# Second ear stapedectomy—a continued controversy

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ALMOST twenty years after the introduction of fenestration of the oval window by Dr. John Shea (1956), otologic opinion is still divided on the arguments over second ear stapedectomy (SES).

A number of factors can influence the decision to operate on the second ear and these include both the patient's own desire to hear better, and the doctor's academic (and financial) interest in stapes surgery. Gone are the times when virtually the whole world of otosclerotics waited at the otologist's door. Now much of that early harvest has been reaped and those who have made stapedectomy an important feature of their surgical lives are liable to be more interested in the second ear than previously.

This paper is one of two which concerns a long-term evaluation of cochlear and vestibular function following various forms of stapedectomy. We believe that the findings are relevant to the current controversy over SES.

There are an increasing number of reports in the otologic literature of delayed cochlear damage, and presumably the actual rate is even greater. It is clear that there is often a prolonged interval between the operation and the occurrence of complications. Ludman and Grant (1973) in an eloquent criticism of SES report two patients totally deaf after bilateral operations, and cite another two dead ears occurring as long as eight and nine years after stapedectomy. It is clear that neither surgeon nor technique are totally immune to disaster.

The case against SES, as stated in the literature, is based largely on the risk of fistula or granuloma. The evidence might be more compelling were also the potential effect of associated vestibular dysfunction and high tone hearing loss taken into account. The insidious threat which lies in SES arises from the supposition that potentially serious vestibular defects arising from stapedectomy will be manifest to both patient and surgeon because of acute imbalance in the postoperative period. Should this occur, neither party will have much inclination to embark on an operation on the second ear. However, it should be noted that defective vestibular function has been demonstrated in the operated ear after a first operation, without there being any vestibular symptoms whatever

—this following a stapedectomy which resulted in a satisfactory hearing improvement (Stroud, 1963; Ali and Groves, 1964). Now, if such a patient should subsequently undergo stapedectomy on the second ear with attendant damage to the second vestibular apparatus, then although there may be a satisfactory hearing gain in both ears, there might now be permanent impairment of co-ordination and balance.

Clearly, the argument against SES is twofold. First, there can *never* be a time after the operation when the possibility of permanent cochlear dysfunction due to delayed fistula ceases to exist. Second, there is always a risk of even minor vestibular damage which, if it occurs in both ears, may cause very real disability which will greatly impair the patient's quality of life.

In bilateral otosclerosis, footplate pathology is frequently symmetrical (Ludman and Grant, 1973), therefore the factor which led to an injury of the first labyrinth, be the symptoms immediate or delayed, probably will again be present at SES. Thus the odds will be weighed heavily in favour of the development of a *bilateral* labyrinthine defect. The potential dangers of SES may indeed be increased because of the false sense of security which is engendered by a paucity of long-term reports. Chance, or a lack of follow-up, may prevent an exact realization of the risks of *immediate* or *delayed* cochlear dysfunction.

### Case history

A 60-year-old male was referred to the Eye and Ear Clinic, Royal Victoria Hospital, because of problems arising out of SES performed elsewhere. He recounted that 12 years previously, mobilization of *left* stapes had resulted in some improvement in hearing which had been maintained. One year previously a Teflon piston operation was carried out on the *right* ear. (Exact details of the operation are not available). Some weeks after this operation he began to complain of persistent unsteadiness. Investigations at that time were reported to indicate depressed right auditory and vestibular function. At a revision operation on the right ear, a perilymph leak was discovered and this was plugged with fat after removal of the Teflon piston. There was no improvement in his imbalance after this procedure and at this stage the patient was referred to us.

