MYRINGOPLASTY AND TYMPANOPLASTY

PLASTIC PROCEDURES TO RESTORE HEARING IN MIDDLE EAR DEAFNESS

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The restoration of hearing in conductive deafness is one of the prominent contributions in the present-day surgery of repair and rehabilitation. Cases can be divided into two groups:

1. Deafness with an intact tympanic membrane, as in otosclerosis, and

2. Deafness with a perforated tympanic membrane, usually resulting from chronic otitis media.

The treatment of otosclerosis by fenestration, and more recently by stapes mobilization, is a well-established procedure, but deafness with perforation of the tympanic membrane has for a long time presented a problem in otorhinolaryngology. This article deals with the restorative techniques developed to treat the latter, which have followed the pioneering works of Zöllner[1-3] and Wüllstein[4,5] in Germany, and Pietrantoni and Bocca[6] in Italy over the past 6 years. This has resulted in a new approach to these problems, with dramatic restoration of function and elimination of infection from the middle ear.

Normal hearing depends on the integrity of the sound-conducting apparatus, which consists of the tympanic membrane and ossicles, acting as a system of levers in the middle ear. The air-borne sound waves on striking the tympanic membrane set it vibrating. This membrane is

attached to the malleus, which articulates with the incus, and in turn with the stapes, which fits into the oval window. The movements of these ossicles transmit the vibrations of the large tympanic membrane to the much smaller membrane in the oval window, with diminished amplitude but with greater force. The conversion of amplitude to force is necessary to set the inert fluid (the perilymph) of the inner ear in motion.

Movement of the perilymph is dependent on the two bony openings in the cochlea, the oval and round windows; the former has the footplate of the stapes held by the annular ligament, and the latter lies free, covered by a membrane facing into the air-filled middle ear. Compression at the oval window causes a movement of the perilymph on one side of the basilar membrane, and a corresponding movement is transmitted to the round window. This movement of the basilar membrane stimulates the auditory nerve, resulting in the sensation of hearing.[7]

Plastic operations for the repair of perforated ear-drums were described as long ago as 1879 by Berthold.[8] Not until the advent of antibiotics and the binocular microscope has his type of surgery been placed on a firmer footing.

The degree of loss of hearing varies in relation to the destruction of the middle-ear components seen in chronic otitis media. Previously, middle-ear surgery dealt with the elimination of infection to produce a dry ear, as in radical mastoidectomy, and necessitated removal of the tympanic membrane and ossicles. These cases were left with a marked deafness, which has been found, from recent investigations, to be due to the fact that the sound waves strike the oval and round windows almost equally so that little if any movement of the perilymph and basilar membrane results. The advent of chemotherapy and antibiotics has changed the radical tendency of surgery of the temporal bone towards conservation of the middle-ear structures, resulting in improved hearing.

Wüllstein and Zöllner observed in some patients after a radical mastoid operation that the ear operated upon, instead of remaining deaf, had improved. In the past this fact had been realized but never explained. It was concluded that the improvement in hearing was brought about by the accidental growth of epithelial tissue, forming an air-filled compartment for the round window and eustachian tube separated from the rest of the cavity. As a result of this isolation of the oval window from the round window the sound waves strike the two windows unequally, because of the air baffle around the latter. Movement of the perilymph and basilar membrane occurred, and the patients attained socially adequate hearing.

From this observation the fundamental principles of myringoplasty and tympanoplasty were established, that is, to reconstruct a closed tympanic cavity. The essential requirements of such a cavity are a normally functioning eustachian tube, where the ossicular structures must be preserved as far as possible. The round and oval windows must recover their function. Good bone conduction, indicating adequate cochlea reserve, must be present.

