ON TYMPANOPLASTY

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PLASTIC surgery of the middle ear has gained tremendous ground in otology, especially through the outstanding work of Professors Wullstein and Zöllner. A patient with a chronic middle-ear inflammation, frequently with greatly impaired hearing, may now be relieved of his infection and the false tumours (so-called cholesteatomas) frequently accompanying these forms of ear inflammation as well as having his hearing improved to a certain extent. Thanks to the advances made by these eminent workers in otological surgery this has become possible not only as earlier through radical operations on the cellular system of the ear but also now through plastic operations on the elements of the middle ear, the mucosa, the auditory ossicles and the tympanum, and in many cases with astonishing improvement to the hearing. There are primarily five different types of operative approach involved.

The plastic operations on the middle ear are included under the common name of tympanoplasty. These all involve a radical approach, either peraurally or retro-auricularly, with operation on the cell system of the ear and creation of different types of middle-ear cavities. These operations are suitable for all forms of chronic middle-ear inflammation and may be performed in a single stage operation or, if the inflammation is very extensive and acute, in two stages. In these latter cases radical operation is first done on the cell system of the ear with elimination of the inflammation and the cholesteatoma that may be present, and a few months later, in a second step, when the middle ear and the radical cavity have healed, the actual tympanoplasty is performed.

All these operations are preceded by a thorough clinical study of the middle ear, frequently under magnification, for evaluation of the appearance and type of the perforation and investigation of the auditory ossicles. With the co-operation of our audiologist special measurements of the hearing are always carried out, primarily with the ordinary pure tone audiogram and sometimes complemented with a speech audiogram. Our audiologist, Lundborg, also assisted the investigations with sonometric studies following Zöllner's pattern. At Söder Hospital these studies are called transmission investigations and include, in addition to the actual vibrating probe, prosthesis tests—both so-called complete prosthesis tests and covering prosthesis tests. The latter involve primarily screening prosthesis over the round window. The methods of transmission investigation

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have been developed to such an extent in the Department of Otology at Söder Hospital that we are able, by this means, even before the operation to a comparatively great extent, to obtain a conception of the condition of the ossicle chain and what screening of the round window will be able to afford in the way of improvement in hearing. Therefore we are able, in a large percentage of the cases, to determine preoperatively the type of operation to be preferred. In many cases this is of tremendous value. The clinical investigation also naturally provides us with a preconception of possible measures and of the type of operation that should be done, but the transmission investigation expediently complements these clinical preliminary examinations and would seem to give this form of surgery a broader scientific foundation.

The different forms of tympanoplasty we perform agree, on the whole, with those of the German otologists.

In chronic middle-ear inflammations, where we have chronic mastoiditis or cholesteatomas of lesser extent that can be removed without injuring the auditory ossicles or tympanic membrane and where the ossicles are in good condition with contact existing between all ossicles, after conservative radical operation a plastic graft is placed over the entire tympanum and the operative cavity, forming a so-called Cavum major cavity according to German nomenclature "eine grosse Pauke". In a case presenting minor destruction of only the long process of the incus we try transposition of the incus so that its long process comes into contact with the stapes.

Transposition of a carious incus so that contact is obtained has been done in four cases. In one the results were particularly good. In these cases a cavum major was constructed despite a defective ossicle chain. This patient has an improvement of more than 40 db in her hearing. The auditory improvement is computed according to accepted methods on the basis of the values obtained in the audiogram for frequencies of 500, 1,000, and 2,000 c.p.s., taking the mean value for these three. Before the operation the mean loss of hearing was 78 db, and now, one and a half years after, it is 35 db.

As a rule with the cavum major procedure a good auditory result is obtained, frequently with values lying about 10 to 20 db. Nor is this particularly surprising, inasmuch as the auditory ossicles are in good condition before the operation. It is merely a matter of performing the operation as smoothly and gently as possible, retaining as much undamaged epithelium as can be salvaged and being careful not to create an opportunity for adhesion formation post-operatively. Among other precautions to be observed, it is necessary to be particularly careful not to injure the extremely thin mucosal epithelium on the auditory ossicles. I am thinking especially here of the incus where the mucosa is easily damaged if special care is not taken to avoid trauma. I also retain as much as

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possible of the mucous membrane of the antrum both on the floor over the semicircular canals and over the incus. An incision is made so the mucous membrane may be raised to permit inspection of the auditory ossicles. On the other hand, it does not seem to matter that we free the tympanum at the limbus and lift it forward to allow inspection of the middle ear. This manipulation does not appear to damage the hearing. The mucosa of the middle ear is disturbed as little as possible. Granulations are carefully lifted out or snared. Curettes must not be used. Introduction of foreign bodies such as oxycel or spongostan into the middle ear is to be avoided if possible because of the risk that they may not be absorbed and may have a deleterious effect on the auditory results. With this procedure we dare to tackle even cases of chronic otitis with chronic mastoiditis and an auditory impairment of from 20 to 25 db.

