STAPEDECTOMY

A REVIEW WITH A PRELIMINARY REPORT ON THE PISTON OPERATION

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THE stapedectomy operation has now been in common use in England for the last 3 or 4 years and during this time the techniques have crystallized and appraisal can be made of the results.

Excluding the hopeless cases the success rate can be as high as 95 per cent. (Daws) and the new Piston operation (Shea) promises an effective operation for difficult cases with far less trauma and resultant cochlear damage than is necessary with the original Shea stapedectomy and vein graft.

In 100 Shea stapedectomy operations with vein graft, the results were as follows:

82 per cent. within a 15 db. limit	Right ear 60 per cent.
7 per cent. successful as far as the patient was concerned	
11 per cent. failures	Left ear 40 per cent.

The audiometer is calibrated to British standards, the readings by air conduction being 10 db. below the American standard and bone conduction being the same on both scales.

The type of disease was as follows:

Portmann Type I	32 per cent.	Fixed blue footplate.
Portmann Type II	22 per cent.	$\frac{1}{3}$ footplate otosclerotic.
Portmann Type III	23 per cent.	$\frac{2}{3}$ footplate otosclerotic.
Portmann Type IV	23 per cent.	Whole footplate otosclerotic.

In selecting cases for stapedectomy age is not considered to be of consequence except that patients over 70 are avoided.

If there is a flamingo blush on the drum this is taken as an indication of possible activity and the operation is usually delayed.

(1) The usual routine of choosing the worse ear for operation is followed but if it is thought that by choosing the better ear the patient's hearing aid can be discarded this ear is operated on. To facilitate this choice an arbitrary line at 35 db. (British standards) is marked on the audiogram

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from the 1,000 to the 3,000 frequencies, as it is to this level or above that one wishes to raise the hearing.

(2) In a severe case it is also desirable to operate on the ear with the less fragile cochlea. The Weber test is taken on all frequencies and the ears are tested for speech discrimination. These tests will help to indicate the ear with the best cochlear reserve.

(3) Finally, if there is little to choose between the two ears the right ear is chosen as technically this is a far easier ear to operate on than the left unless one is completely ambidextrous. However, the better ear is only chosen if a hearing aid can be used in the other ear, as sometimes it is found that the patient cannot change over his hearing aid.

The following observations on technique are offered:

The auricle is prepared but the external meatus is left severely alone, except for the instillation of Achromycin drops, as it is felt that attempts at sterilizing the canal will possibly introduce organisms and traumatize the skin of the meatus, thus lowering its resistance.

Only one otitis media has occurred in about 120 cases and this occurred at the usual period of 12 days post-operatively but was controlled by antibiotics and did not jeopardize the result.

Pre-operative swabs from the meatus have shown the following organisms:

	%		%
Sterile	16	Diphtheroids	5
Yeasts	2	B. subtilis	6
Staphylococcus saphrocyticus	42	Streptococcus viridans	3

	%
Non-hæmolytic Streptococcus	7
B. coli	7
Staphylococcus aureus	12

Anæsthetic

A bad anæsthetic converts this operation from a technical *tour de force*, taking from 1 to 2 hours only, into a hard and long struggle jeopardizing the patient's hearing.

The present series was given by six anæsthetists. Although the pre-medication and basic anæsthetic were roughly the same, the results varied rather considerably. Dr. Gray, the Senior Consultant Anæsthetist, has commented on the technique as follows:

The method of anæsthesia chosen should provide freedom from explosion risk, minimal bleeding, a guarantee that the patient will not move or cough throughout the proceedings, and tranquil, but not depressed, respiration in order to reduce chest movement. An abrupt post-operative return of reflexes and consciousness is not particularly important,

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as neither the age group of the patient, nor the site of operation, predispose to chest complications.

Previously recommended as anæsthetic techniques for stapedectomy, and other operations for otosclerosis, have been:

(1) Local anæsthesia.

(2) Some form of inhalation anæsthesia, with induced hypotension (Beales, 1958; Holmes, 1961; Vincent, 1958). Where local anæsthesia alone is employed, however, "a substantial amount of bleeding frequently occurs" (Colman, 1962).