Five types of reconstruction procedures are described, which vary with the destruction of the middle-ear components:[9]

1. Lesions affecting the tympanic membrane without damage to the ossicular chain.

2. Lesions affecting the tympanic membrane with minor damage to the ossicular chain.

3. Lesions affecting the tympanic membrane, tympanic cavity and ossicular chain, without damage to the stapes.

4. Lesions affecting the tympanic membrane, tympanic cavity and ossicular chain, with damage to the stapes.

5. Lesions affecting the tympanic membrane, tympanic cavity and ossicular chain, with fixation of the stapes.

The operations in cases of chronic otitis media aim at complete eradication of disease in the middle ear and temporal bone, and the restoration of the sound-conducting apparatus to improve hearing. This is achieved by retaining the healthy ossicles and forming a closed tympanic cavity, with a full-thickness skin-graft placed over the perforation. The re-

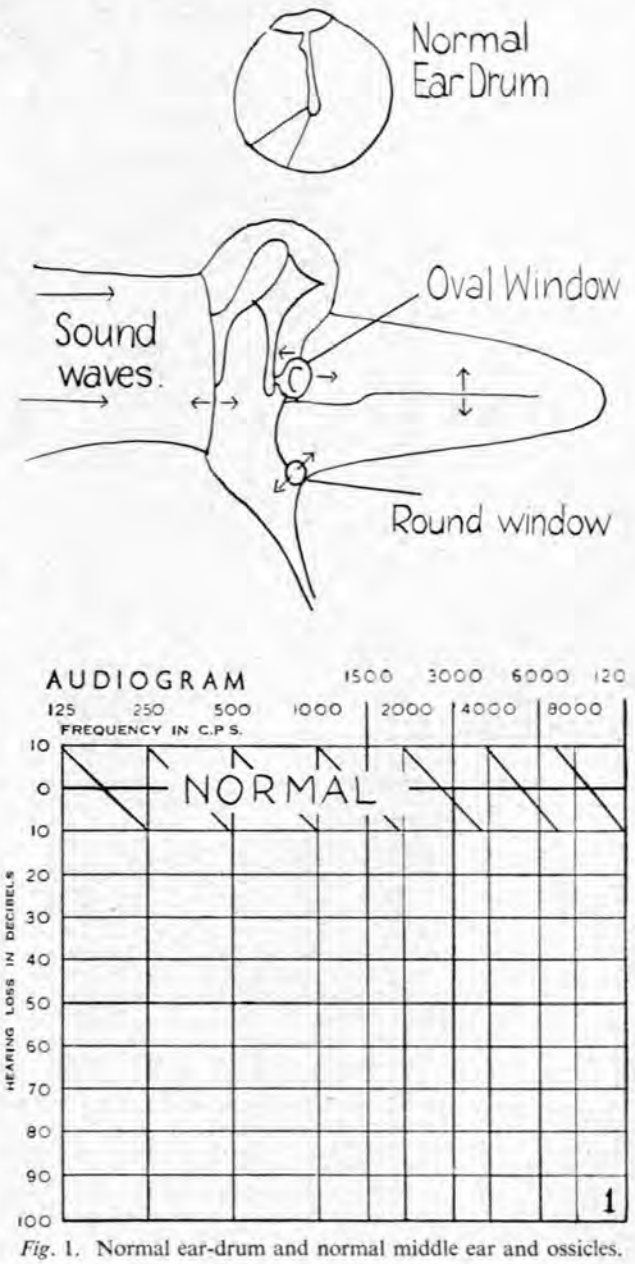
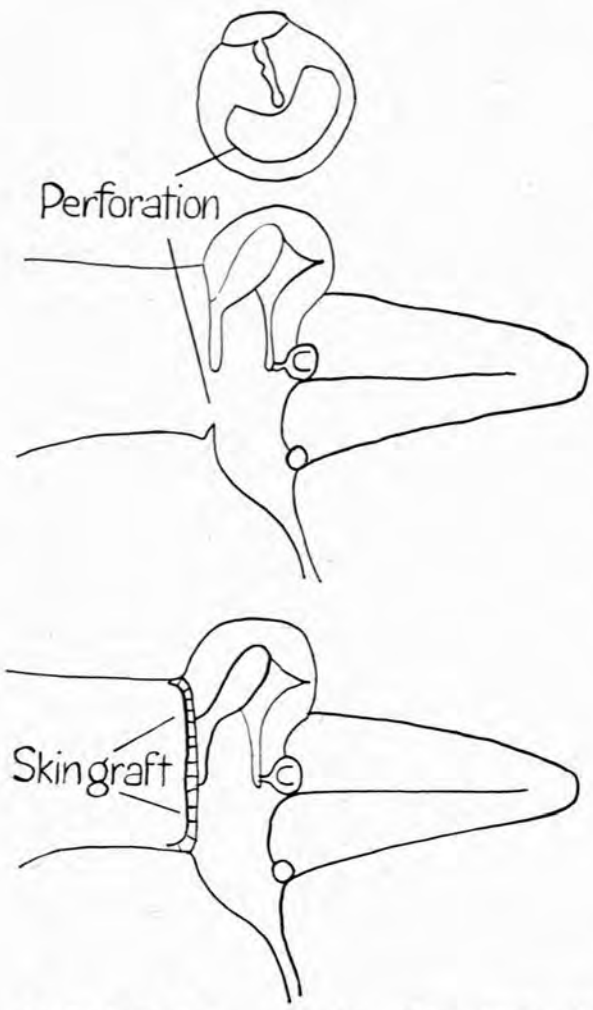


