# RECONSTRUCTION OF THE SOUND CONDUCTING MECHANISM BY THE MALLEOMYRINGOPLASTY AND PROSTHESIS METHOD*

PROGRESS REPORT

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SUMMARY

*In this progress report on a new tympanoplastic procedure for reconstructing a disrupted sound conducting mechanism characterized by destruction of the handle of the malleus, it is shown that by reconstructing a tympanic membrane and a handle of the malleus from a patient's own tissue and by utilizing a prosthesis for reconstituting the ossicular chain, it is possible to obviate all the difficulties experienced with the conventional malleus bypass procedures or with the use of a homograft tympanic membrane and ossicular chain. In all 21 cases reported, the tympanic membrane was successfully reconstructed in permanent continuity with the ossicular chain as a primary procedure. Inter-ossicular continuity was also established with a wireclip or wireclip polythene tube prosthesis in 15 out of the 16 type 2, 3 and 4 cases with a mobile stapes, and the hearing was improved to a serviceable level. A second-stage procedure is required to connect the malleus replacement bone incorporated within the tympanic membrane to the oval window in type 3 cases with fixed stapes and in type 4 cases. The latter phase has not yet been completed and will be reported on at a later date.*

It is now 85 years since the first attempt was made to reconstruct a disrupted sound conducting mechanism with a view to restoring hearing in cases where the tympanic membrane and the handle of the malleus had been destroyed, and this has proved to be a most challenging problem. Because of the loss of the handle of the malleus, the major problem is to establish and maintain a permanent connection between the reconstructed tympanic membrane and an ossicular chain capable of transmitting vibrations to the labyrinthine fluids.

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In this progress report on a new tympanoplastic procedure previously described,[1,2] it will be shown that by reconstructing a tympanic membrane and the handle of the malleus (malleomyringoplasty) as an integrated unit and by utilizing a prosthesis for reconstituting the ossicular chain, it is now possible to overcome all the major problems associated with reconstructing a partially or totally destroyed sound conducting mechanism in this large group of cases.

## HISTORY

### *Malleus Bypass Procedures*

The concept for the classical malleus bypass procedures in common use today was originated by Kessel[3] in 1885 and revived and elaborated upon seventy years later by Juers,[4] Wullstein,[5] Zöllner,[6] and Hall and Rytzner.[7] These methods aim at compensating for the loss of the handle of the malleus, which is the vital connecting link between the tympanic membrane and the ossicular chain, by placing a temporalis fascia graft in direct contact with the long process of the incus in Wullstein type 2 cases (myringo-incudopexy), the head of the stapes in Wullstein type 3 cases (myringostapedopexy) and with either a bone or cartilage strut positioned onto the mobile stapedial footplate or onto a vein graft covering a stapedectomized oval window in cases with total destruction of the ossicular chain—the intention being to establish a fibrous connection between the tympanic membrane fascia graft and the ossicular structure. Unfortunately, and not infrequently, the reconstructed sound conducting mechanism becomes disrupted because the temporalis fascia graft loses contact with the underlying ossicle as it moves in a lateral direction in the process of stiffening.

There are additional problems in type 3 cases: (*i*) with the myringostapedopexy method, the middle ear air-containing space is severely encroached upon and this

reduces the effectiveness of the reconstructed sound transformer mechanism; and (*ii*) it is not possible to reconstruct the ossicular chain in continuity with the tympanic membrane if the stapes is deeply situated in a narrow oval window niche and is partially obscured by an overhanging facial nerve.

*Homograft Replacement Transplants*

Glassock and House,[8] influenced by Marquet's[9] work on the tympanic membrane homografts, reported on a method for replacing the destroyed structures of the sound conducting mechanism with a homograft tympanic membrane and attached ossicular components. These structures are obtained from a fresh cadaver and are preserved until ready for use.

