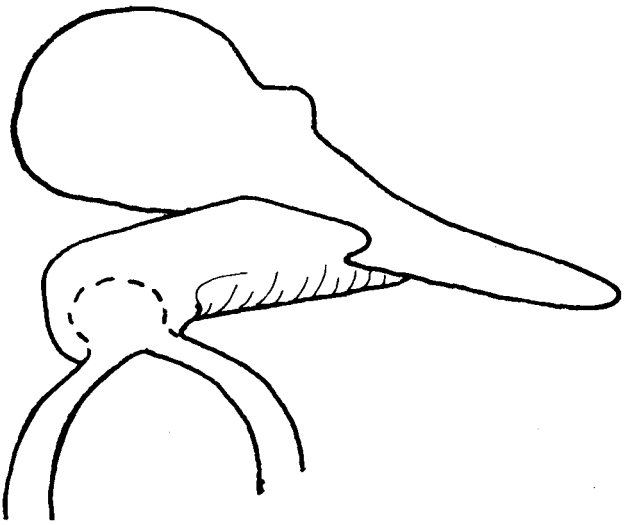


FIG. 3

HOMOLOGOUS bone keyed between stapes and handle in the absence of the incus long process.

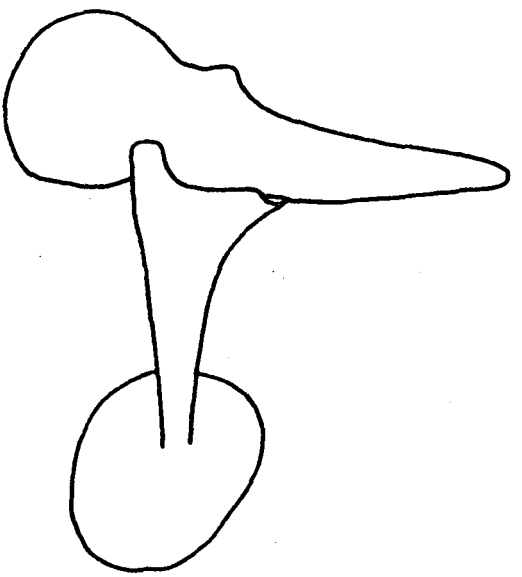


FIG. 4

Modified Homologous ossicle between the footplate and the handle of the malleus.

Without the stabilizing effect of the handle, the drum can gradually change its position in relation to the medial wall of the middle ear, so that the contact between homograft and stapes is lost, the part of the stored ossicle in contact with the drum can gradually be absorbed, or the drum can develop a perforation at the site of contact with the prosthesis.

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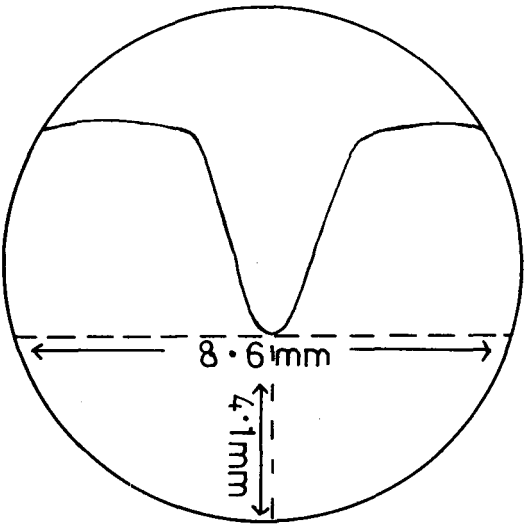


FIG. 5
Important tympanic measurements.

To overcome the problem, the introduction of a drum-malleus graft as the first part of reconstruction is a logical step. The second stage, done a few months later, consists of connecting the new handle to the host stapes by another homologous ossicle.

The successful use of a full block, consisting of drum and ossicular chain, was reported by Glasscock and House in 1968 and adopted by Marquet into his homograft programme, which had originally started in 1966. It was hoped that with this graft a near perfect restoration of hearing could be obtained consistently. Unfortunately, closure of the air-bone gap is never obtained and rarely does it close to ten decibels.

Experience with these block grafts has demonstrated the reasons, both immediate and delayed, for this less than perfect solution.

1. *Placement of the homograft block*

The annulus of the homologous drum must fit exactly into the tympanic sulcus if rapid healing without distortion of the drum is to take place. Unfortunately, there is a considerable variation in the size of tympanic membranes. Ars (1977) showed that the vertical diameter from the umbo to the inferior margin is 4·1 mm. with a variation of 0·7 mm. and the horizontal diameter through the umbo is 8·6 mm. with a variation of 0·9 mm.—this is without the annulus, which is 0·7 mm. in thickness anteriorly and 0·9 mm. inferiorly and posteriorly (Fig. 5). To achieve an exact fit it is necessary to document the measurements of the homologous drum when it is dissected from the bone and, pre-operatively, the patient's tympanic membrane diameters should be measured so that the correct

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size of homograft will be washed in Ringer's solution one hour prior to requirement. Thus, it becomes essential to have a bank of grafts containing Lefts and Rights of varying dimensions. Each preservative bottle should indicate date of placement in formalin or glutaraldehyde, date of placement in Cialit and the horizontal diameter and umbo-inferior margin length.