Fig. 1. Normal ear-drum and normal middle ear and ossicles.

constructed tympanic cavity has a normally functioning eustachian tube and functioning round and oval windows which stimulate the basilar membrane.

TYPE I. LESIONS AFFECTING THE TYMPANIC MEMBRANE WITHOUT DAMAGE TO THE OSSICULAR CHAIN

In this stage of the disease, very little damage has resulted to the ear. A dry perforation of the tympanic membrane of varying size is present, following otitis media or traumatic rupture. A mild degree of hearing loss results, approximately 10-35 decibels.[10] There is no sign of active disease or of ossicular damage, although periodic discharge may occur, associated with upper respiratory infection. This causes further damage to the middle-ear structures, and increasing deafness.



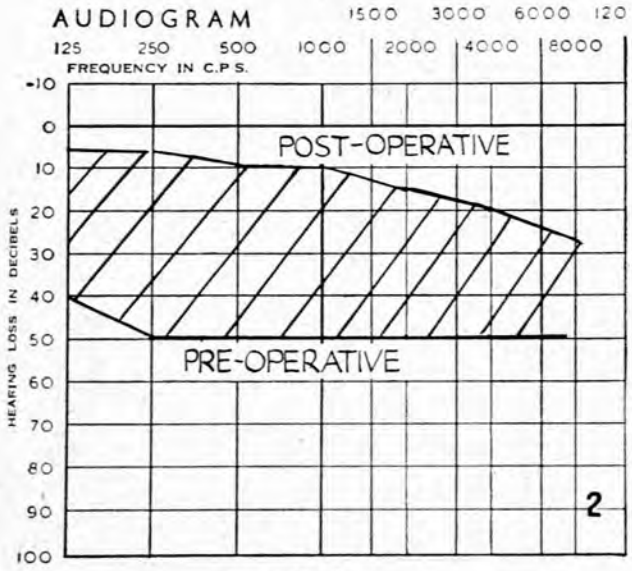
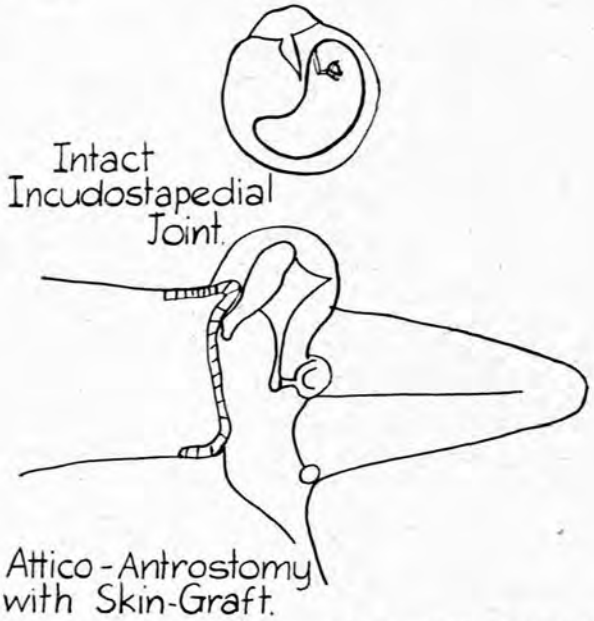