Although technically this method overcomes the major problem of reconstructing a tympanic membrane in continuity with the ossicular chain, it has the following disadvantages: (*i*) to obtain tissue from a cadaver introduces practical problems; (*ii*) of the homografts, 35% failed to survive either because of rejection by the host or because of supervening primary infection of the graft—Smythe and Kerr[10] reported these figures after doing 20 cases by this method; and (*iii*) the procedure cannot be performed on a radical mastoid case.

*Reconstruction with Autografts and Prosthesis*

This method for reconstructing a tympanic membrane and the handle of the malleus as an integrated unit (malleomyringoplasty) and for utilizing a prosthesis for ossicular reconstruction in continuity with the tympanic membrane was described in 1968 and 1970.[1,2]

The advantages of this method are as follows: The tympanic membrane can be reconstructed in continuity with the ossicular chain as a primary procedure in all cases and the middle ear air-containing space is not encroached upon. The risk of rejection is eliminated and primary infection of the graft rarely occurs. The entire mechanism can be reconstructed as a primary procedure in type 2 and all varieties of type 3 cases if the stapes is mobile. In type 3 cases complicated by fixation of the stapes and in type 4 cases, the tympanic membrane and ossicular chain are reconstructed in continuity as a primary procedure. This facilitates connecting the ossicular chain to the oval window as a secondary procedure.

Since the technique for this procedure has been described in detail in previous publications, only a brief description will be given here.

## PROCEDURE

In order to reconstruct the tympanic membrane and the handle of the malleus as an integrated unit, it is essential to incorporate a bone graft between two adherent layers of fascia. The loosely woven subcutaneous temporalis fibrous tissue layer and the underlying temporalis fascia to which it is attached, are ideal tissues for this purpose. The malleus replacement bone is prepared from a section of the mastoid cortex.

*Technique*

To gain access to these tissues and to the middle ear, the postauricular approach is used. The initial incision is made through skin and subcutaneous tissue only. In the temporalis area the plane of dissection is strictly maintained between the subcutaneous tissue and the underlying loose connective tissue layer. Great care is taken to preserve this connective tissue layer and to avoid exposure of the underlying temporalis fascia. The periosteum covering the mastoid surface is then stripped forward and the external auditory canal is entered by incising the posterior membranous canal wall transversely.

*Construction of the Malleus Replacement Bone*

A section of bone approximately 1 cm long, 5 mm wide and 2 mm thick is removed from the mastoid cortex with an osteotome. This is clamped between the two pins of an ossicle vice-holder and, under magnification, it is drilled into a T-shaped structure approximately 5 mm long, 3 mm wide and 1 mm thick. Using a fine hand-operated drill, the vertical projecting bar of the T is perforated. A fine catgut suture is threaded through the perforation and given to the assistant to hold. This prevents the completed malleus replacement bone graft from shooting away as it is snapped off from the main bulk of bone with a fine watch-spring forceps. The graft is then placed in a bowl of saline until ready for use (Fig. 1).

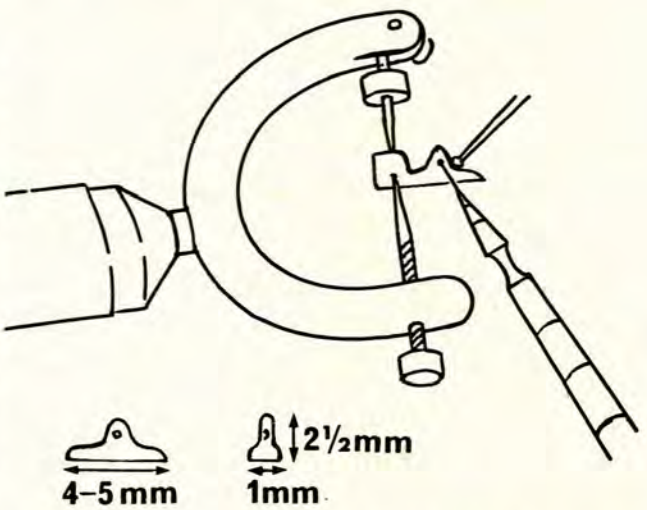


*Fig. 1.* Drawing illustrating piece of bone clamped between the pins of the vice-holder. It is being shaped and perforated. A complete MRB graft is also illustrated.

