Stapedectomy complications

By Rory Willis (Melbourne, Australia)

Introduction

To cover *all* the possible complications both early and late which can follow stapedectomy is beyond the scope of this paper. Accordingly I will exercise a certain amount of selection, and will also assume that the surgeon is reasonably dexterous. John Shea is probably the most deft and gentle ear surgeon of all. He has repeatedly mentioned with more than a little sadness the inherent danger of a student watching a skilled man make everything seem so simple. The student goes home and rushes into this apparently easy operation with disastrous results. His paper before the Section of Otology of the Royal Society of Medicine (Shea and Sanabria, 1963) makes this abundantly clear.

Fortunate indeed were the first in this field. Fenestration had given them early practice with the operating microscope, reinforced by years of stapes mobilization surgery, and the opportunity to handle instruments in the confined space of the middle ear without the risks which follow opening the vestibule. When removal of the footplate became the next step, they were already fully trained.

How best to teach this delicate branch of surgery worries everyone and it behoves us to be blunt with our students. If we notice that one of them obviously has 'two left hands' we should be brutal and tell him to take up some other branch of surgery. On the other hand, dexterity can be improved and I encourage practice in shaping a House-type prosthesis free-hand under the microscope out of 40 S.W.G. stainless steel wire. This is an excellent and safe way of finding out when hand and eye coordination is good enough to let the trainee operate upon a patient, particularly as you can watch his efforts through the observer eyepiece of the microscope.

Complications of stapedectomy

These are listed in Table I, and broadly fall into the two categories of early and late.

TABLE I.
STAPEDECTOMY COMPLICATIONS

Early	1. Excessive vertigo and nausea
	2. Infection. Otitis externa and media
	3. Failure to get anticipated hearing gain
	4. High-tone S.N. loss
Late	5. Mechanical Failure: (a) 'Extrusion' of the prosthesis
	(b) Fibrosis/reossification
	(c) Epitympanic fixation of the Malleus and/or Incus
	6. Dysequilibrium
	7. Sensorineural loss

https://doi.org/10.1017/S002221510008172X Published online by Cambridge University Press

1. *Excessive vertigo and nausea*

In order to study this we must know what the normal post-operative pattern should be. I regularly use general anaesthesia except for certain selected revision cases. My anaesthetist knows exactly how long the operation will take and delay in regaining consciousness is rare. The patient is then nursed with the head slightly raised on two pillows to minimize escape of perilymph around the prosthesis.

In the immediate post-operative period nystagmus beating to the operated side is the rule, accompanied by slight nausea, and a definite spinning vertigo if the head is suddenly moved. The 250 fork Weber is heard in the operated ear, and the patient is aware of his own voice echoing strongly in this ear. At 24 hours nausea should be gone, although nystagmus can still be elicited on extreme lateral gaze. The patient is allowed out of bed to the toilet only, and is still nursed on 2 or 3 pillows. At 48 hours there should be no nausea and only minimal nystagmus, usually on extreme gaze to the operated side. Some neck and diaphragm stiffness from the anaesthetic muscle relaxants is noted, but the patient is discharged from hospital. He is warned to avoid straining, lifting, sexual relations, etc. for 21 days, and is also told not to be alarmed should slight vertigo recur at about the 8th day.

These early labyrinthine signs are evidence of 'back-splash' (Goodhill, 1967) caused by inefficiency of the primary seal around the prosthesis at the oval window. A departure from the above pattern would constitute an early complication.

I consider the most important to be *continuing nystagmus away from the operated side* because it indicates that the labyrinth has been damaged to some degree. Continuing vomiting or nausea and dysequilibrium beyond 72 hours have a serious import as far as inner ear function is concerned.

Incidentally the Weber remains to the operated ear until a firm and functioning seal has formed in the Oval Window about the 10th post-operative day. At this stage the Weber shifts to the opposite unoperated ear, provided it also has a conductive loss.

Management of excessive vertigo. There is no place for urgent re-operation within the first few days, and sedation and bed rest are all that is possible. If surgical insult has occurred it will only be made worse by further interference. Persistence of vertigo beyond the 21st day, coupled with a poor hearing result, indicates that the expected sealing of the oval window around the prosthesis has failed to occur. Exploration is then strongly advised if the inner ear is to be saved.