Fig. 2.



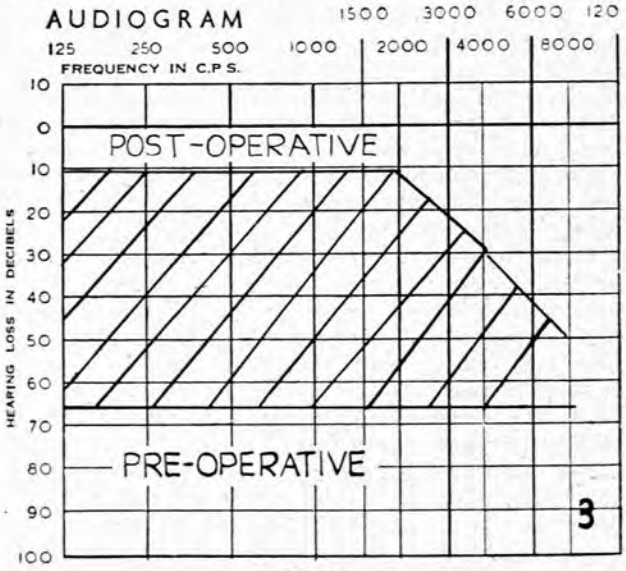
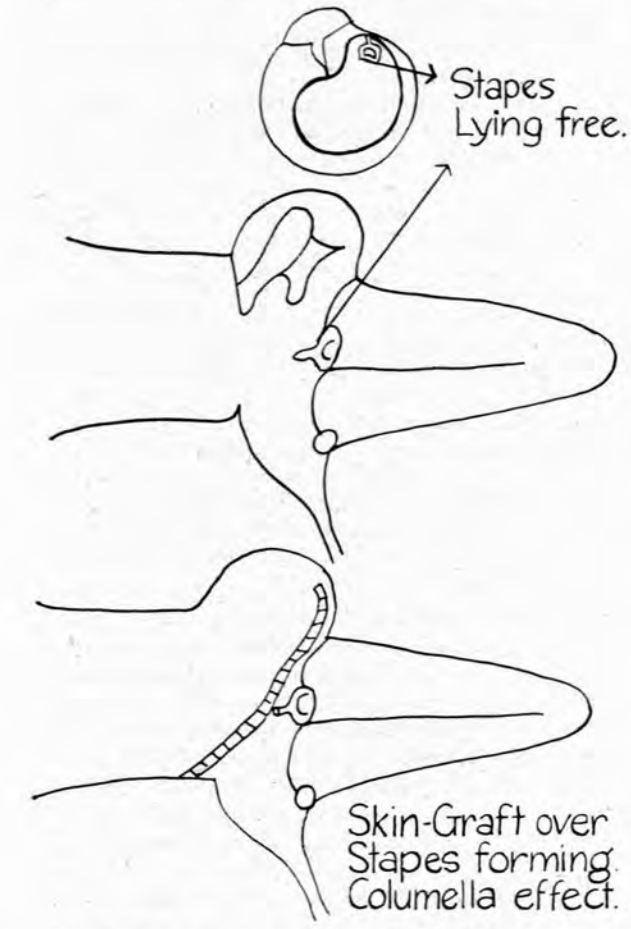


Fig. 3.