Type 3 (Wullstein) of the plastic middle-ear operations is the co-called tympanostapediopexy or according to German nomenclature, the formation of "eine flache Pauke". This is used as a rule in cases where there is pronounced destruction of the ossicle chain, but a relatively intact stapes. The residual tympanum is then dropped with the accompanying plastic flap down against the head of the stapes, thereby achieving transmission of the oscillations directly from the tympanum to the stapes. We do not usually use a columella. I make it a rule not to introduce foreign bodies into the middle ear if it can be avoided. The primary results of this type of operation have been good both with respect to healing and hearing, but the late results have been poorer in some cases, frequently due to the occurrence of a perforation in the flap over the stapes.

Instead, in the cases where we have a pronounced defect in the ossicle chain, I have employed type 4, the so-called cavum minor technique. In many cases this has afforded astonishingly good results even in cases of extremely grave auditory impairment. Many encouraging results were obtained with this technique, even in the early days two years ago when I started seriously to engage in tympanoplastic operations. Stimulated by the excellent results, I have therefore been particularly interested in undertaking treatment of the extremely grave cases of auditory impairment in chronic otitis in order to see what results can be attained with this special technique. Among about 100 tympanoplastic operations I have performed at Söder Hospital no less than 39 patients were operated on according to the cavum minor technique, with minor variations from case to case, but with the consistent purpose of establishing a difference in pressure between the fenestra ovalis and the fenestra rotunda. It will consequently be this type of operation I shall discuss in detail now, particularly with respect to technique, diagnosis and primarily the auditory results.

As in all other plastic operations on the middle ear, it is also true in this case that the tube should be patent, permitting easy passage of

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inflated air. The operative procedure is largely as described by Wullstein and Zöllner. First the radical operation is performed with thorough removal of polyps and granulations about the residual stapes or the footplate of the stapes and the round window and tube without damaging the epithelium more than necessary. An incision is then made in the mucous membrane of the medial wall of the middle ear below the prominence of the facial nerve canal and farthest forward over the tube above the facial prominence so that a narrow flap is obtained there to fold up against the tube. The rest of the mucous membrane is turned downward. The epithelium forms a bed for the transplant. At operation it is generally found that part of the limbus is still present. This shall be treated with great care as it provides an excellent bed for the transplant, which is obtained retroauricularly in all cases in conjunction with the application of the retroauricular incision. It is important that there can be an open communication between the hypotympanon, the tube, and the round window. The transplant is subsequently held in position with oxycel, which is treated with penicillin, hyaluronidase and prednisolone trimethylacetate (Ultracortenol, Ciba). As a rule this is absorbed within a week or 10 days. The fenestra ovalis is exposed, with or without the stapes. Another full skin graft is applied over the defect remaining in the mastoid process and the upper part of the middle ear.

The cases we selected for this technique comprised chronic adhesive otitis media—adhesive otitis with a healed thin scar adherent to the promontory or with a small perforation in the thin scar with bad hearing. Roentgen examination has shown chronic mastoiditis. Five such cases were operatively treated. Seven cases of chronic otitis media with attic or antrum fistula with cholesteatoma are included in the series. In addition there are five cases of chronic otitis media with attic or antrum fistula without cholesteatoma. There are other groups with chronic otitis with central perforation and chronic mastoiditis. Five such cases including one with dry ear and four with suppurating ears were operatively treated. The series also includes 11 cases of earlier radically operated chronic otitis with continued discharge and greatly impaired hearing as well as six cases of clean radically operated cavities with greatly impaired hearing. Altogether the series comprises 39 cases.

A somewhat more detailed review of the condition of the auditory ossicles and the mucous membrane of the middle ear observed at operation in these cases would perhaps be of value here. Special attention will be given to the importance of a stapes in good condition as opposed to a residual stapes base only. It will also be possible to observe the auditory results when the operation revealed granulation, free fenestra ovalis and rotunda.