The following technique, when properly employed, has been found satisfactory. Premedication is by intramuscular injection, 1 hour prior to operation, of Pethidine mg. 100, Chlorpromazine mg. 50, Promethazine mg. 50 and Atropine ·6 mg. This would be suitably modified if the patient were under 16 or over 60, but none such were found in this series. The patients arrive in theatre well sedated and indifferent to their situation. An intravenous injection of a small amount of Thiopentone (average 200 mg.) is followed by 40 mg. of Succinylcholine. After mask inflation for six or seven breaths with 30 per cent. nitrous oxide and oxygen, intubation is carried out with a size 8, 9 or 10 uncuffed endotracheal tube, well greased with 10 per cent. Nupercaine ointment. Manual inflation of the lungs with the same gas mixture, with added ·5 per cent. Trichlorethylene, is continued until the paralysis wears off. If, as occasionally happens, the patient "bucks" at this stage, a temporary change from Trichlorethylene to Halothane is made until the patient settles. The whole table is now given a 5° head-up tilt and the head section another 5° more. The blood pressure is then recorded. As a result of the premedication the systolic level is commonly already down to 100 mm. Hg. A transfusion of ·5 per cent. Thiophanium ("Arfonad") is now set up in a vein on the dorsum of the foot, or at the ankle, and the flow rate is adjusted to produce a systolic blood pressure of about 70 mm. Hg. (60–80). The addition of "Trilene" to the gas mixture and the "Arfonad" drip are continued until near the end of the operation when the microscopic work is finished.

A temporary change from Trichlorethylene to Halothane may be required, if the lifting of the patient's head for the initial towelling starts a fit of coughing. This can usually be avoided if the anæsthetist himself does the gentle lifting.

The use of Halothane rather than Trichlorethylene may occasionally be indicated throughout, when the blood pressure will not fall satisfactorily on the "Arfonad" alone, or tachycardia develops as a compensatory mechanism.

There is often a considerable rise in blood pressure (as much as 40 mm. Hg.) at the beginning of the operation, a few minutes after the surgeon's injection of Adrenaline-containing solution into the external

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meatus. The level, however, falls to its previous figure within 5-10 minutes and no attempt need be made to correct it by increasing the "Arfonad" flow rate.

With this technique, the premedication, the positioning of the patient and the use of "Arfonad", supplemented if necessary by Halothane, all predispose to reduced bleeding.

An endaural incision is used and the bleeding is controlled by diathermy. The antitragus is stitched to the skin of the neck, thus funnelling the meatus and giving far better access than working through a speculum. The chorda tympani is often cut and in those patients only three complained post-operatively. However, on sending out a questionnaire, 51 per cent. stated that they had noticed no alteration in taste, 15 per cent. had noticed an alteration in taste which had now recovered and 34 per cent. stated that this alteration in taste had persisted.

The complaints were as follows:

(1) Dentures going black, which was cured by altering the dental cleanser.

(2) Musty taste.

(3) Numbness of tip of tongue.

(4) Metallic taste.

(5) Bitter taste.

(6) Loss of pleasure in cigarette smoking.

The bony meatal rim is cut down by Wilson's forceps, supplemented by curette and sometimes by micro-drill. Portmann's micro-hooks and Cawthorne's micro-hooks are used in the middle ear. Portmann's hooks are excellent but, unfortunately, they are made of strip steel instead of rod steel and are not rigid enough. The present tendency is to perform the operation without using the drill. However, it is not considered that this is feasible in many cases, nor do I consider that the relatively slow-running Shea drill used with care damages the labyrinth. It is considered that the labyrinth is most often damaged either by the pressure of an intact footplate being dislocated inwards or by the suction caused when the whole stapes comes out intact. To avoid this the crura are nibbled away and not fractured against the promontory. The usual method of dealing with the footplate is to drill away any overhanging edges and the footplate is then cut across transversely. If the footplate does dislocate into the labyrinth it is usually hinged on one end and can be retrieved by levering on the stump of the crus close to the hinge without inserting a micro-hook deep into the labyrinth itself. The edges of the window are avoided as danger areas and conservation of the perilymph is considered essential.

The Shea drill is not an ideal instrument as the engine intrudes into the field of vision and it is rather under-powered at slow speeds. In this connection the battery should always be tested under load. The burrs

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have no shields. I have had a shield fitted to my Shea burrs with, I think, some advantage.

A $4\frac{1}{2}$ mm. Shea prosthesis is used or a 4 mm. incus grip. It is now considered that protrusion of the prosthesis into the labyrinth is harmless as, in fact, it always occurs with the Piston operation. It is considered, therefore, that the use of the larger prosthesis gives more uniform results. It cannot impinge on the walls of the oval window nor does it become dislocated post-operatively. It is also felt that blocking the window with this larger prosthesis tends to give less post-operative giddiness. In view of this, the use of the stapes as a strut, either by the Portmann technique or by the Ruedi technique, will probably become less and less frequent. The wire and fat graft technique with individually made wires in my opinion has no advantages, and many disadvantages, over the Shea prosthesis and vein graft.