*Construction of the Malleomyringoplasty Graft*

In order to incorporate the malleus replacement bone between the two layers of fascia, a piece of the loose areolar tissue is elevated with a fine tooth forceps and a small incision is made through it to expose the underlying temporalis fascia.

A tunnel is then created between the two fascial layers using a scissors (Fig. 2). The malleus replacement bone is then grasped with a curved Arrugas cup forceps and after removing the catgut suture the bone graft is buried between the fascial layers with its perforated projecting end uppermost (Fig. 3). The loose fibrous tissue covering the perforated projection is incised and teased away until the drill-hole is clearly visible (Fig. 4).

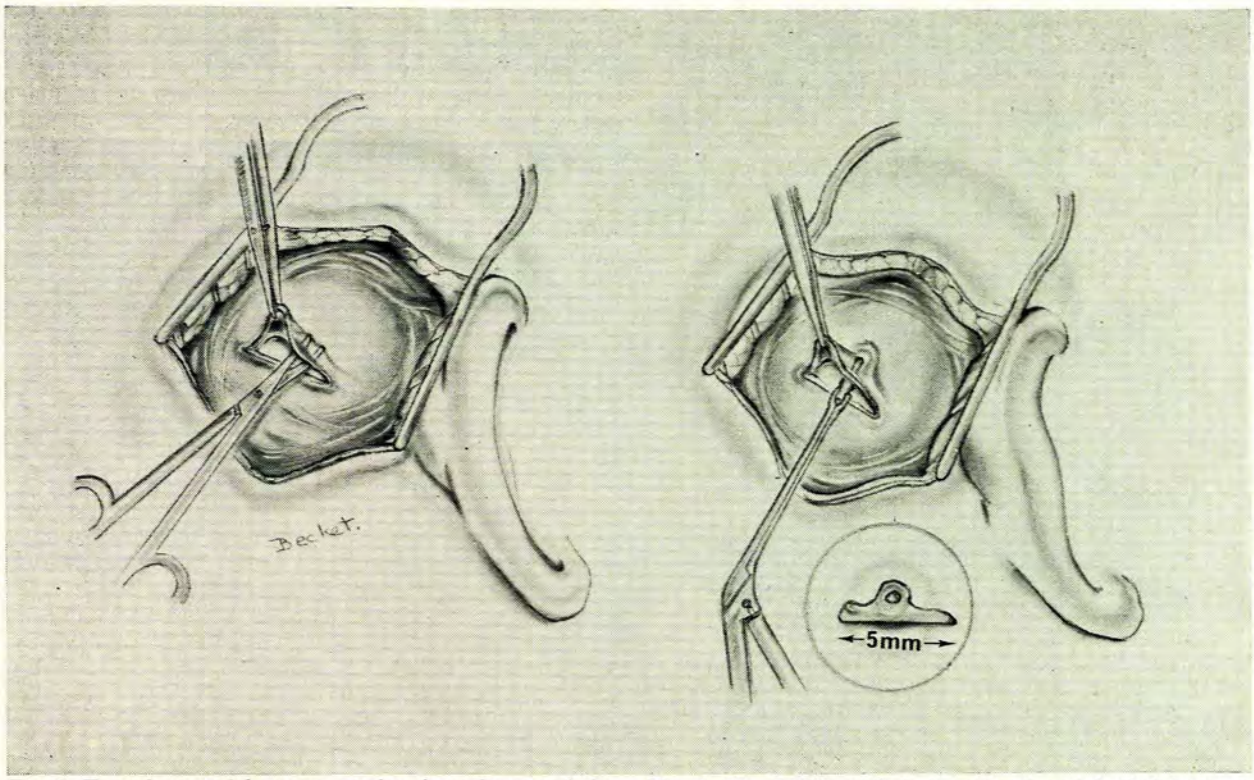


*Fig. 2.* Tunnel created between areolar tissue layer and the underlying temporalis fascia.