This series includes three cases in which the malleus and incus were found at operation to be absent. Only the stapes, which was movable,

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could be seen. In seven cases only a stapes base remained. In 19 cases the ossicles were extremely carious, and in 10 cases the malleus, incus and stapes, except for the base, were removed. In nine cases the stapes, which had good mobility, was retained.

In eight cases the ossicles were in rather good condition, but caries was present and no contact existed between the incus and stapes. In three cases the malleus was left, and in five both the malleus and incus. The stapes and fenestra rotunda were granulation free in three cases, while there were abundant granulations in 27 cases in the regions of both fenestrae. The mucous membrane of middle ear was otherwise clear in nine cases but granulated in 26. No granulations in the tube were present in 30 cases, but granulations were observed in the tubal orifice in seven.

Description of Some Cases and Auditory Results

One case is worth detailed description. This patient's hearing became very good, almost unbelievably good, and certainly far better than could have been expected. It is the case of a 25-year-old woman who had earlier undergone radical operation with removal of osteitic malleus and incus. The radical cavity was clean and clear in this patient, but her hearing was poor, with 51 db the mean level for 500, 1,000, and 2,000 c.p.s. The tympanum presented a large perforation covering about three-quarters of it. The stapes was freely visible and easily accessible for vibrating probe, which showed good transmission *viâ* the stapes. Revision of the radical operation was done with tympanoplasty with a free transplant (cavum minor). The stapes lay embedded in granulations but was satisfactorily movable. The niche of the fenestra rotunda was very deep, without granulations. The tube was normal and the middle ear mucosa otherwise pale and normal. The mucous membrane was divided in the usual manner on the promontory and folded downward. The mucosa was removed from the epitympanum, and a transplant was applied there. Thereafter a cavum minor was created in the usual manner. The ear healed rapidly. After only one month the auditory level was 33 db and now, after 18 months, is not only still good but has shown further improvement to a mean of 21 db from an initial preoperative 51 db. Accordingly, there has been a thus far permanent improvement of 30 db. The stapes is now covered by a thin epithelium, and the fenestra rotunda is well isolated under the plastic flap. The tube affords air passage. This is another case in which it is difficult to explain the excellent resultant hearing. The patient has only the stapes left and has screening of the fenestra rotunda. She now hears a whisper at 1 m. and conversational tone at more than 5 m. with the operated ear. The auditory improvement in db is shown in Fig. 1.

One more case in this series will be reported as it demonstrates how it is possible for an auditory invalid to recover good hearing through

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tympanoplasty and to return to his clerical position without needing to use a hearing aid. Both ears had earlier been radically operated on for cholesteatoma. In the right ear there was a previously created fistula over the horizontal semicircular canal, and the fenestra rotunda had been plugged with resultant exceedingly poor auditory effect. In addition there was an auditory impairment corresponding to a mean of 71 db. The right ear perceived conversation at a distance of 0·4 m. and the left of 1·5 m. Revision of the operation on the left ear was done with creation of a

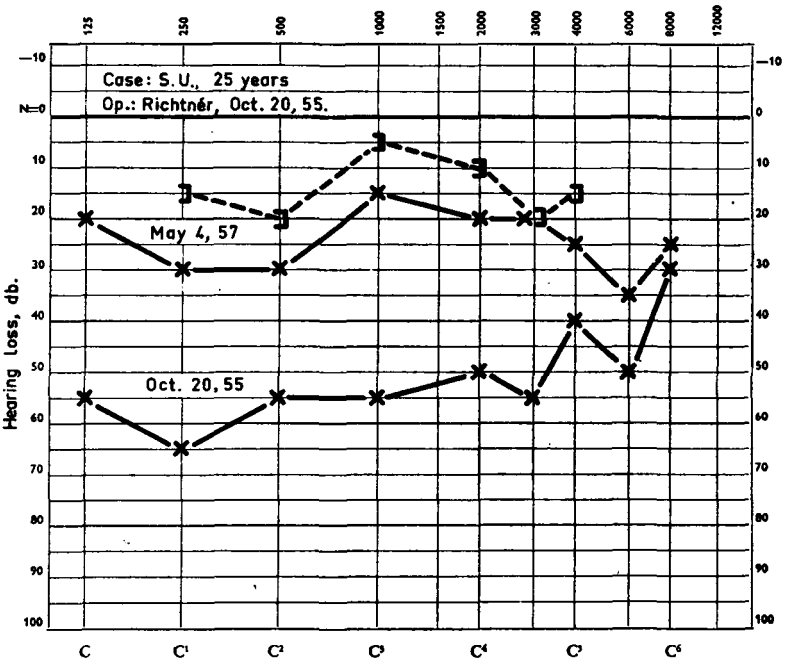


FIG. 1.