2. *Infection*

Here I plead guilty of being a radical because I do not prepare the ear either beforehand or at the operating table. Every effort should be made to

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work through a speculum thus avoiding an endaural incision. A wider external incision makes no difference to the working space available in the critical 4 square millimetres of the oval window niche. Otitis media is rare, and patients often comment upon the freedom from pain of the whole procedure. In my experience infection is a very rare complication, but constant vigilance and attention to detail is necessary to keep this so. The penalty for any lapse is almost certainly a 'dead ear'.

3. *Failure to get the anticipated hearing gain*

About 5 in every 100 operations in expert hands will fail to gain hearing. *Misdiagnosis* is an important factor, i.e. the case is not otosclerosis; or alternatively it is cochlear otosclerosis with little or no conductive element. Special care in diagnosis is required in all cases with unilateral deafness or with a considerable difference in the thresholds of the two ears.

When a patient presents with conductive deafness in both ears, but with a big difference between the left and right air thresholds, the full battery of tests for sensori-neural function is necessary. Simple B.C. threshold tests even with full masking must not be accepted as an accurate level of inner ear function. In practice the speech discrimination score is the most reliable, and unless the value of the worse ear is within 20 per cent of the better ear, pessimism regarding the outcome of surgery on the worse ear should be expressed (Fig. 1). Never neglect the Barany Box or

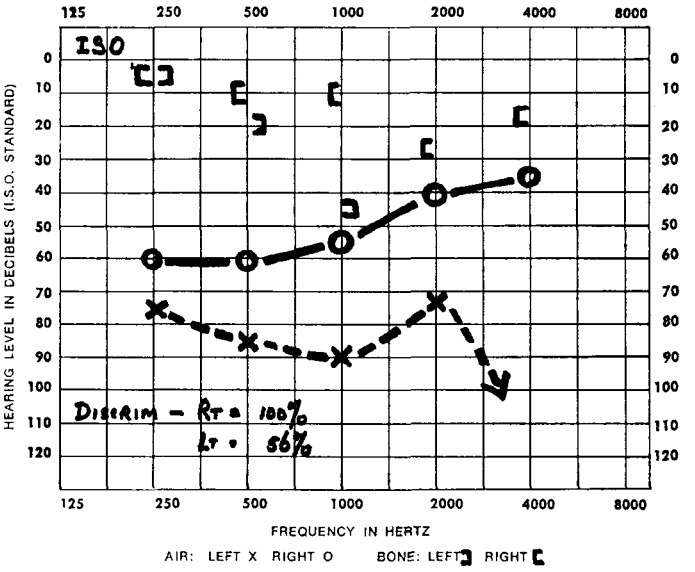


FIG. 1.

Audiogram of an otosclerotic patient in whom it would be very difficult to be absolutely sure of the inner ear function of the worse ear. Every available test must be used.

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your own loud voice. Sheehy (1962) remarked upon the diagnostic value in assessing the function of the inner ear by the successful use of a hearing aid, despite a non-measurable B.C. threshold. He was speaking of far-advanced otosclerosis, but the principle is the same in the situation we are discussing.

Increasing experience with impedance measurements has proved valuable when the hearing tests still leave doubts regarding the presence of a conductive component.

If the diagnosis of stapedial otosclerosis was correct, failure to get anticipated improvement must mean that the inner ear has been damaged, *or* that the prosthesis is at fault, *or* that a persistent fistula is present.

In my experience the patient is always willing to undergo re-exploration if you explain the situation to him. You are also duty bound to offer him a second opinion with another surgeon.

4. *High-tone sensori-neural loss*

This always indicates some damage to the basal turn of the cochlea due to the surgery. It can occur with any technique. Reports several years ago tended to implicate the Fat-Wire prosthesis in particular, but I suspect that it was the way that this method was used rather than anything specific to the fat. Probably the blob of fat was made too large.

High-tone loss can occur with any technique and results from localized Organ of Corti degeneration traumatic or toxic in origin. Experimental work by Williams, McNeill and Schuknecht (1964) failed to demonstrate any inner ear damage in cats by repeated forceful pressure upon the oval window graft area and they concluded that the helicotrema permitted rapid release of any pressure rise within one compartment of the inner ear.

Follow-up reveals that this early high-tone hearing loss increases year by year, but always keeping the same sloping graph. Strangely the patients may not remark upon any increasing disability, and the process must be very slow permitting progressive compensation to occur. I have never seen sudden severe sensorineural loss develop at a later stage in these cases, a fact which makes easier the difficult decision regarding operation upon the second ear.