Clinical tests of balance were poorly performed. Vestibular tests with ENG recording showed only minimal excitability on the right with reduced excitability on the left side. Bone conduction thresholds for the right and left ears respectively (averaged at 500, 1000, 2000 and 4000 cps), were at 55 dB and 30 dB and air conduction thresholds at 60 dB and 55 dB. Speech discrimination scores for the right ear were 64 per cent and for the left ear 88 per cent. It was concluded that bilateral labyrinthine depression was complicating bilateral ear surgery. We considered that the most likely cause of the patient's symptoms was a persistent right perilymph fistula. It was hoped that if right-sided fistula was eliminated, the patient would return to his status *prior* to the second ear operation. Nevertheless, it was recognized that success in this depended entirely upon the reversibility of the disease affecting the right labyrinth—a factor which we could not predict.

At re-exploration of the right middle ear, a profuse oval window perilymph leak was immediately evident and this was repaired with temporalis fascia using the method of Harrison *et al.* (1970).

Subsequently, because the right ear had virtually no recordable function and there was little improvement in the patient's balance, a right total labyrinthectomy was performed. The internal auditory meatus was opened and the terminal 3 mm. of the superior vestibular, saccular and singular nerves was excised.

Although there has been some subsequent improvement in equilibrium, this patient has failed to compensate fully and continues to complain of postural imbalance using a stick when walking. Advancing arthritis of the spine and lower limbs must be a contributing handicap. The hearing in his left ear has now deteriorated further so that this unfortunate man is at present considerably incapacitated.

The relative contributions of labyrinthitis and musculoskeletal disease to this patient's incapacity cannot be accurately apportioned. It would appear that he has suffered a grave and permanent injury to his balancing mechanism as a direct result of SES and that many others may easily suffer likewise in the future. Clearly, it would behove us both as otologists and doctors, to establish more exactly the risk of operating on the second otosclerotic ear. With this aim in view we have set up an investigation to measure the changes in cochlear response and vestibular reaction at fixed intervals following SES. We had two aims:

1. To delineate the limits of cochlear tolerance in the immediate post-operative period excess of which would demand urgent treatment by either medical or surgical means.
2. To compare and evaluate the risks of SES in relation to other types of stapedectomy procedures.

This paper concerns our evaluation of changes in vestibular function following stapedectomy. The results of an investigation into the behaviour of the cochlea in a similar group of patients will be published later.

## Method

The purpose of our investigations was to quantify and evaluate the effects of various types of stapedectomy on cochlear and vestibular function.

All these patients suffered from oval window otosclerosis and were treated by a variety of stapedectomy procedures. For the purposes of this investigation, these operations have been arbitrarily categorized as:

I. 'Small fenestration stapedectomy' (SFS). The diameter of the foot-plate fenestration was 0·4 mm. or less.

II. 'Large fenestration stapedectomy' (LFS). The diameter of the footplate fenestration was greater than 0·4 mm., usually half or more of the footplate being removed.

There was no particular selection of cases on the basis of footplate pathology. The type of operation was dictated by our preference at the time. All of the early cases in the series were operated on during 1965, when we were using 0·8 mm. diameter Shea type teflon piston and 0·8 mm. diameter teflon-wire and gelfoam-wire Schuknecht type prostheses. Consequently, most of the early oval window fenestrations were in the 'large' category (LFS). The remaining patients were mostly operated upon during 1972 and 1973. At that time, whenever possible we made a central fenestration about 0·4 mm. in diameter with the straight Schuknecht needle. The 0·3 mm. Cawthorne teflon piston was used and thus the majority of these patients are in the 'small fenestra' group (SFS). With a view to making the most realistic possible assessment of the findings, all of the patients were allocated to Shambaugh and Juers groups. Preoperative bone conduction thresholds were corrected for the Carhart notch, on the basis of the observations of Woods (1948) and later Juers (1948), on the effect of fenestration on certain bone conduction thresholds. In Group A, the average bone conduction threshold was not greater than 30 dB., through 500, 1,000, 2,000 and 4,000 cps.; in Group B, the bone conduction threshold was not greater than 40 dB. through the same frequencies; and in Group C the bone conduction threshold average was greater than 40 dB. at these frequencies.