If the graft is too small the chances of vascularization and take are reduced, whereas if the graft is too large wrinkles on the drum result. If left, and the graft takes, these wrinkles are permanent and obviously interfere with function.

At the medial end of the monoblock, the placement of the donor stapes on to the host stapes head or footplate can be a problem, for not only are there variations in the diameter of the tympanic membrane, but in the ossicles and their relationship to one another. Such is the disparity that occasionally the donor incus can be removed and the donor malleus umbo placed directly onto the head of the host stapes. In other instances one sometimes has to carry out a secondary procedure at the end of six months to one year to modify the contact with the host stapes head or footplate.

2. *Effects of preservation*

(a) *Toughening of soft tissues*

The block homograft is difficult to dissect intact from the temporal bone in its fresh state, or if it has been stored only in Cialit. Even when toughened by immersion in formalin the complete removal with attached stapes is not always achieved and, in fact, if there is a wastage of only one specimen in three, one should be satisfied. Unfortunately, the toughened drum cannot act physiologically as the normal and although there may be a gradual replacement by the host tissue, we know that the fibrous layer of the graft can survive for long periods.

Furthermore, the toughening of the ligaments by formalin, which allows a higher percentage of intact dissections at the same time, must reduce the movements of the grafted chain. Although, according to Gundersen (1972), movement between the components of the chain is not necessary to achieve a good hearing result some loss occurs.

(b) *Incomplete inhibition of autolytic enzymes and antigenic factors*

Although it was originally assumed, as a result of the immediate and long-term acceptance of the homograft by the ear, that there must be complete inhibition of autolytic enzymes and antigenic factors by preservation methods, there is both clinical and experimental evidence to show that this is not so.

(i) *Perforation*

Perforations sometimes develop after implantation, commonly posteriorly although occasionally anteriorly. This is not due to poor

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vascularization, as the remainder of the graft drum is well nourished and secondly because a simple measure such as a fat plug myringoplasty is successful in closing these perforations. By immersing the block initially in glutaraldehyde instead of formalin these perforations are no longer encountered.

(ii) *Rejection*

If preservation techniques are not properly applied, then the whole block can be rejected immediately without any attempt at healing. On one occasion this was encountered when the graft had been immersed in Cialit for only five days.

More insidious, however, are those cases of recurrent myringitis reported by Veldman, Kuijpers and Overbosch (1978). This persistent condition necessitated the removal of three grafts which had been in position for a year or more. The histological examination suggested that the lesions might be evidence of rejection.

Veldman and his associates suggest that the acceptance of the preserved graft by the ear might be due to immuno-tolerance, the conditions for which are:

(a) low immunogenicity of antigen—concentration of antigen too low to immunize, but high enough to induce tolerance;
(b) the form of antigen, the rate and route;
(c) immuno-suppression by irradiation or drugs.

The third, (c), is not involved, but the other two conditions may well be affected when the preserved graft has a long meatal cuff and thus a relatively large amount of suppressed antigen; or, if an infection such as an external otitis develops, the increased vascularity may result in an increase in the output of partially suppressed antigen from the graft, thus stimulating a response from the host tissues with a lymphocyte infiltration of the fibrous layer and perivascularly. Further tests have revealed that this is a T-cell rejection phenomenon.

3. *Natural healing*

Routine exploration of ears subjected to combined approach tympanoplasties have revealed that ligaments have not formed, but mucosal folds and adhesions have.

In an ear where much drilling had to be undertaken at the time of the first operation, the short process at exploration was found to be firmly fixed by bony union to the horizontal canal.

Such changes can, in many cases, be obviated by not injuring the mucosa covering the homologous ossicles and by the use of Silastic sheeting, but there is a limit to the number of pieces of Silastic that can be inserted, in such a way that they will not move about in the middle ear or interfere with function.

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4. *Eustachian function*

Occasionally, as with other reconstructive measures, after successful block grafting with a perfect take, one observes the gradual development of retraction indicating that the tubal function is inadequate to ventilate the ear.

Conclusion

At this stage it seems that implanted homologous ossicles achieve a stable state within the middle ear but the tympanic membrane occasionally gives rise to signs of rejection. For the biologist this is an intriguing problem which should keep him happily engaged for years. As surgeons we can help by recording precisely our methods and duration of preservation, and the conditions in which we use these valuable tissues, and by following up the patients for at least five years and preferably longer.

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