STAPEDECTOMY AT THE SINGAPORE GENERAL HOSPITAL – USE OF FUNCTIONAL HEARING ANALYSIS

S C Huang, R E Stanley

ABSTRACT

The results of stapedectomy surgery performed in Singapore General Hospital covering a period of over two years are reviewed.

The diagnostic importance of selected clinical features and investigative procedures in otosclerosis is studied.

The post-operative hearing status of twenty-six cases of primary stapedectomy is analysed using traditional audiometric and modern functional methods.

Seventeen patients (65.4%) achieved closure of air-bone gap to less than 10 dB while the overall mean hearing gain was 28.6 dB. Using the Glasgow Plot parameter, 73.1% showed significant benefit from surgery, whilst the corresponding figure using the Belfast Rule of Thumb assessment technique was 57.7%.

The validity of the foregoing evaluation techniques is compared.

Different operative techniques, including variations in fenestra size and method of oval window seal showed statistically similar results.

The scarcity of stapedectomy cases poses problems in the training of future specialists.

Keywords: *otosclerosis, stapedectomy, Glasgow Benefit Plot, Belfast Rule of Thumb.*

SINGAPORE MED J 1995; Vol 36: 158-162

INTRODUCTION

Otosclerosis is a localised disease of the otic capsule in which new spongy bone causes ankylosis of the stapes footplate. This usually leads to conductive deafness. The aetiology of this condition has not been satisfactorily explained.

More than 30 years have passed since Shea[1] in 1958 introduced stapedectomy for the surgical correction of stapedial otosclerosis and to this day it remains the surgery of choice.

The striking success of the Shea operation heralded a dramatic change in the fortunes of otosclerotic sufferers, resulting in an avalanche of untreated patients seeking a surgical solution to their problem. Thus during the subsequent 1-2 decades the otological surgeons of that era acquired a unique experience of the stapedectomy operation by operating on a large back-log of cases. Since then the flood of cases has diminished to a trickle so that the present day otologists lack the unique opportunity to acquire experience enjoyed by their predecessors. This is reflected in the Singapore scenario, since in a large centre such as Singapore General Hospital, only 26 primary stapedectomy operations were carried out in a period of 25 months – an average of only 12 cases per annum.

The dwindling numbers worldwide has aroused worldwide concern among the otolaryngologic fraternity[2] as the drastic reduction renders it difficult for aspiring otologists to gain adequate proficiency in the operation.

Department of Otolaryngology
Singapore General Hospital
Outram Road
Singapore 0316

S C Huang, MBBS, FRCS(Edin), FRCS(Glas)

R E Stanley, MBBS, FRCS(Edin), FAMS

Correspondence to: Dr S C Huang
Huang Ear, Nose & Throat Surgery Pte Ltd
6 Napier Road #09-15
Gleneagles Medical Centre
Singapore 1025

AIMS OF STUDY

The present review was designed to provide a picture of the stapedectomy scene as it applies to Singapore at the present time and thus afford guidance to doctors in advising patients regarding the outcome of surgery in a local context.

The study also provided an opportunity for a comparative analysis between conventional forms of postoperative hearing evaluation and functional, patient-oriented methods, recently developed in UK using the Glasgow Benefit Plot and the Belfast Rule of Thumb as advocated by Browning[3] and Smyth and Paterson[4] respectively. Finally, the review afforded an opportunity to evaluate other parameters, including the diagnostic significance of certain clinical features and investigative methods in otosclerosis, and the variations in stapedectomy technique, such as the size of the fenestra[5] and the different methods of sealing the oval window, in relation to the hearing results.

MATERIALS AND METHODS

A retrospective study of consecutive stapedectomies done at the Department of Otolaryngology, Singapore General Hospital over a 26-month period (August 1990 to October 1992) was carried out. Thirty-two cases of stapedectomies for otosclerosis were done, of which 26 cases were included in the study. Five revision operations were excluded as was one case of primary stapedectomy which had incomplete documentation. It is well recognised that revision stapes surgery is not as successful as primary stapes operations in restoring hearing[6,7].

RESULTS

Patients' Profile

There were 13 males and 13 females. The age range was from 23-64 years with a mean of 39.1 years. There were 18 Chinese (69.2%), 4 Indians (15.4%), 2 Malays (7.7%) and 2 designated as Others (7.7%).

Nineteen patients (73%) had bilateral deafness and 7 (26.9%) had unilateral deafness.

Only 5 patients had a family history of unexplained deafness.