The present paper is confined to our findings in regard to vestibular function. Eighty-six patients were evaluated immediately before and then at intervals postoperatively, by means of the bithermal caloric test of Cawthorne *et al.* (1942). The test was performed with water at 30 °C. and 44 °C. delivered from Grant tanks for 30 seconds. The patient lay in the supine position, the head raised to 30° from the horizontal, with eyes closed. Mental alerting was employed in every case. The total number of patients is divided into:

*Category I.* Forty-nine consecutive patients in whom assessment was based on naked eye observation of the duration of nystagmus.

*Category II.* Thirty-seven patients in whom assessment was based on the speed of the slow phase of nystagmus as derived from an electronystagmographic recording (ENG). Hewlett Packard electrodes were used with the Commonwealth Acoustic Laboratory Nystagmograph.

The significance of differences of intensity and directional preponderance was estimated by means of the formula of Jongkees and Philipszoon (1964). These authors set the limits of normal differences at 15 per cent for excitability and 18 per cent for directional preponderance.

**Results in Category I patients**

Category I consisted of 42 ears treated by LFS and seven treated by SFS. In the LFS section according to the Juers (1948) classification, 24 ears were in Group A, and nine each in Groups B and C. In the SFS section, six ears were in Group A and one in Group C.

Bilateral bithermal caloric tests were carried out as previously described on the day before operation, and repeated one month after operation. The duration of nystagmus was measured by naked eye observation. Tests of significance for differences in excitability and directional preponderance were made (Jongkees and Philipszoon, 1964).

All of the preoperative tests were normal. Forty-seven out of the 49 postoperative tests were normal. In the two remaining patients who had undergone LFS, parallel labyrinthine and cochlear postoperative defects were detected.

*Case 1* had a normal caloric response preoperatively. The air conduction and bone conduction thresholds, averaged from 500 to 4000 cps, were 80 and 50 dB respectively, but speech discrimination on repeated tests could not be made more than 24 per cent. A thick footplate was fenestrated with the penetrating burr and the posterior two-thirds removed. A 0·8 mm. Tefwire piston was placed between the incus and oval window with surrounding gelfoam in the oval window. The oval window was noted to be open for two minutes during a total operative time of 15 minutes. The one-month postoperative caloric test indicated significantly reduced excitability in the operated ear and at this stage and subsequently, the averaged audiometric responses were found to be practically identical to those obtained preoperatively, very poor speech discrimination scores being maintained. An examination of the daily bone conduction tests performed during the first postoperative week indicated that the response at 1500 cps was completely lost by the third postoperative day. It has not returned subsequently. Fortunately, imbalance for this man has been nothing more than a rare and minor problem throughout. In retrospect, this operation on such a poorly discriminating ear had limited prospects of success.

*Case 2* had complained of a three-hour attack of vertigo with falling, followed by several momentary attacks of vertigo during the four weeks prior to operation. The immediate pre-operative caloric response was normal. At operation, most of a biscuit footplate was removed and a Shea type 0·8 mm. Teflon piston was implanted with gelfoam around it in the oval window. It was noted (1) that blood had entered the vestibule following fenestration of the footplate, and (2) placement of the prosthesis presented difficulties to the surgeon and contributed substantially to a total operating time of over two hours. Nevertheless, the immediate postoperative course was normal. One month postoperatively there was complete closure of the air-bone gap but surprisingly (with this hearing gain) there was no caloric response in the operated ear to tests at 37 °C. and 44 °C. Iced water produced a minor response. There was no complaint of imbalance and postural tests were excellently performed.

At review two-and-a-half years after the operation, the patient complained of recurrent imbalance over the previous two months, accompanied by increasing dullness of hearing in the operated ear. Although he performed clinical tests of balance quite well, his high frequency response in the previously operated ear was considerably diminished and his speech discrimination score had fallen from 92 to 32 per cent. In spite of intensive therapy with vasodilators and steroids, there was no improvement in discrimination. The possibility of a perilymph leak was ruled out by tympanotomy. Cochlear failure proceeded until all ability to discriminate for speech was lost. Meanwhile, recurrent variable attacks of imbalance continue.