Myringoplasty

This operation aims at healing the perforated tympanic membrane, and does not necessitate opening the temporal bone, since the middle ear is free of infection and has been dry for a considerable period. The technique requires the utilization of a full-thickness skin-graft taken from the post-auricular area. An ellipse of skin is removed and thinned by trimming the subcutaneous tissue with curved scissors. Then



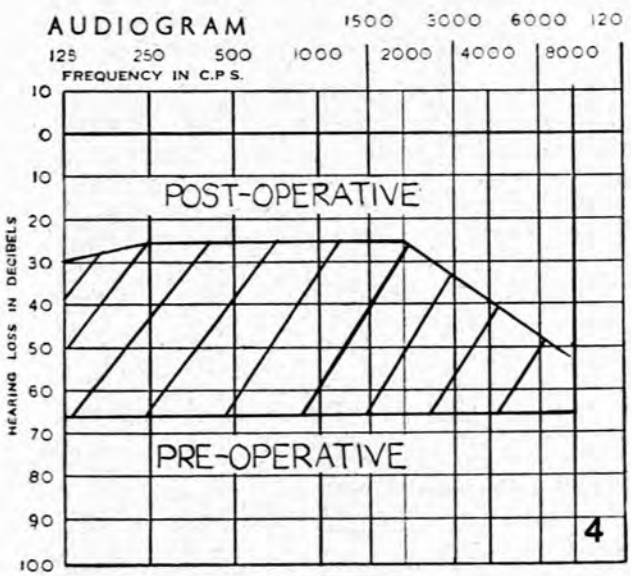
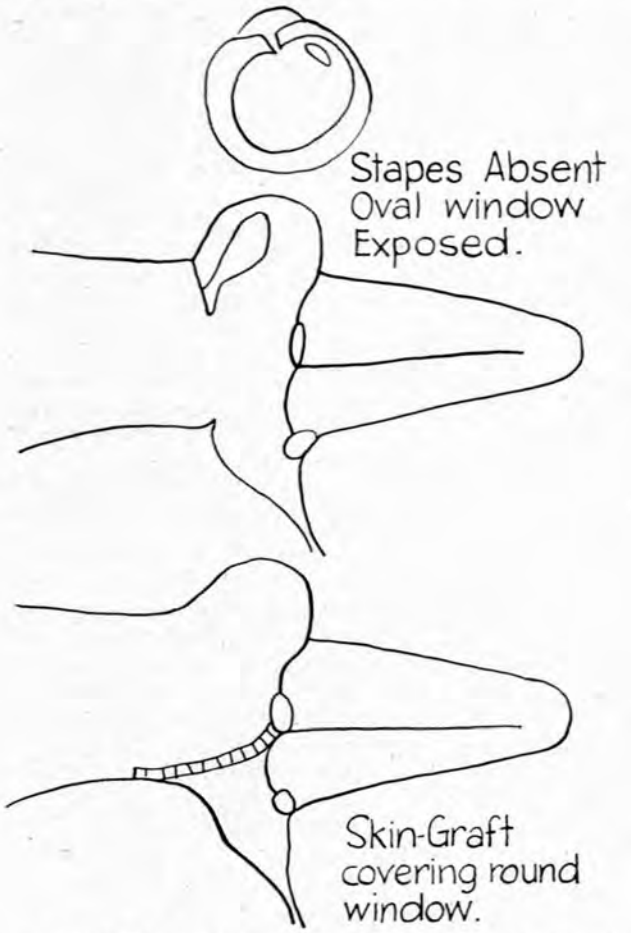


Fig. 4.