Preoperative audiological test

Pure-Tone Audiogram
The majority of patients (ie 17 patients which make up 65.4%) had air-bone gap of between 30 to 40 dB. One patient (3.9%), 4 patients (15.4%), 1 patient (3.9%) and another 3 patients (11.5%) had pre-operative air-bone gap of 10 to 20 dB, 20 to 30 dB, 40 to 50 dB and more than 50 dB respectively.

Stapedial Reflex Test
When this was performed in 10 patients, it was absent in all of them. This is expected as no reflexes can be elicited from a firmly fixed stapes. A diphasic response typically seen in early disease in which the footplate mobility is decreased but not totally fixed was not seen in any of our cases.

Tympanometry
Tympanometry was done in 14 patients. The Type As pattern which signifies reduced compliance because of ossicular fixation and conventionally thought to be characteristic of otosclerosis was found in only 6 patients (42.9%).

Surgery
Surgery was performed by consultants (for 12 patients) and trainees under supervision (for 14 patients).

General anaesthesia was used in all the operations.

The majority of the cases (18 patients or 69.2%) were large fenestra operations (stapedectomy) in which part of or the whole footplate was removed, and 7 patients (26.9%) had small fenestra operation (stapedotomy) in which a hole was made in the footplate just sufficient for insertion of the prosthesis.

Clinical classification of footplate
Seventeen patients (65.4%) had stage I footplate. Two patients and 3 patients had stage II and stage III footplates respectively. The staging was unknown in four patients.

The classification is as follows:
Stage I – less than half footplate is involved
Stage II – whole footplate involved but not grossly thickened
Stage III – whole footplate thickened but margins still recognisable
Stage IV – margins unrecognisable

Oval window seal
Gelfoam was used in 13 patients (50%) whilst 9 patients (34.6%) had fat as sealing material. Blood clot was used in 1 case and in 3 patients it was not documented.

Prosthesis (Table I)
Schuknecht Teflon-wire prosthesis was used in all the cases and the commonest prostheses were either 4.0 mm (12 patients) or 4.25 mm (13 patients) long and 0.6 mm in diameter (22 patients).

Table I – Prosthesis used

Length (mm)	4.0	4.25	4.5
No.	12	13	1
Dia (mm)	0.6	0.8	unknown
No.	22	1	3

Post-operative Stay
In the post-operative period, the patients were instructed to rest in bed on the first day, allowed to ambulate on the second, and discharged in the evening of the second or on the third day. They were instructed against blowing the nose and told to keep their mouths open if they have to sneeze. The mean post-operative stay was 2.3 days.

The follow-up period ranged from 3 to 27 months. The mean was 18 months.

Complications
One patient was found to have profound sensorineural hearing loss about three months after the operation. Another patient experienced loss of taste.

POST-OPERATIVE HEARING RESULTS

A. Conventional methods
i. Closure of air-bone gap (Speech frequencies 0.5, 1, 2 kHz)
Seventeen patients (65.4%) had air-bone gap of less than 10 dB. Table II shows the detailed results.

Table II – Postoperative air-bone gap (speech frequencies 0.5, 1, 2 kHz)

Air-bone gap (dB)	Patient no.
0 to <10	17 (65.4%)
10 to <20	6 (23.1%)
20 to < 30	1 (3.8%)
>30	1 (3.8%)
Total	25

One patient had profound sensorineural hearing loss. The hearing loss remains unexplained. The operation was routine except for the fact that this was the only patient in which a 4.5mm prosthesis was used. Overly long prostheses have been known to cause damage to the inner ear membranes.

ii. Hearing gain (Improvement in air-conduction thresholds)
In 88.5% of the 26 patients, there was improvement of greater than 10 dB in the air-conduction thresholds, averaged over 0.5, 1 and 2 kHz. In 2 patients (7.7%) the improvement was greater than 40 dB; in 12 patients (46.2%) between 30-40 dB; in 8 patients (30.8%) between 20-30 dB and 1 patient each who had improvement of 0-10 dB and 10-20 dB respectively. One patient had mean decrease in air-conduction threshold of 20 dB and is awaiting exploration. One patient had profound sensorineural deafness. Overall, there was mean gain of 28.64 dB. This compares favourably with Browning et al's[3] series of 40 patients in which there was mean improvement of 28 dB.

B. Functional methods
The conventional methods mentioned above have been found to be inadequate on several counts.

Listening is a binaural task. A patient's disability is mainly determined by the hearing level of the better ear. In stapedectomy as in most other middle ear surgery, the worse ear is chosen for the operation. Post-operatively, if a marked asymmetry in hearing levels remains despite improvement in hearing thresholds of the poorer (operated) ear, the patient may not reap any benefit from the surgery as he will continue to use only the non-operated ear.