The first patient (Juers Group C) is not significantly worse off, apart from the loss of time and finance involved in his hospital treatment and attendances. Unfortunately, the second patient (Juers Group A) is significantly affected.

**Results in Category II patients**

Category II comprised four LF and 33 SF operations. The caloric test technique was identical with that used for Category I patients, except that (1) the first postoperative test was delayed until three months postoperatively, and (2) nystagmus was recorded by ENG. When a statistically significant abnormality was detected then the test was repeated at 12 months after operation.

I. *Large fenestra operations* (4 ears)

All the patients in this category belonged to Juers Group A. In three, both pre- and postoperative test results were normal. None had a prior stapes operation in either ear. In the fourth patient, decreased vestibular excitability was present one year postoperatively but interpretation of this finding was complicated by (1) a previous contralateral (right) large fenestra stapedectomy (postoperative airbone gap, 10 dB., speech 92 per cent) about which there is no caloric information, and (2) a history of two severe head injuries from horse-riding which occurred during the interval between her stapes operations and caused a dislocation of incus in the second ear.

II. *Small fenestra operations* (33 ears)

Because of the complexity of the postoperative caloric responses in the 33 ears treated by SES, a summary of our findings is set out as follows:

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| Response remained normal | 18 |
| Initial normal response, becoming abnormal at three months but reverting to normal at twelve months | 8 |

| | |
|---|---|
| Initial abnormal response reverting to normal at twelve months | 6 |
| Initial abnormal response persistent at twelve months | 1 |

The data from which this summary was derived are detailed in the following section:

1. The pre- and postoperative test results were within normal limits in 18 patients. Four of these patients had prior contralateral operations two LFS and two SFS.

2. A significant *preoperative* abnormality was detected in seven of the 33 patients.

(*a*) There was a difference of excitability (DE) in four. In one of these patients, who had prior left LFS, there was now decreased excitability of this ear. Two other patients who had no prior surgery, had decreased excitability of the ear about to be operated upon, which in each case was the worse ear audiometrically.

(*b*) In three patients, all of whom had prior LFS, the abnormality consisted of directional preponderance (DP) towards the non-operated ear.

The response of all these patients had reverted to normal at the three-month postoperative test.

3. A significant *postoperative* caloric abnormality detected in eight patients at three months was not recorded at the 12-month test.

Two ears showed significant differences of excitability (suggesting depressed function in the operated ear) and seven other ears showed directional preponderance. Apart from one patient, the three-month postoperative caloric test results were consistent with an interpretation of ipsilateral depressed vestibular function. In other words, there was depression of excitability on the operated side, with or without DP. When DP was present it was towards the contralateral, and presumably more normal, labyrinth (Hallpike, 1964). The exception was one Group A patient in whom we have difficulty in explaining the findings. This patient had previously had left LFS and prior to right stapedectomy his caloric results were normal, but afterwards there was diminished excitability of the left ear with DP to the right ear which was no longer present at the 12-month test.

## Discussion

This investigation revealed an unexpected and disturbingly high incidence of vestibular abnormality following stapedectomy. In our early experience vestibular *symptoms*, once the immediate postoperative period was over, were extremely uncommon in stapedectomy. The reports of Stroud (1963) and Ali and Groves (1964) prompted us to investigate the risks of vestibular trauma in our own patients.

We were already studying immediate postoperative cochlear function in an attempt to discover a means of detecting early signs of cochlear failure at a treatable stage. Thus, we enlarged the investigative programme for our patients to include caloric as well as bone conduction evaluation, immediately before and at intervals following stapedectomy. As already stated, the results from the first category of patients may well have been dangerously misleading because the method of measurement was insufficiently sensitive.