cavum minor. All auditory ossicles were gone with the exception of the footplate of the stapes, which was movable. There were granulations over the fenestra rotunda and ovalis and granulating middle-ear mucosa as well. The tube was fully patent. An optimal flap was obtained over the hypotympanum. After only 14 days there was appreciable improvement in hearing with an increase from an initial level of 71 db to 53 db. After another 14 days the improvement had progressed to 43 db, and the patient perceived conversation at a distance of more than 5 m. His hearing has since consistently been very good, now being at a level of 41 db 18 months after the operation. He is able to hear conversation up to a distance of 15 m. In this case only the base of the stapes remained and no new columella was introduced. Because of the extensive polypous

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granulations in the middle ear much of the mucous membrane had to be removed. Therefore oxycel was applied as a bed for the transplant in order to allow time for the mucosal epithelium to develop and to prevent the formation of adhesions between the flap and the promontory. In this case the use of oxycel in the middle ear proved advantageous rather than the contrary. However, this should not be taken as grounds for generalization, and introduction of foreign bodies into the middle ear should be avoided whenever possible. If anything is to be used in such cases as this,

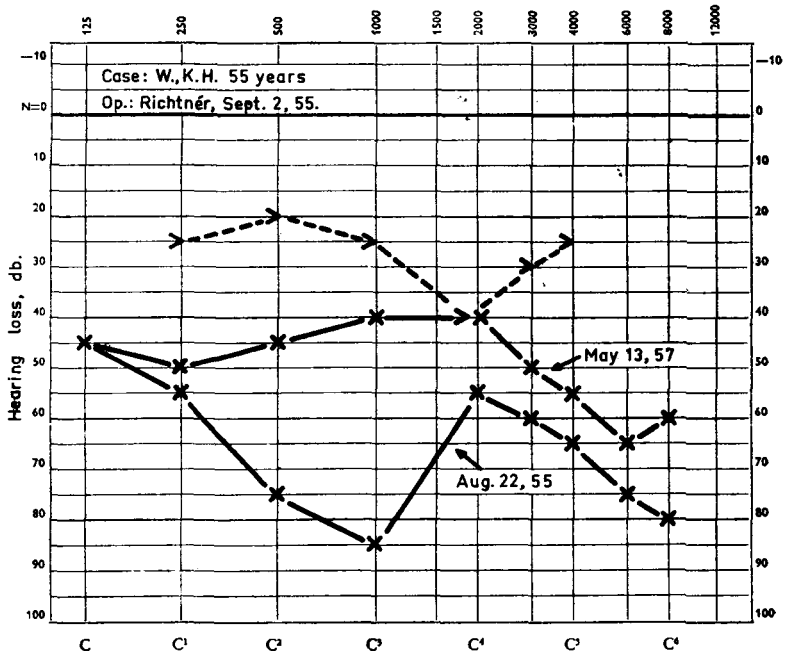


FIG. 2.

it is my experience that oxycel saturated with penicillin, hyaluronidase and ultracortinol is best, but only applied in small bits and not in large clumps (see Fig. 2).

Another case was that of a 30-year-old man who had undergone radical operation some years earlier for cholesteatoma. The incus was removed at that time, but the malleus was left *in situ*. There was considerable loss of hearing, and the ear did not heal, suppurating from time to time. Bilateral tubal catheterization revealed nothing abnormal. Revision of the radical operation was done with tympanoplasty and free transplant (cavum minor). A cholesteatoma was encountered at the site of the head of the malleus. No residue of the malleus was found. The limbus of the tympanic membrane was still partially present. There were abundant granulations

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in the region of the fenestrae ovalis and rotunda. The stapes was easily movable. The tube was fully patent and without granulations. Cavum minor was created in the usual manner. The upper part of the middle ear above the fenestra ovalis was denuded of mucous membrane, and the transplant was applied directly to the bone there. An ideal flap was obtained from above the hypotympanum. Fourteen days after the operation there was considerable auditory improvement. The improvement continued subsequently, and now, six months after the operation,