Many middle-ear conditions present with mixed deafness so that even if there were complete closure of the air-bone gap, the hearing level would still be imperfect.

Thus the following methods were introduced to address this problem ie to include the contribution of the non-operated ear when determining patient benefit from middle-ear surgery.

i. Glasgow Benefit Plot
Browning et al[3] proposed grouping the patients into pre-operative and post-operative groupings:-

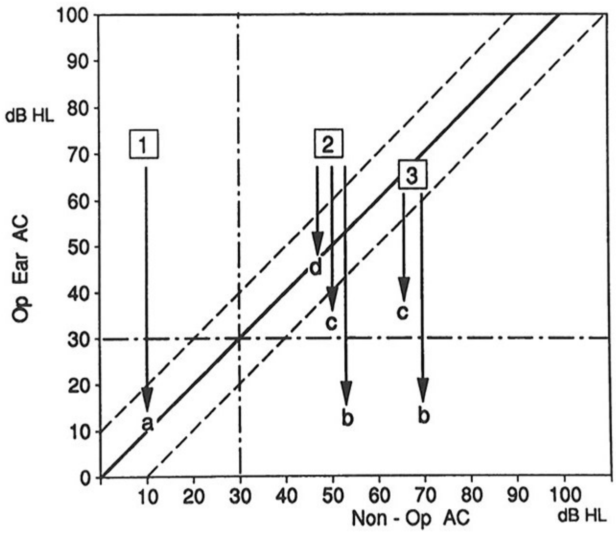
Pre-operative impairment groups
Group 1: Unilateral deafness
Group 2: Bilateral deafness – asymmetrical
Group 3: Bilateral deafness – symmetrical

Post-operative categories
Category a: Bilateral normal hearing
Category b: Unilateral normal hearing
Category c: Operated ear improves but is still impaired
Category d: Symmetrical but impaired thresholds

The aim of surgery is to convert the hearing thresholds from the pre-operative groups to the corresponding post-operative categories. Each patient can be identified on the plot and will be represented by a vertical line. The length of this line represents the change in the air-conduction thresholds: this should be in a downward (positive) direction.

Fig 1 shows the potential benefits of each pre-operative impairment group.

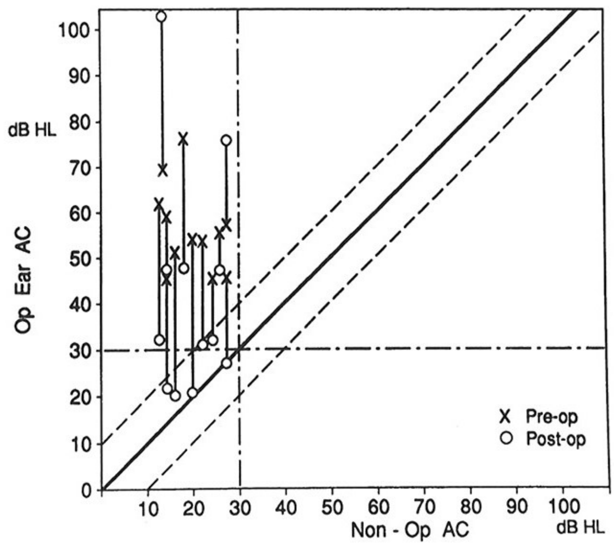
Fig 1 – Potential changes from pre-operative impairment groups 1,2,3 to post-operative impairment categories a, b, c and d



Each impairment group is plotted separately as the achievable aims of each group are different.

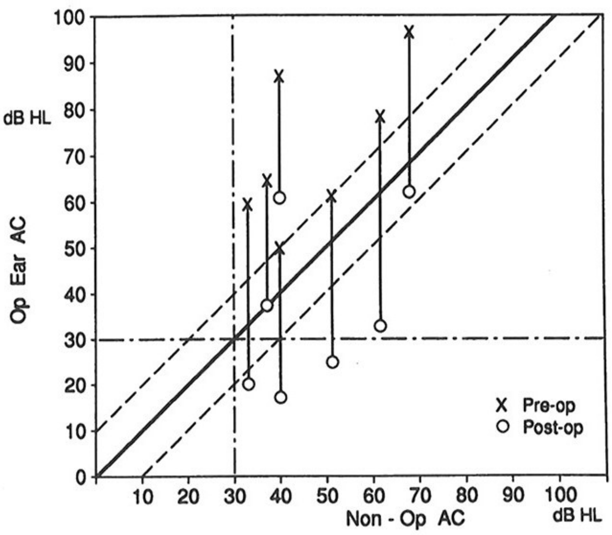
Pre-operative impairment group 1 (Fig 2)
Patients in this group (12 patients) have unilateral hearing impairments and thus asymmetric thresholds. Four patients (30%) achieved bilateral normal hearing (Category a). This is of course most desirable as the patients now have normal hearing bilaterally.