*Fig. 3.* The MRB graft is introduced and buried between the two fascial layers.

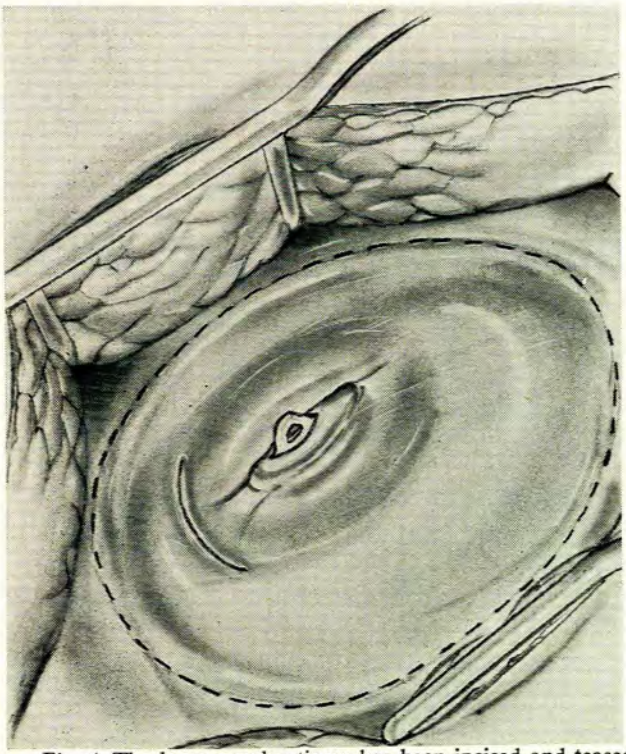

*Fig. 4.* The loose areolar tissue has been incised and teased away to expose perforated process of the MRB graft.

*Connecting a Wireclip Prosthesis to the Malleus Replacement Bone*

A corrugated wireclip prosthesis, 6 mm in length, is attached to the malleus replacement bone by threading one limb through the drill-hole. The prosthesis is crimped at its U-bend and firmly but loosely secured to the bone graft.

*Excising the Malleomyringoplasty Graft and Attached Prosthesis*

A requisite area of the loose areolar tissue and the underlying temporalis fascia, together with the incorporated malleus replacement bone and the attached prosthesis, is then excised and set aside to dehydrate (Fig. 5).

*Preparation of the Middle Ear*

The next phase of the procedure is devoted to preparation of the middle ear for reconstruction of the sound conducting mechanism. As this is standard practice, only the steps taken to facilitate positioning of the combined malleomyringoplasty graft and to increase the middle ear air-containing space will be noted.

In the *de novo* case, the posterosuperior rim of the bony canal wall is curetted as for a stapedectomy—in order to expose the entire stapedial area and the transverse section of the facial nerve.

In radical mastoid cases, a thin sheet of silastic sponge is placed along the denuded medial attic wall so as to raise the area and increase the air-containing space of the middle ear.