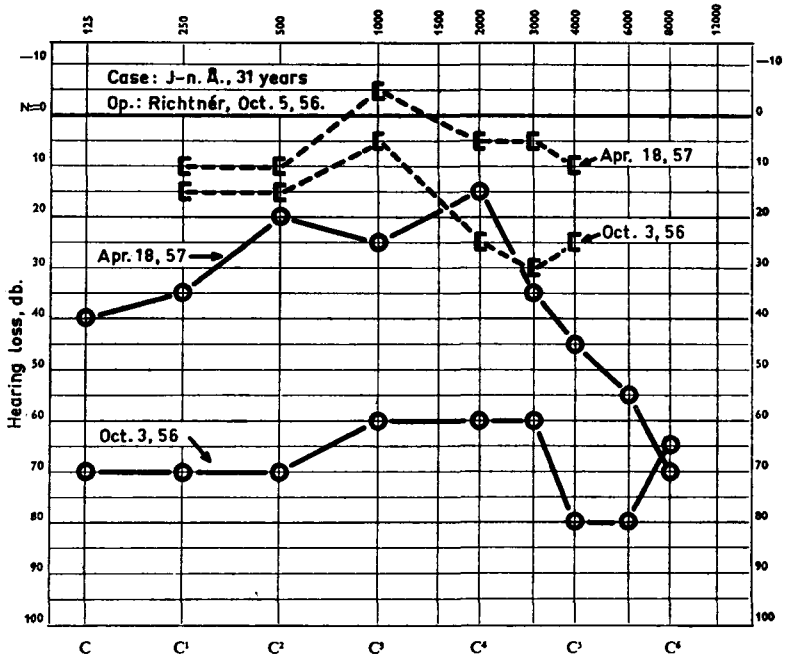


FIG. 3.

the patient's auditory acuity is 20 db as opposed to the pre-operative level of 63 db, in other words, an increase of 43 db. This strikingly good result is also difficult to explain audiologically inasmuch as the patient has only the stapes left. It is empirically useful to know that there are possibilities for achieving such good hearing after both malleus and incus are gone. This is good to know especially in cases of large cholesteatomas, where a conservative approach is not sufficient and where one is frequently forced to remove both malleus and incus. I will return to this problem later in this paper (see Fig. 3).

It is remarkably interesting that it is possible in cases of cholesteatoma to remove the cholesteatoma from the middle ear together with carious auditory ossicles and, by means of plastic screening of the round window,

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still retain hearing that does not differ greatly from the pre-operative acuity, or, in some cases, even achieve an improvement.

The following case is a beautiful illustration of the point I wish to make. The patient was a 7-year-old girl who had a long history of chronic inflammation of the right ear with a marginal perforation combined with osteitis and suspected cholesteatoma. Her hearing was good, and as mild an operation as possible was planned in order not to damage her hearing. It was found, however, that she had a cholesteatoma that extended far

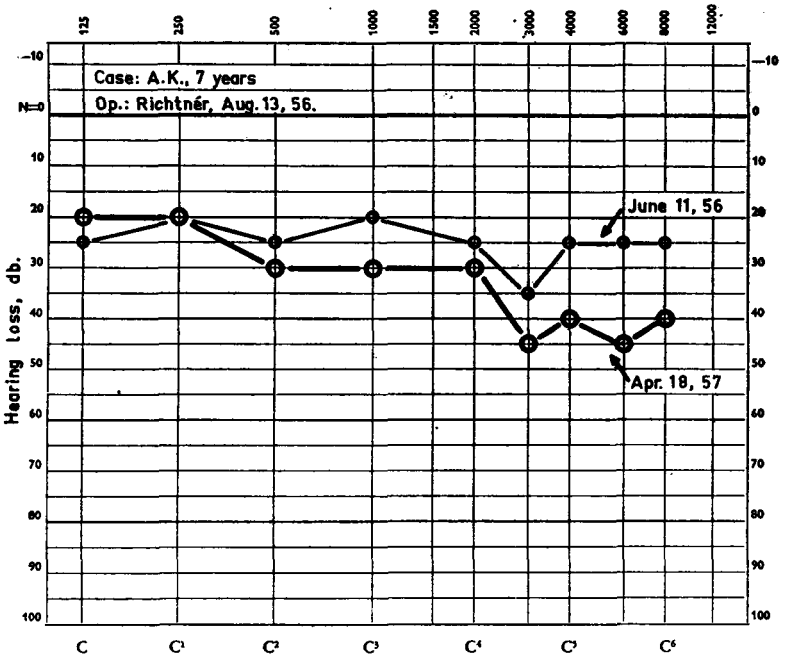


FIG. 4.

into the middle ear about the ossicles and even down to and over the fenestra ovalis. The incus was carious and the head of the stapes lay loose in the cholesteatoma. Nothing of the posterior limb of the stapes remained. The cholesteatoma extended even under the malleus and incus. Consequently, in order to remove the cholesteatoma completely, it was necessary to remove both the malleus and incus and it was decided to create a cavum minor. The base of the stapes and the fenestra rotunda region were normal. The tympanic ring was retained to provide a seat for the transplant. Optimal closure was obtained with the flap over the hypotympanum. No oxycel was used in the middle ear.