Operation upon the second ear

The 1st ear must be completely trouble-free before the 2nd is operated. Records show that about 6 per cent of all stapedectomies develop some 'unsatisfactory' symptoms and signs, the majority within the first 3 years. Because both ears in any one patient tend to behave the same, it is wise to wait 3–4 years for symptoms to become manifest. Only in this way can we avoid compounding the problem. Patients under 30 are more likely to have trouble than those over 60.

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Stapedectomy complications

Late complications

Anything which causes concern in the follow-up of an initially successful stapedectomy requires particular study. To study these a small punch-card which can be hand-sorted is ideal (Willis, 1971). It saves checking the many hundreds of completely satisfactory cases because the cards are only prepared for the relatively few patients who have later trouble (between 5 and 6 per cent).

The code for such a punch-card is specifically designed to uncover factors which may predispose to later failure. Accordingly certain details are listed from the patient's history, from the findings at operation, from the operation itself, and from the presenting symptoms of later trouble.

Only by a continuing study such as this can defects in an operative technique be detected and corrected. Such a study in mid-1963 led to my abandoning the original Shea vein graft/polythene strut operation in favour of the Tef-wire piston prosthesis without a tissue graft which continues to be my standard operation. Similarly a study of the Tef-wire piston results in mid-1969 led me to modify the shape of the incus-attachment hook and to shorten the whole prosthesis.

Late complications fall broadly into three categories: Mechanical Failure: Dysequilibrium: Sensori-neural Loss.

5. *Mechanical failure*

A glance at Table II reveals that during the years 1960 to 1963, when I was routinely using a vein graft and plastic strut reconstruction following stapedectomy, I was torn between the two desires of having a prosthesis long enough to prevent mechanical failure due to fibrosis or reossification, and yet short enough to prevent fistula formation. When the prosthesis was $4\frac{1}{2}$ mm. or longer the rate of mechanical failure was low, but some 5 per cent developed fistula. On reducing the length of the prosthesis the fistula rate dropped dramatically, but mechanical problems increased.

As mentioned earlier, the Tef-wire Piston technique without a tissue graft beneath the prosthesis has become my standard. The mechnical problems now to be discussed refer specifically to this technique.

(a) *Extrusion of the Prosthesis*

The primary success rate (i.e. closure of the bone/air gap to within 10 db of the preoperative B.C. threshold) with the Tef-wire piston technique is very high, in the order of 97 per cent. Of these successful cases, 5 per cent

TABLE II.

11-YEAR STUDY OF 1000 STAPEDECTOMY WITH VEIN GRAFT AND PLASTIC STRUT OPERATIONS (1960–1963)

	Mechanical Failure	Fistula
Prosthesis $4\frac{1}{2}$ mm. or longer	2%	5%
Prosthesis less than $4\frac{1}{2}$ mm.	10%	1%

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can be expected to give some sort of trouble as the years go by. Many patients have only minor symptoms, but 3 per cent of the whole will require revision surgery. Most of these will have a mechanical cause. This preponderance of mechanical troubles was also noted by Feldman and Schuknecht (1970) studying 1750 primary stapedectomy cases. One hundred and fifty-four were revised (a 9 per cent rate) and all but 5 had mechanical problems.

No matter what type of prosthesis is used there is a tendency for its rejection and again, on revision findings, I believe that rejection is encouraged by two factors operating at the point where the oval window seal forms deep to the prosthesis. Firstly there is the fluctuating inner ear fluid pressure both with postural change and with coughing, straining, etc. No longer is there the correctly designed stapes footplate with elastic annular ligament to resist these forces. Secondly healing processes in the oval window niche tend to move the first flimsy seal, which forms at about the level of the original footplate, outwards in the niche as shown in Figure 2. Recently Shea (1974) described this process in great detail, referring to it as 'eversion of the lining membrane of the vestibule'.

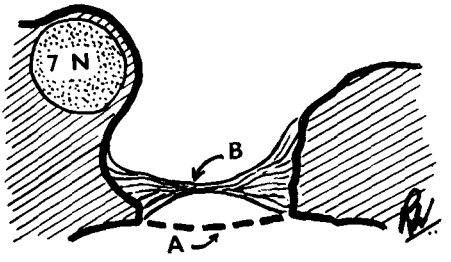


FIG. 2.