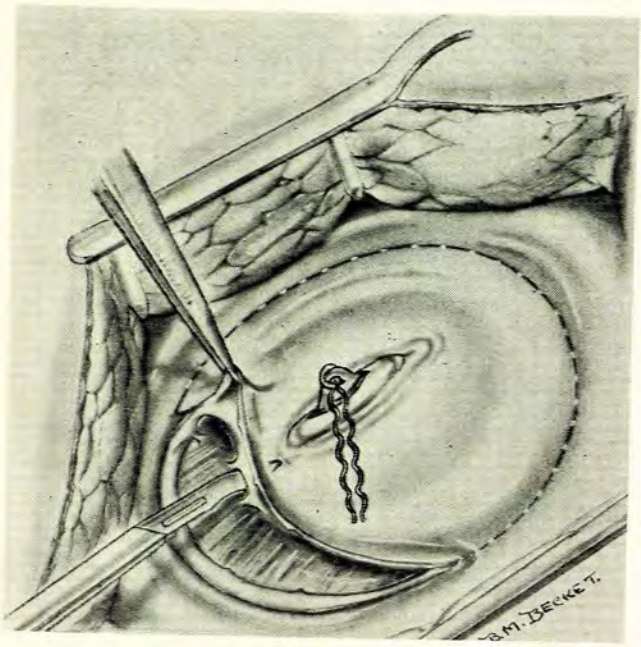


*Fig. 5.* Requisite area of composite graft with attached wireclip prosthesis is dissected from the underlying temporalis muscle. The dotted line indicates the area of composite graft to be excised.

*Selection of Prosthesis for Ossicular Reconstruction*

After having exposed the entire stapedial area, a decision is made as to the type of prosthesis required for the reconstruction of the ossicular chain. For type 2 cases with a mobile incudostapedial complex and for type 3 cases where the entire stapes superstructure is clearly accessible and the stapes is mobile, the wireclip prosthesis attached to the malleus replacement bone is satisfactory.

For type 3 cases, where the stapes is deeply situated in a narrow oval window niche and the structure is partially obscured by an overhanging facial nerve, and for type 4 cases, the wireclip prosthesis is converted into a wireclip polythene tube prosthesis in the following manner: The corrugated limbs of the prosthesis attached to the malleus replacement bone in the dehydrated graft are trimmed to 4 mm in length. Then a polythene strut 4 - 6 mm long and bevelled at one end is constructed from a section of size 0 polythene tubing. The square end of the polythene strut is slipped over both limbs of the wireclip prosthesis and guided along towards the malleus replacement bone until it is felt to be gripped by the second proximal row of corrugations. The length of the prosthesis is easily altered by adjusting the position of the polythene strut or by using a strut of varying length.

*Repair of a Sound Conducting Mechanism*

The dehydrated malleomyringoplasty graft and attached wireclip or wireclip polythene tube prosthesis is introduced into the middle ear with the prosthesis suspended from its undersurface (Fig. 6). The posterior area of the tympanic membrane is elevated to visualize the prosthesis and the graft is manipulated until the limbs of the prosthesis lie suspended over the stapes superstructure or the oval window. In type 2 cases the wireclip prosthesis is clipped to the long process of the incus (Fig. 7(a)). In type 3 cases with accessible stapes, the wireclip prosthesis is clipped to the anterior crus of the stapes (Fig. 7(b)). In type 3 cases where the stapes is deeply situated in a narrow oval window niche and the superstructure is obscured by an overhanging facial nerve, the bevelled end of the polythene tube wireclip prosthesis is guided into the groove between the promontory and the undersurface of the stapes superstructure so that its tip approximates the stapes footplate and the strut makes contact with the stapes superstructure (Fig. 8). In type 4 cases, the bevelled end of the wireclip prosthesis is positioned onto the mobile stapedial footplate (Fig. 9). If this loses contact with the footplate during the process of healing, it becomes necessary to readjust the position of the prosthesis as a secondary procedure.

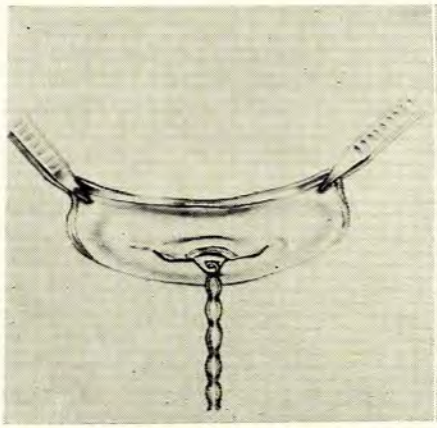

*Fig. 6.* Combined graft reversed and ready for positioning in the middle ear. The wireclip prosthesis hangs suspended from the MRB graft which is securely embedded between the two fascial layers.