The patient's good hearing before the operation must have been due to a contact established by the cholesteatoma between the tympanum

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and the fenestra ovalis. In this case we were intensely interested to see what the auditory result would be. The middle ear healed well, and now, 9 months after the operation, there has been no occurrence of the cholesteatoma. Strange to say, this patient's hearing did not deteriorate greatly. Four months after the operation her auditory acuity was as good as 25 db and now, after 9 months, it is still at about the same level. Thus, with our operation, we have eliminated the cholesteatoma with removal of the ossicles and have still been able to conserve her hearing, thanks to this closure of the hypotympanum. The tubal passage is excellent. The auditory curve is shown in Fig. 4.

The material is too limited to permit any general conclusions on the effect of the treatment of adhesive otitis according to the cavum minor technique. Nevertheless, the results obtained would seem to indicate that we should continue along these lines. It is probable that we shall be able to form a definite opinion only after application of the technique for several more years. A broad field awaits the otologist.

We have now heard about the auditory results in the different individual groups. Taking the material as a whole we obtain the figures shown in Table I. The material comprises altogether 39 cases operated according to cavum minor technique, and almost half the cases have now been followed for one and a half years after the operation. The results of audiograms taken during the course of healing have been grouped as follows:

Group I comprises 37 cases with audiograms from 1 to 4 months after operation.

Group II comprises cases with audiograms from 5 to 9 months after operation.

Group III comprises cases with audiograms from 1 to $1\frac{1}{2}$ years after operation.

We may say that throughout the patients subjected to operation had extremely pronounced auditory impairment.

As the Table shows, 37 patients were examined during the first four

TABLE I.

AUDITORY RESULTS IN ALL CASES AFTER TYMPANOPLASTY (CAVUM MINOR), 39 CASES

	1-4 months post-op.			5-9 months post-op.			12-18 months post-op.		
	Nb.	%	M.db	Nb.	%	M.db	Nb.	%	M.db
Improved	18	49	22	16	48	25	9	53	25
Status quo	18	49	—	17	52	—	7	41	—
Impaired	1	2	13	0	0	—	1	6	19
Total	37	100	—	33	100	—	17	100	—

M.db = mean decibels.

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post-operative months. An improvement of more than 10 db occurred in 18 cases or 49 per cent. of the material. The mean improvement was 22 db. In 18 cases the hearing remained at status quo, i.e. there was neither improvement nor deterioration of more than 10 db. This represents 49 per cent. In one case there was a deterioration, and in that case it was 13 db.

During the period 5 to 9 months after the operation, 33 patients were followed, with 16 patients or 48 per cent. showing a mean improvement of 25 db. In 17 cases the hearing remained at *status quo*. No cases showed deterioration of hearing.

During the period from 1 year to 1½ years after the operation, 17 cases were followed. Nine patients showed auditory improvement. This represents 53 per cent. of the cases followed. The mean improvement was 25 db. *Status quo* may be reported in 7 cases or 41 per cent. One case showed deterioration. Examining these figures more closely we see that the mean improvement in hearing was already a mean of 22 db during the first four months after the operation and that the mean improvement after five to nine months and 12 to 18 months after the operation was 25 db. Thus, on the whole, the improvement measured in decibels was the same. This shows in the whole material that the improvement once attained with the cavum minor technique is not only maintained but even occasionally increased after five to nine and 12 to 18 months. On the whole, we may say the radically operated ears and the free transplants have healed well, and in almost 100 per cent. of the cases the tube is patent.

Prednisolone trimethylacetate (Ultracortenol, Ciba) has been a great help in the postoperative local treatment of the radical cavities. Tampons have been saturated with ultracortenol and packed in the radical cavities during operations and post-operatively. The inhibitive effect of prednisolone trimethylacetate on granulation formation is excellent. It has, moreover, proved an effective medium against infection.

I have nothing to contribute from my own material on the fifth form of tympanoplasty. I refer here to the cases where the aforementioned methods have failed, in which the stapes is fixed, and where a new fenestra is created in the wall of the horizontal semicircular canal. Perhaps, instead, in these cases an attempt should be made to mobilize the stapes.

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