In the second category of patients (ENG recorded), we were naturally extremely concerned to find that eight out of 26 ears (30 per cent), all of whom had normal preoperative caloric responses, had an abnormal response at the three-month postoperative test. Fortunately, this abnormal response had diminished to less than 'significant' proportions, and in some cases completely disappeared, at the 12-month test. Note that the fact that none of our patients with abnormal postoperative caloric test results complained of any unusual disturbance of equilibrium may be extremely significant. Prior stapedectomy may have been the cause in three of these seven patients. Whilst speculating on the cause in the remaining patients, in the present state of our knowledge, the possibility of labyrinthine otosclerosis as an aetiological factor certainly cannot be ruled out (Sando *et al.*, 1974). At the same time, we must recognize the inevitable limitations of the bithermal caloric test. It is not possible to quantify the stimulus precisely and in spite of electronystagmography, methods of evaluation are not yet standardized. It could also be argued that the range of normal response proposed by Jongkees and Philipszoon (1964) may be too stringent.

Unfortunately, we cannot compare the relative merits of LFS and SFS in our patients in regard to their effect on vestibular function because the caloric reaction of each group was assessed by a different and therefore not comparable method. Had we used ENG recording to measure the speed of the slow component of nystagmus in the first group of patients (Category I), then we might well have detected evidence of vestibular disturbance following LFS sufficient to cause concern about the risks of SES. A comparison with the results reported by Ali and Groves (1964), using an LFS technique (marked depression of caloric response in the operated ear in 10 per cent of 48 ears at one year) support this supposition.

Recent evidence indicates that LFS causes a significantly greater degree of cochlear dysfunction than SFS (Smyth *et al.*). Thus, although we cannot *prove* a greater risk factor to the vestibule with LFS, the available evidence suggests that for the inner ear as a whole, SFS is likely to be a less hazardous operation. However, any complacency we may have had about even SFS prior to this investigation has been totally dispelled since we detected such a high incidence of caloric abnormality in our SFS patients at the three-month test.

The outstanding fact which emerges above all else from this investigation is that fenestration of the stapes footplate, no matter how carefully and delicately it be performed, will frequently cause an alteration in vestibular function. Although this dysfunction may subside so that subsequent tests may register a normal response, in some cases a dissimilarity between the activity of one vestibular system and the other will persist. We cannot be sure that latent degrees of DP or DE which by our criteria are less than 'significant' after the first operation, will not be increased by a second operation sufficiently to then become 'significant'. In such a case the patient could become a labyrinthine cripple. For most patients such a risk far outweighs the advantages of bilateral hearing. If patients with alterations in labyrinthine function following unilateral stapedectomy, as indicated by the caloric response can be asymptomatic, then it follows that the decision to operate on the second ear should not ever be made without considering the current status of the patient's labyrinthine function.

Our conclusion must be that bilateral stapedectomy is only rarely justified and certainly should never be performed without as much proof as is possible of intact vestibular and cochlear function following the first operation. Fortunately for patient and otologist alike, changing fashion in hairstyle and the recent developments in transistors may make an ear level hearing-aid a more acceptable solution than the risk of a stapes operation on the second ear.

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**Summary**

This paper presents the results of an investigation into the effects of stapedectomy on vestibular function.

We detected a disturbingly high incidence of vestibular abnormality in the results of caloric tests at three months postoperatively. Surprisingly, this was not usually accompanied by concurrent vestibular symptoms and there was no evidence of cochlear dysfunction in most cases. Although the caloric response at 12 months postoperatively showed an improvement in most instances, the responses rarely became symmetrical.

We believe that a long-term alteration in vestibular response is not uncommon following stapedectomy. Although most patients will com-

pensate quite quickly after unilateral stapedectomy we suspect that this occurs much less readily after *bilateral* stapedectomy and not at all should *bilateral* impairment of vestibular function occur.

On the basis of this evidence, we submit that bilateral stapedectomy is justified only when vestibular function can be shown to be normal prior to the second ear operation.

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