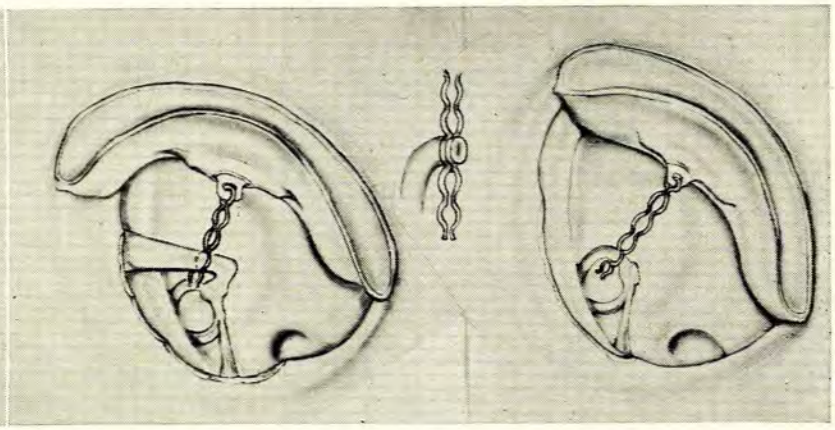

*Fig. 7.* Drawings illustrating (*left*) the composite graft reproducing the tympanic membrane and handle of the malleus positioned in the middle ear, with its posterior section reflected forwards; (*centre*) corrugated wireclip prosthesis connecting MRB graft to a long process of the incus and to a stapedial crus; and (*right*) the ossicle embraced between the indentations of the corrugated limbs of the prosthesis.

TABLE I. ANALYSIS OF RESULTS

| Case No. | Pathology: Wullstein classification* | MRB incorporated between fascial layers | Results and time observed | Methods of ossicular reconstruction | Hearing gain (air-bone gap) Pre-operative | Hearing gain (air-bone gap) Post-operative | Comment on hearing results |
|---|---|---|---|---|---|---|---|
| 1 | Type 3 | Constructed from body and short process of incus | Successful take —120 weeks | MRB connected directly to head of stapes | 35 db | 5 db | Not maintained |
| 2 | Type 3 | Constructed from body and short process of incus | Successful— 110 weeks | MRB connected directly to head of stapes | 35 db | 15 db | |
| 3 | Type 2 tympanosclerosis, stapes movement stiff | Constructed from body and short process of incus | Successful— 109 weeks | MRB connected directly to long process of incus | 25 db | 0 db | Initial gain not maintained. Requires stapedectomy |
| 4 | Type 3 radical mastoid | Constructed from body and short process of incus | Successful— 107 weeks | MRB IRP stapes strut footplate | 50 db | 50 db | Initial gain not maintained |
| 5 | Type 3 | Constructed from mastoid cortex | Successful— 80 weeks | MRB wireclip stapes crus | 35 db | 5 db | |
| 6 | Type 3 | Constructed from mastoid cortex | Successful— 75 weeks | MRB wireclip stapes crus | 40 db | 10 db | |
| 7 | Type 3 radical mastoid | Constructed from mastoid cortex | Successful— 71 weeks | MRB wireclip stapes crus | 60 db | 15 db | |
| 8 | Type 3 fixed footplate | Constructed from mastoid cortex | Successful— 70 weeks | MRB wireclip stapes crus | 45 db | No change | Requires stapedectomy |
| 9 | Type 3 | Constructed from mastoid cortex | Successful— 68 weeks | MRB wireclip stapes crus | 35 db | 10 db | |
| 10 | Type 3 | Constructed from mastoid cortex | Successful— 62 weeks | MRB wireclip stapes polythene strut footplate | 40 db | 5 db | |
| 11 | Type 3 | Constructed from mastoid cortex | Successful— 60 weeks | MRB wireclip stapes crus | 30 db | 10 db | |
| 12 | Type 3 radical mastoid, fixed footplate | Constructed from mastoid cortex | Successful— 57 weeks | MRB wireclip stapes crus | 35 db | 10 db | |
| 13 | Type 3 | Constructed from mastoid cortex | Successful— 56 weeks | MRB wireclip stapes polythene strut footplate | 35 db | 10 db | |
| 14 | Type 3 radical mastoid | Constructed from mastoid cortex | Successful— 49 weeks | MRB wireclip stapes polythene strut footplate | 35 db | 15 db | |
| 15 | Type 3 | Constructed from mastoid cortex | Successful— 47 weeks | MRB wireclip stapes polythene strut footplate | 60 db | 10 db | |
| 16 | Type 3 tympanosclerosis, stapes movement stiff | Constructed from mastoid cortex | Successful— 39 weeks | MRB wireclip stapes polythene strut footplate | 45 db | No change | Requires stapedectomy |
| 17 | Type 3 | Constructed from mastoid cortex | Successful— 34 weeks | MRB wireclip stapes crus | 25 db | 5 db | |
| 18 | Type 3 radical mastoid | Constructed from mastoid cortex | Successful— 24 weeks | MRB wireclip stapes crus | 60 db | 20 db | |
| 19 | Type 3 | Constructed from mastoid cortex | Successful— 20 weeks | MRB wireclip stapes crus | 40 db | 10 db | |
| 20 | Type 3 | Constructed from mastoid cortex | Successful— 12 weeks | MRB wireclip stapes crus | 35 db | 10 db | |
| 21 | Type 3 | Constructed from mastoid cortex | Successful— 9 weeks | MRB wireclip stapes crus | 30 db | 5 db | |