Fig 2 – Results of patients in pre-operative group 1



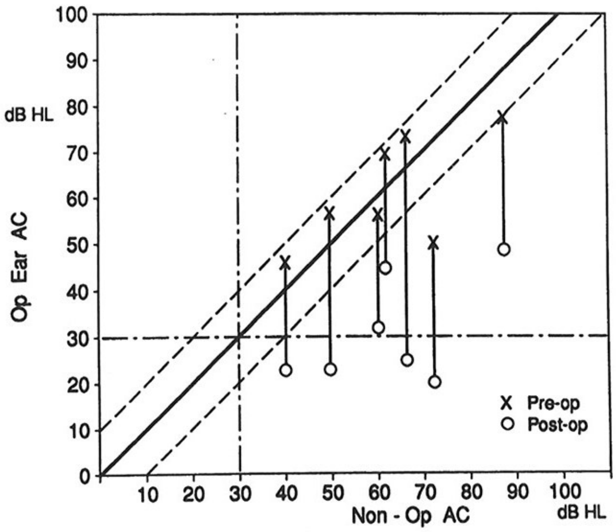
Pre-operative impairment group 2 (Fig 3)
Patients in this group (7 patients) have three different post-operative outcomes. Three patients (42.9%) have normal hearing in the operated ear (Category b). This could mean that a patient who previously required a hearing aid may dispense with it now. One patient ((14.3%) had the operated ear as the better ear (Category c). Although the hearing of the operated ear is still not normal, this is still desirable as the disability would be less than pre-operatively if not using a hearing aid. Another 3 patients (42.9%) remain bilaterally impaired (Category d) but post-operatively, the thresholds of the poorer-hearing ear is similar to that in the non-operated ear. This might be of minor advantage when the patient is unaided, especially in a noisy environment if the speaker is located on the side of the bad ear.

Fig 3 – Results of patients in pre-operative group 2



Pre-operative impairment group 3 (Fig 4)
Pre-operatively, 7 patients had bilaterally impaired but symmetrical hearing.

Fig 4 – Results of patients in pre-operative group 3



Four patients (57.1%) had a normal operated ear (Category b) and 3 (42.9%) had improved operated ear becoming the better, although hearing is not normal (Category c).

Overall, 19 patients out of 26 (73.1%) benefitted from surgery in some way or other. The benefit of course varies according to which pre-operative group the patient belonged to. The best outcome would of course be normal bilateral hearing but this is only attainable if the patient had unilateral deafness pre-operatively.

Smyth and Patterson's Belfast Rule of Thumb
This form of post-operative assessment was devised by Smyth and Patterson (1985)[4] following their analysis of the correlation between subjective patient benefit and the post-operative audiometric changes. They reported that the patient is likely to report significant benefit only if:

* post-operative air-conduction mean threshold over the speech frequencies (0.5, 1, 2, 4 kHz) is less than 30 dB, and/or
* interaural air-conduction mean threshold is less than 15 dB.

Based on this rule, 15 out of 26 patients (57.7%) benefitted from surgery.

When the hearing results of the operation were compared with respect to type of fenestration (large or small) and type of material used for oval window seal (gelfoam, fat, blood), no statistical difference was found (Student's paired t test). These results however cannot be regarded as conclusive in view of the small numbers of cases in the various categories.

DISCUSSION

This study is considered of relevance to the ENT community as the number of otosclerosis cases have been decreasing worldwide and the number available to aspiring otologists may not be sufficient for them to attain proficiency in the operation.

In our series, the sexes were equally represented whereas most series have a female preponderance ratio of 2:1 (Robinson, 1983)[8]. Nineteen patients (73%) in our series had bilateral conductive deafness which is comparable with most studies. Seventeen patients (65.4%) had pre-operative air-bone gap of 30-40 dB, and as most authors agree, the air-bone gap is rarely wider than 50 dB (Shambaugh and Glasscock, 1980)[9].