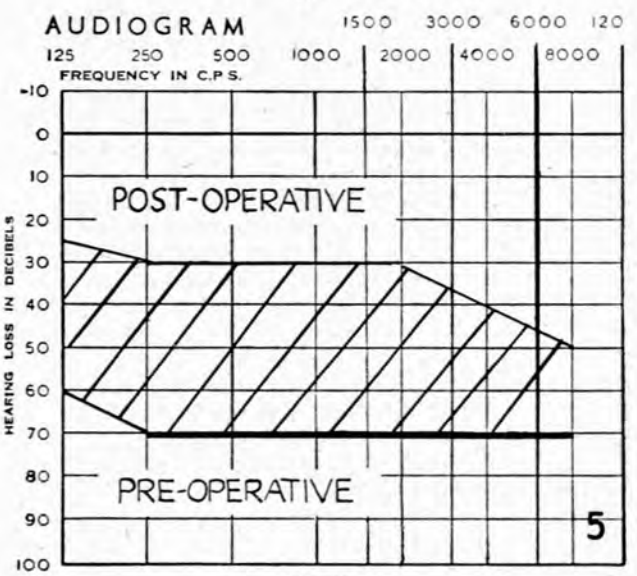


Fig. 5.

the graft is cut to a size to fit the defect. This skin has the advantage of few elastic fibres, and, unlike skin obtained from other parts of the body, does not tend to contract and curl.

With the aid of a binocular dissecting microscope[11] the perforation in the tympanic membrane is inspected through a speculum or, if necessary, the external auditory meatus is widened by a small vertical incision. The skin in the deep bony meatus is incised concentrically around the tympanic membrane, two or three millimetres proximal to it. Then with suitable instruments the meatus is denuded of epithelium and the tympanic membrane detached from the periphery towards the perforation. Small pieces of gelatin foam are placed in the tympanic cavity to act as a support for the skin-graft and to prevent its adhering to the inner wall of the middle ear. The skin-graft is laid on this prepared bed, and held in position by more gelatin foam applied to the outer skin surface. A short length of ribbon gauze helps to maintain pressure.

The dressing is left undisturbed for 10 days, the patient being maintained on antibiotics and instructed against nose-blowing. At the end of 3 weeks the ear may be politzerized, and hearing is usually restored to almost normal.

No further treatment is required and, later on, the patient can resume swimming and bathing without risk of infection.

TYPES II-V

Tympanoplasty

In these more advanced lesions, where the ossicular chain has been damaged, it is necessary to open the temporal bone (attico-antrostomy), in order to eradicate the disease within the middle ear; to ascertain the condition and function of the ossicular chain, the oval and round windows, and the eustachian orifice; and to reconstruct a closed, air-containing tympanic cavity with a whole-thickness skin-graft, in order to restore the functional properties of the middle ear. This procedure has been named 'tympanoplasty'.

Type II. Lesions affecting the tympanic membrane with minor damage to the ossicular chain

In these cases, there is a central perforation of the tympanic membrane associated with active discharge. The hearing loss is not severe, usually being below the 35-decibel level in the speech frequencies.[8]

Before operation a culture and sensitivity test are made of the organisms in the ear discharge, in order that the appropriate ear toilet and antibiotics can be given for a few days.

At operation either the endaural or postaural route may be chosen for the attico-antrostomy. Microscopically the antrum and attic spaces are examined without removal of the bridge. The incus and stapes are freed from adhesions and granulations. The incudo-stapedial joint is examined, and the integrity of the ossicular chain is tested; this can best be observed by the movement seen at the round window when the stapes is made to move. The tympanic cavity and eustachian orifice are examined and cleaned if necessary. The prepared skin-graft is then placed meticulously over the perforation, anteriorly covering the remnants of the tympanic membrane, which has been denuded of its surface epithelium, and reaching the attic and antrum posteriorly. Lying over the bridge it is prevented from adhering to the incus. Gelatin foam is used as a scaffold in the tympanic cavity to prevent the graft from sinking in.