There is a tendency for the membrane which seals the Oval Window after stapedectomy to shift externally with time. The initial seal may have been at 'A', but a number of factors cause it to 'rise' in the niche to position 'B' (Shea, 1974).

Whatever the forces acting, the prosthesis may be slowly forced off the incus. New bone forming beneath the prosthesis can also cause the incus attachment to give way (Proctor, 1970).

Considerable success in the control of the extrusion problem attended the modification of the incus attachment hook of the Tef-wire piston prosthesis as shown in Figure 3. This was begun in 1969 and has produced a very satisfactory drop from 1·4 per cent to 0·6 per cent. The modification of the hook, which is simply achieved by freehand bending under the microscope, also effectively shortens the prosthesis and anticipates the final position which the oval window seal will take up. Records show that mechanical failure will manifest itself within the first 2 or 3 years of the original stapedectomy. It affects males more commonly than females.

The management of extrusion discovered at revision surgery depends

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upon the state of the incus which is usually so weakened that it is necessary to bypass it to the malleus. Unless reossification has occurred, the oval window seal is good but appears domed up towards you, with a clear central area indicating where the prosthesis originally rested. It is sufficient to adjust the new prosthesis to this membrane rather than break through it into the inner ear.

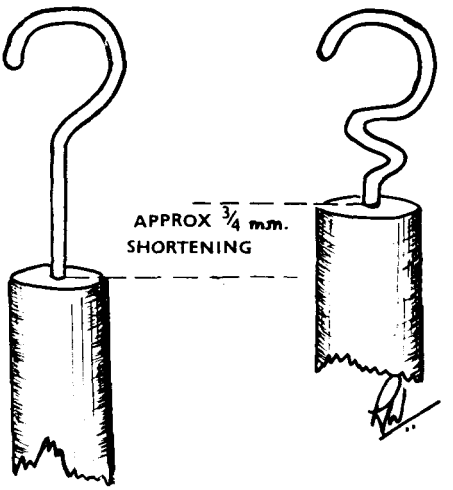


FIG. 3.
Recommended modification of the incus-attachment hook of a standard prosthesis.

(b) *Fibrosis and Reossification in the Oval Window*

The degree of activity in the otosclerotic lesion, how widely the mucoperiosteum is elevated away from the oval window margin, whether a promontory overhang requires removal, and many other factors influence the amount of post-surgical reaction of the tissues. I have demonstrated to my own satisfaction that a thick footplate (Types 3A, 3B, 4) is more likely to give later trouble with fibrosis.

Very early in 1960 the use of a microdrill in the niche was abandoned because I was sure that increased bone reaction resulted. Later, in 1963, the use of a tissue graft beneath a prosthesis was also given up because figures indicated that it could encourage reossification. In my hands only half the cases of fibrosis and reossification get lasting hearing benefit from revision surgery. Further trouble seems to occur and moreover there is a very real danger that revision surgery will damage the inner ear. This applies particularly when reossification is found. When I am faced with this situation nowadays the operation is stopped and the patient must be satisfied with a hearing aid.

(c) *Epitympanic Fixation of Malleus or Incus*

Goodhill (1966) covered fixation of the malleus very fully in his mono-

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graph, but makes no mention of it as a possible consequence of stapes surgery. This possibility is raised by Sleeckx *et al.* (1967) who reported that many of their cases were found only at the second operation. Garfield Davies (1968) supports these findings.

My own figures show that 48 cases of fixed malleus, fixed incus, or fixation of both bones were discovered at operation for conductive deafness. All but 10 had associated otosclerotic stapes fixation. Provided that appropriate ossicular chain reconstruction could be carried out, none of these cases gave later trouble.

Figures also reveal that at revision surgery for mechanical failure, malleus fixation was only recorded once, and in that patient there was gross tympanosclerosis of the drum. My opinion therefore is that malleus or incus fixation is a very rare cause of late mechanical failure after an initially successful stapedectomy.

6. *Dysequilibrium*

As mentioned earlier, unsteadiness produced by stapedectomy should all have passed within 2 weeks of the operation; continuing symptoms must be considered unsatisfactory. We realize that many otosclerotics suffer from unsteadiness anyway, presumably due to some direct effect of the abnormal bone upon the labyrinth. In these patients the post-operative symptoms will be the same as the pre-operative and can be ignored.