Abnormalities

One case of absent stapedius tendon.

One case of small, deformed stapes.

One case with the round window on the surface and no round window niche.

One case of completely exposed and overhanging facial nerve.

Complications

(1) One otitis media at 14 days.

(2) One partial facial paralysis at 14 days which recovered within a week.

(3) Five tears of the tympanic membrane—these were covered by a vein graft placed externally and all healed.

(4) One case of probable utricular damage. The patient, when she put her head backwards was thrown to the floor but did not suffer from the usual type of post-operative giddiness—a benign paroxysmal vertigo. This recovered completely.

(5) Two cases sufficiently disturbed psychologically to require psychiatric treatment—one required hospitalization and E.C.T.

(6) One case which had a successful stapedectomy with closure of the air-bone gap but had to be re-admitted to hospital at 1 month and 2 months with gross giddiness and nystagmus. She has recovered and has a good hearing result.

Giddiness

(excluding failed cases)

Ten per cent. had giddiness pre-operatively and all but one now finds

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it less troublesome. Apart from these patients, 20 per cent. had post-operative giddiness, 10 per cent. had post-operative giddiness persisting but none consider it to be a serious disability.

Of the seven out of 11 failed cases who replied to the questionnaire, four had giddiness since the operation but none of very severe extent, with three cases persisting after 6 months.

Tinnitus

Before operation 68 per cent. had tinnitus and 32 per cent. no tinnitus.

Of those who had pre-operative tinnitus, after operation in 30 per cent. the tinnitus ceased; in 56 per cent. the tinnitus decreased; 8 per cent. remain the same and in 6 per cent. the tinnitus increased.

There was only one complaint of the tinnitus having changed in type and no cases who were free of tinnitus pre-operatively developed it post-operatively.

Of the seven failed cases who answered the questionnaire, three complained of increased tinnitus.

Cochlear Damage

It is very difficult to estimate minor degrees of cochlear damage. After allowing for the Carhart's notch, which makes allowance for the freeing of the labyrinthine fluid, any loss in bone conduction can be taken as indicating cochlear damage. However, in actual fact, only four cases, excluding one dead ear (see later) had a post-operative fall in bone conduction and this fall is within, I think, the limits of the testing conditions.

We, unfortunately, still use the broad band masking and the acoustic conditions are not good. I do not think failure of the high tones to rise immediately denotes cochlear damage, as the ear at this time is full of blood and mucoid adhesions. I have cases in which the drill has not been used and the footplate has been extracted with minimal trauma, and no suction exerted on the labyrinth, which have had marked 40% loss post-operatively. One has, therefore, to estimate cochlear damage by the failure of the high tones to rise by the average amount by which the lower tones have risen at 6 months. About 12 per cent. appear to have this loss but it must be a rather approximate figure.

Causes of Failure

(1) Too small a fenestra. This occurred in the early period of the series with patients with thick footplates and would now be treated by a Piston operation—four cases in all, Portmann Type IV.

(2) One case of traumatic deafness with a good air-bone gap but very poor speech discrimination—38 per cent. P.B.'s at 100 db. At operation

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the anterior crus was found to be fractured but the footplate was thick and white and was proved to be otosclerotic on histological examination. It is considered that the good bone conduction was a false reading, in spite of masking and checking.

This was obviously a case with a dual pathology.

(3) One further case of probable traumatic deafness—it was expected to find a dislocated incus—there was a chronic suppurative otitis media on the other side.

Both ears showed a good air-bone gap.

At operation the footplate was blue and appeared to mobilize immediately and may not have been fixed. A stapedectomy was proceeded with, with no fault in technique but the hearing did not rise.

It is noted that the Weber was to the side of the chronic suppuration on all frequencies and it is considered that this is either another failure due to poor audiometric interpretation or possibly a missed round window closure. Probably it was not a case of otosclerosis at all.

(4) Two cases in which a 3 mm. prosthesis was used.

(5) One dead ear. This occurred 3 months after a successful stapedectomy. There was some immediate post-operative high tone loss but a good rise for the low tones. The cochlea failed suddenly whilst the patient was driving his car. Caloric tests showed no reaction in the operated ear. This case has never had any giddiness. It must, therefore, be postulated that, although the cochlea failed suddenly, the labyrinthine degeneration must have been gradual.

(6) One case of dislocated incus due to an accident in the theatre.

(7) One case in which the stapes was standing upright and the long process of the incus was deficient and not in contact with it and a satisfactory functional mechanism was not obtained. The hearing did go up by 20 db.