*Pathology: Type 2 = tympanic membrane and handle of malleus destroyed; type 3 = tympanic membrane, handle of malleus and long process of incus destroyed; type 4 = tympanic membrane, handle of malleus, long process of incus and stapes superstructure destroyed.
MRB = malleus replacement bone.
MRB wireclip stapes crus = MRB connected to stapedial crus by wireclip prosthesis.
IRP = incus replacement strut.

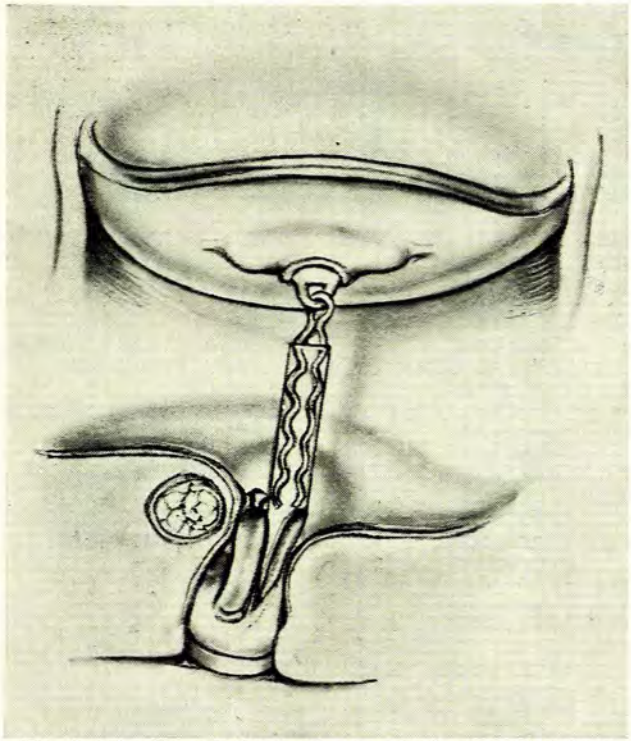

*Fig. 8.* Wireclip polythene tube prosthesis suspended from MRB incorporated between reconstructed tympanic membrane and connected to the stapes superstructure and footplate. It is positioned in the groove between promontory and stapes superstructure.