Post-operatively antibiotics are given as a routine measure. The dressing is removed on the 10th day. Auto-inflation is tried after 4 weeks and, if necessary, eustachian inflation by means of eustachian catheterization. Toilet is performed at first twice weekly and then once weekly until the cavity has healed satisfactorily.

Type III. Lesions affecting the tympanic membrane, tympanic cavity and ossicular chain.

The disease in this lesion is more advanced, disrupting the lever system of the ossicles at the junction of incus and stapes. At operation the bony process of the incus is found to be eroded. Here the object of operation is to restore a conducting system. This is achieved by reconstructing the columella mechanism of a bird's middle ear; in satisfactory cases a hearing loss of 60 decibles can be reduced to about 25 decibels below normal.

The operation entails the removal of the malleus, incus, tympanic bridge, and diseased tissue in the tympanum. The round-window reflex is noted when the stapes is moved. The skin-graft is then tailored to lie over the tympanum, supported on gelatin foam except at the head of the stapes, to which it must become adherent to form the 'columella'. This achieves the transformation of sound waves across the middle ear and, with inflation of the middle ear, the air baffle surrounding the round window restores a difference in sound pressure at the oval and round windows, as a result of which hearing becomes socially adequate.

Type IV. Lesions affecting the stapes

In this more extensive form with destruction of the stapes, the skin-graft is placed over the lower portion of the tympanum to form a sound-protecting air-buffer for the round window. Hearing in these cases, which may be between 60-80 decibels below normal, may reach a 30-40 decibel level after operation, and thus socially adequate hearing is attained.

Type V. Lesions with associated fixation of the stapes

These cases are characterized by the exhibition of tympanosclerosis[12] with adhesions, which fixes the stapes. If stapedial mobilization[13] cannot be achieved before placing the skin-graft in position, it is necessary to perform a secondary fenestration of the lateral semicircular canal some months later, when the ear cavity is healed and devoid of infection.

RESULTS

The results of different authors, and those of the present writer, are set out below:

Wüllstein: 350 *cases*

Type	*No. of Cases*	*Improved Hearing*	*No Improvement*	*Aggravated Deafness*
I ..	89	84%	16%	4%
II ..	64	70%	30%	3%
III ..	118	75%	25%	1%
IV ..	37	69%	31%	2%
V ..	42	84%	10%	7%
Pietrantoni and Bocca: 150 *cases*				
I ..	15	100%	—	—
II ..	110	60%	—	13%
V ..	110	60%	—	13%
Ormerod and McLay: 39 *cases*				
I ..	12	75%	33%	0%
II ..	6	67%	0%	33%
III ..	13	62%	23%	15%
IV and V	8	50%	38%	15%

Beales: 57 *cases*

Type	*No. of Cases*	*Improved Hearing*	*No Improvement*	*Aggravated Deafness*
I and II	13	84%	15%	0%
III ..	21	49%	9%	4%
IV ..	8	63%	12%	2%
Present Author: 34 *cases*				
I ..	10	80%	20%	—
II ..	9	75%	25%	—
III ..	12	75%	25%	—
IV ..	2	50%	50%	—
V ..	1	—	100%	—

SUMMARY

During the past 6 years, operations have been devised to eradicate infection, and to restore the function of the ear in deafness due to discharging ears. The pioneers in this field of plastic surgery are Zöllner and Wüllstein in Germany, and Pietrantoni and Bocca in Italy. From the European continent this work has spread to the rest of the world.

This operation is one of the most important recent developments in surgery of the ear, and aims at forming an air-filled middle-ear cavity by using a full-thickness skin-graft to cover the perforated ear-drum. This requires the aid of a binocular microscope and delicate instruments especially designed for this work.

In the opinion of the authorities quoted, the old 'mastoid operation' should be abandoned in favour of these recent surgical advances.

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