The causes of partial failure are more difficult to find. Three cases were noted to have had excessive bleeding at operation and, although it is not considered that blood getting into the labyrinth has any effect on the final result, certainly bleeding at the time of operation leads to poor technique.

Four cases were of the Portmann type IV disease.

One case had been previously mobilized. The stapes was buried in adhesions with free fluid tented beneath them.

The Piston Operation

Up to the time of writing, the Piston operation has been performed on 20 cases and is not routinely done but only performed when the footplate is thick or there are anatomical reasons for doing it instead of using

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the Shea prosthesis and vein graft. Dr. Shea claims for the Piston operation:

(1) that it is less traumatic and there is, therefore, less chance of cochlear damage;

(2) there is less chance of bony closure;

(3) the hearing is better than following the routine Shea procedure;

(4) that it can be performed in cases where a vein graft operation is impossible.

I do not consider that failed stapedectomies should be subjected to revision operations. However, if this is undertaken a Piston operation would probably have a better chance of success.

My cases have borne out to some extent these claims.

In one case where the oval window was completely covered by the facial nerve, although the window was a blue one, the operation was easily completed by the insertion of a piston and perivenous areolar tissue.

It is worthy of note that my two stapedectomies which have had the greatest rise in hearing—over 60 db.—one was a piston operation and in the other I had inserted an incus grip prosthesis. This is probably due to the more direct thrust of the piston or the incus grip and the better attachment that they have to the long process of the incus. A piston has been used in several cases where the footplate has been removed entirely and the perivenous tissue appears to close the window safely and easily.

In performing this operation it is not considered that the measuring rod is of much practical importance and the size of the piston can best be judged by direct vision. The piston introducer is not used as the lenticular process is now left on the incus and the piston is opened out and placed under the long process. This is somewhat difficult at times and sometimes it is found more easy to place it between the long process of the incus and the handle of the malleus as a first stage. Dr. Shea has now produced a new piston which is cut on the side and this should make this stage of the operation easier. Dr. Shea cuts the neck of the piston half way through to angle it if necessary and always does this when, in cases of failed fenestration, he attaches the piston to the middle third of the malleus, the tympanic membrane having been dissected from the malleus in this situation.

The trephine burr drills the footplate slowly and atraumatically and is a delight to use. However, the hole it makes in my opinion allows very little tolerance. In fact, I believe it is ·2 mm. and to construct a perfectly functioning mechanical system I think that at least this hole should be reamed out with the penetrating burr.

The perivenous areolar tissue used to pack around the piston in the oval window is extremely easy to handle and makes a beautiful fit, especially when used in small pieces.

The question is whether, with the advance of the otosclerosis the piston

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will become stiff and fixed. Certainly it can be jammed. In one case where the trephine drill only was used, apparently with a good mechanical system, the tolerance appeared not to be adequate and the piston did not wink nicely on testing. The winking test should be performed by pressure on the handle of the malleus and not on the long process of the incus. The hearing went up very slowly and not completely. For about half a day once a week the hearing goes up with full power. Obviously the piston has not freed itself. It is now 9 months since operation and there is still a large air-bone gap. I wrote to Dr. Shea about this and he replied as follows:

"I have carefully noted the size of the fenestra in every case and related this to hearing improvement as follows:
(*a*) smaller hole = better ultimate result;
(*b*) larger hole = quicker result.
I have *no* case in my series where a fair or poor result is due to limitation of motion of piston because the hole is too small. Other factors, yes; hole too small, no."

In my successful cases where a small fenestra has been made the hearing has risen very slowly over a period of 6 months. I think, therefore, that it is important that an adequate sized fenestra should be made, provided the trauma is kept down to a minimum.

Conclusion

A series of stapedectomies has been described and it has been suggested that to get the best results the Shea technique with vein graft should be utilized with a long prosthesis but in difficult cases the Shea piston technique should be substituted.

It is emphasized that the cause of failure in most cases is due to poor technique and it is thought that in the next series of cases the percentage of successes will be higher.

The importance of good audiometry in evaluating the results and deciding on difficult cases for operation is emphasized. I do not as yet consider that the Piston operation should be used routinely, especially as it is possible that it is more likely to cause late cochlear degeneration.

Addendum

Since this article was written it has become routine to perform the Shea vein graft operation on Portmann type I and II cases and the Piston operation on Portmann type III and IV, always using either a $4\frac{1}{2}$ mm. Shea prosthesis or $4\frac{1}{2}$ mm. Shea piston. Fifty further cases can be reported on, of which forty-five have closure of the air-bone gap to 15 decibels. There were no cochlear failures in this series.

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