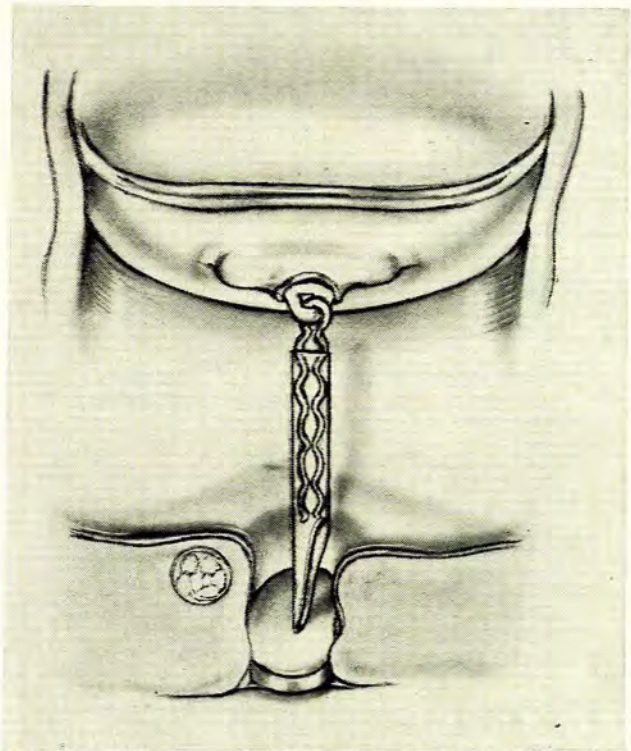

*Fig. 9.* Wireclip polythene tube prosthesis connecting malleus replacement bone to footplate of stapes.

## RESULTS

The results are analysed in Table I.

*Complications*

In case 9 a small postero-inferior perforation developed in the tympanic membrane temporalis fascia graft 3 weeks postoperatively. This has persisted but the ear has kept dry and the hearing gain has been maintained.

## COMMENT

The most significant feature of these results is that the malleomyringoplasty graft and the attached prosthesis, assembled in continuity as a primary procedure, was successfully accepted in 100% of the cases. This is a marked improvement on the results obtained with the malleus bypass procedure and with the use of a homograft tympanic membrane and ossicular chain. The high rate of success is attributed to the following:

1. Autogenous grafts are not rejected.
2. They are far less likely to become infected.
3. The risk of infection is further reduced to a minimum by the liberal postoperative use of a broad-spectrum antibiotic.

The perforated malleus replacement bone incorporated within the tympanic membrane, re-establishes the vital connecting link which permits the facile use of a suitably-designed wire prosthesis for reconstructing the ossicular chain in permanent continuity with the tympanic membrane. In 15 out of the 16 cases where the incudostapedial complex, the complete stapes, or only the stapedial footplate was found to be mobile, the sound conducting mechanism was reconstructed and the hearing has been restored to a serviceable level. These include 4 old healed radical mastoid cases.

In order to restore hearing in the type 2 and 3 tympanosclerotic cases complicated by fixation of the stapes and the type 3 and 4 cases with otosclerotic fixation of the stapedial footplate, a second-stage vein-graft stapedectomy is required. When confronted with such cases in future, it may prove to be more advantageous to insert the malleomyringoplasty graft and attached prosthesis and perform the vein-graft stapedectomy as a primary procedure. This should enable one to position the prosthesis onto the stabilized vein graft with greater accuracy a few months later.

The initial hearing gain in the type 4 case operated upon early on in this series, has not been maintained. Presumably this is due to the fact that the IRP strut has lost contact with the stapedial footplate. A secondary adjustment of the strut has been suggested but the patient refuses reoperation.

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