Diagnosis depends on having a high index of suspicion and is aided by audiological tests. Supposedly typical otoscopic findings of Schwartze's sign in which there is a "flamingo flush" due to hyperemia of the promontary region was not documented in any of our patients. The phenomenon of Paracusis of Willisi in which the patient claims to hear better in an environment of background noise was also not documented although the authors feel that this was due to poor history-taking as in the last three cases of stapedectomies done (not included in the study) in which detailed history was taken, the patients readily volunteered experiencing paracusis.

Of the audiological tests, absent stapedial reflex was most reliable for diagnosis, and tympanometry in which reduced compliance causes a lowered peak was found to be unreliable in our series.

When the hearing results of the operation were compared with respect to type of fenestration (large or small) and type of material used for oval window seal (gelfoam, fat, blood), no statistical difference was found (Student's paired t test). These results however cannot be regarded as conclusive in view of the small numbers of cases in the various categories.

Conventionally, the results of middle-ear surgery were reported in terms of closure of air-bone gap and improvement in the air-conduction threshold (ie hearing gain). This is no longer considered adequate as it is felt that although air-bone gap closure is useful for comparing the performance of different materials or techniques, it does not give any indication as to how much the patients' disability has been alleviated. The same criticism applies to the measurement of post-operative hearing gain which also ignores the contribution by the non-operated ear. This is a serious flaw in assessment as hearing is a bilateral sense requiring input from both cochleae and the patient's disability is determined by the hearing of the better ear. Hence, assessment of the operated ear alone does not evaluate the effect of surgery on binaural hearing ability.

For these reasons, Browning et al and Smyth and Paterson advocated two ways of measuring patient benefit.

Browning's Glasgow Benefit Plot is an innovative method which can be used to predict the likely outcomes in terms of restoring bilateral normal hearing, unilateral hearing and bilaterally abnormal but aidable hearing. The plot provides a visual representation which groups patients into three pre-operative impairment groups having different achieveable aims. It is easily understood, informative and each patient can be considered separately.

Smyth and Paterson's Belfast rule of thumb lays down the basic criteria deemed necessary before surgery can be considered to be of benefit to the patient. They concluded that for significant benefit to be achieved, the post-operative air-conduction average over the speech frequencies must be less than 30 dB or the interaural difference reduced to less than 15 dB. Otherwise the patient is unlikely to be aware of the audiometric improvement.

By conventional measurements, 65.4% of the patients achieved closure of the air-bone gap to less than 10 dB. Mean hearing gain was 28.6 dB. By the Glasgow Benefit Plot, 73.1% of patients benefitted whilst by the Belfast rule of thumb, 57.7% met the criteria.

CONCLUSION

Stapedectomy is a good operation for otosclerosis and improves the hearing of the operated ear in almost all cases. In our series, there was no significant difference in the results of large fenestra surgery versus small fenestra stapedotomy and results are similar whatever material was used to seal the oval window, but the numbers in the different categories were too small for any meaningful conclusions.

In our series, 65.4% had air-bone gap closure to less than 10 dB and according to the Glasgow Plot and the Belfast rule of thumb, this operation benefitted 73.1% and 57.7% of our patients respectively.

The use of the Glasgow Plot and the Belfast rule of thumb as means to evaluate the results of middle-ear surgery is strongly recommended as it gives us a true indication of patients' benefit.

References

1. Shea JJ. Fenestration of the oval window. Ann Otol Rhinol Laryngol 1958; 67:932-51.
2. Harris JP, Osbourne E. A survey of otologic training in US residency programs. Arch Otolaryngol Head Neck Surg 1990; 116:342-5.
3. Browning GG, Gatehouse S, Swan IRC. The Glasgow Benefit Plot: a new method for reporting benefits from middle ear surgery. Laryngoscope 1991; 101:180-5.
4. Smyth GDL, Patterson CC. Results of middle ear reconstruction: do patients and surgeons agree? Am J Otol 1985; 6:276-9.
5. Fisch U. Stapedotomy versus stapedectomy. Am J Otol 1982; 4:112-7.
6. Farrior J, Sutherland A. Revision stapes surgery. Laryngoscope 1991; 101:1155-61.
7. Glasscock ME, McKennon KX, Levine SC. Revision stapedectomy surgery. Otolaryngol Head Neck Surg 1987; 96:141-8.
8. Robinson M. Juvenile otosclerosis: a 20-year study. Ann Otol Rhinol Laryngol 1983; 92:561-5.
9. Shambaugh GE, Glasscock ME. Surgery of the ear. 3rd ed. Philadelphia: W B Saunders Co. 1980.