The later occurrence of vertigo or unsteadiness should be considered as probable 'fistula' unless proven otherwise. This is particularly so if the prosthesis length is $4\frac{1}{2}$ mm. or greater, measured from the inner aspect of the incus shaft. Over the years I have had occasion to manage 52 cases of post-stapedectomy fistula, only 12 occurring with a prosthesis shorter than $4\frac{1}{2}$ mm. I strongly suspect that there are very many patients with constant slight fistula leaks around long prostheses. The risk of sudden and severe sensori-neural loss is high in these patients.

Diagnosis is not easy. The classical distortion and loss of discrimination is by no means common, but very often the patient reports a recurring 'popping' sensation, like a bubble bursting. Sensitivity of the ear to finger pressure at the meatus, or vertigo induced by Siegle's pressure is common (but is also noted in the case of a too-long prosthesis without a fistula).

Perhaps the most reliable test is the E.N.G., with positional-induced nystagmus being present when the suspect ear is down (Harrison *et al.*, 1970).

Revision surgery is straight-forward and the results in terms of controlling the unsteadiness are excellent. This is not to say that it is easy to demonstrate the fistulous track. At times the mucosa covers the prosthesis like a cuff and fluid can be seen escaping as the prosthesis is gently moved. Sometimes it is a hidden fistula, the membrane having formed over the

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top of the prosthesis instead of beneath it. In most cases the original prosthesis must first be removed before it is noted that there is no sealing membrane beneath it.

For repair, the original prosthesis is removed and the mucosal edges of the fistula are teased with a hook and folded down into the oval window. An Ehmke platinum prosthesis with the standard gelfoam inner end is then fitted; further pieces of gelfoam being added to complete the seal.

Repair as above has completely restored the hearing and balance in 26 of the 52 cases. Ten 'dead ears' have followed fistula formation, but no less than 7 occurred with the initial symptoms and *before revision could be arranged.* This points up the ever-present risk when perilymph is escaping around a prosthesis, and the need for urgent revision surgery once suspicion is aroused.

The possibility of 'true hydrops' developing post-stapedectomy, or the coexistence of otosclerosis and Menière's Disease has been raised to account for dysequilibrium. Undoubtedly this must occur on rare occasions, but I doubt if stapedectomy surgery can cause hydrops.

Certainly a too-long prosthesis can somehow irritate the utricle or saccule, the patient experiencing a joggling sensation of the head whenever the ear is touched. A satisfactory remedy is to shorten the prosthesis. In the case of a prosthesis with a thin wire shaft this is accomplished by kinking the wire, thus drawing the prosthesis a little out of the oval window.

7. Sensori-Neural Loss

Late severe sensori-neural loss affecting all frequencies and in effect producing a 'dead ear' is almost always due to a chronic fistula.

However the more common form of late sensori-neural failure after an initially successful stapedectomy is of progressive high-tone type. There is some fall in discrimination but often the decline is so slow that the patient may be unaware that he has been classified 'unsatisfactory'. Audiometry suggests that it is due to outer hair cell failure and the aetiology remains obscure.

I do not think that this is presbycusis. Currently I am studying the sensori-neural changes which occur with time in a series of otosclerosis patients with only one ear operated. I suspect that I will find that the high-tone loss is occurring in both ears simultaneously. A direct toxic effect upon the organ of Corti in the basal turn of the cochlea by the otosclerotic focus is possible, but the physical proximity of this to the surgical site must be significant.

Granuloma formation in the oval window area and also within the labyrinth as suggested by Schuknecht (1970) must be considered although I have yet to detect such a case. Sabiel (1968) reported to me that he had reopened two cases showing sensori-neural losses and had found granulo-

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matous lesions. Histological section noted loose fibrous tissue containing foreign-body giant cells. In both cases the revision was within 5 weeks of the primary operation and in both cases 'dead ear' was the outcome. Such a short interval would raise suspicion that the granuloma was a direct inflammatory reaction to some noxious contaminant.

In support of this was a recent paper by Burtner and Goodman (1974) who investigated 42 cases of granuloma, finding refractile foreign bodies which were later traced to a contaminant in the Ringer's solution used.

Conclusion

Stapedectomy is a wonderful operation but there must be no technical errors, and it sets a real challenge for the young surgeon if he is to achieve a good success rate.

Continuous review of the operative technic and results, as well as of the otosclerotic lesion itself, is essential if a high standard of treatment is to be maintained.

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https://doi.org/10.1017/S002221510008172X Published online by Cambridge University Press