The Journal of Laryngology and Otology
January 1981. Vol. **95**. pp. 23–28

Pre-operative bone conduction curves in stapedectomy

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Introduction

THE modern operation of stapedectomy has been performed for otosclerosis for over 20 years, since it was described by Shea (1958). Results have been reported with regard to case selection and technique, but the emphasis has been on the latter.

Pre-operative selection with regard to bone conduction (BC), the well-described 'cochlear reserve', has long been recognized to be of vital importance.

Mawson (1963) recognized four stages of otosclerosis, and indicated that results of operating are less satisfactory the more advanced the disease process has become in terms of cochlear loss, particularly in the higher frequencies.

Not all cases fit into the categories mentioned above, however, since there is a variety of bone conduction curves obtainable in otosclerosis.

Smyth and Hassard (1978) compared post-operative cochlear losses with the pre-operative BC, age of the patient, and oval window pathology, and concluded that all three factors independently increase the risk of cochlear dysfunction.

Method

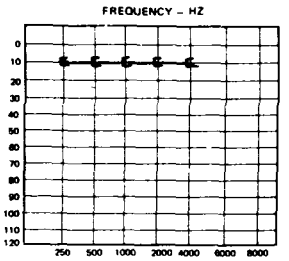
This paper investigates the relationship between the BC 'curve' pre-operatively, and the post-operative cochlear function. 139 cases of stapedectomy performed in the ENT department at the Royal United Hospital, Bath, were selected for study using the following criteria:

(1) The operation was performed by either a consultant or an experienced senior registrar.
(2) There was no technical difficulty during the operation.
(3) There were no other factors, medical or anaesthetic, liable to jeopardize the result.
(4) The same audiometrician performed the pre-operative and post-operative audiometry.
(5) Post-operative BC was taken as that recorded three months after operation.
(6) Pre-operative BC was taken as that recorded immediately prior to operation.
(7) The pre- and post-operative BC in the unoperated ear was the same, within an error of 5 db, at any frequency.

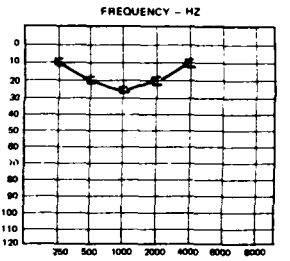
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(8) Where variation in BC thresholds of the operated ear occurred, the worst pre-operative result and best post-operative result were used.

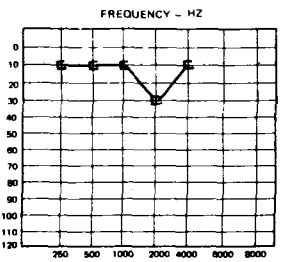
The pre-operative BC curves were analysed and grouped into seven basic types (Fig. 1).



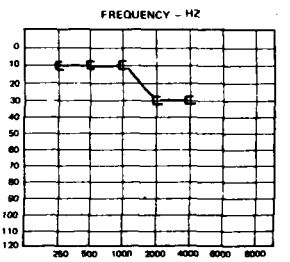
Type 1 Flat, variable within 10dB



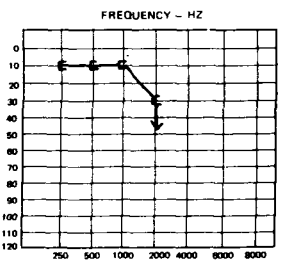
Type 2 Trough-shaped.



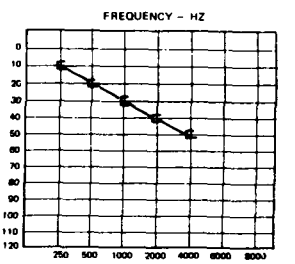
Type 3 Carhart's notch.



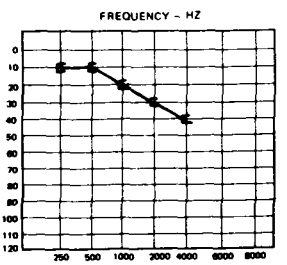
Type 4 Dip at 2 KH_z with 4KH_z at the same level.



Type 5 Dip at 2KH_z with nil recordable at 4KH_z .



Type 6 Progressive loss from left to right, each frequency at least 5dB worse than preceeding frequency.



Type 7
Progressive high frequency loss.

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An average post-operative BC loss of 11 db or more over the range 0·25, 0·5, 1·0 and 2·0 KHz was defined as significant cochlear loss, and was assessed with reference to the individual curves. This degree of loss was also assessed in three groups of averaged pre-operative BC levels <20 db (Group A), 20–39 db (Group B) and >40 db (Group C).

Results

The results are shown in Table I. The one curve to demonstrate a significantly greater percentage of post-operative cochlear losses was number 6, where there is a gradual sloping loss from left to right (the descending audiometric curve). In 14 patients who had this curve, 43 per cent suffered significant post-operative cochlear loss. Statistical analysis using the Chi-squared method (with Yates' modification) demonstrated a highly significant difference ($x^2 = 18{\cdot}54$, $p < 0{\cdot}001$).

TABLE I

Curve	Numbers	Post-operative >10 d loss	Average age	Average age failures
1	17	0	46	–
2	19	1	38	36
3	25	0	39	–
4	23	3	47	57
5	12	2	48	56
6	14	6	59	63
7	29	0	51	–

Post-operative loss >10 db

Overall 12/139 = 8·6%
<50 years 2/ 76 = 2·6%
>50 years 10/ 63 = 15·9%

($x^2 = 6{\cdot}07$ $p < 0{\cdot}05$)

Group A 0/55
Group B 10/72
Group C 2/12

43% type 6 curves gave >10 db loss.
4·8% all other curves gave >10 db loss.

($x^2 = 18{\cdot}54$ $p < 0{\cdot}001$)

Curve number 6 constituted, on average, the oldest age group (59 years) and was the main reason for the percentage of significant cochlear losses in the over-50 age group being 15·9 per cent ($p < 0{\cdot}05$), compared with 2·6 per cent for the under-50 age group.

If the curve 6 group are eradicated, the over 50 percentage becomes 8·2 per cent, the difference now becoming non-significant.

Averaged pre-operative BC groups, A, B and C were examined with regard to post-operative BC, and it was found that no losses occurred in group A, 2 in group C, and 10 in group B. These figures represent 16·6 per

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cent of group C and 14 per cent of group B, the difference being non-significant.

Comparing group A with group B, the difference is significant ($x^2 = 6{\cdot}49$, $p < 0{\cdot}05$). Similarly, group A compared with groups B and C shows a highly significant difference ($x^2 = 6{\cdot}88$, $p < 0{\cdot}01$).

From the above, groups B and C are more at risk than group A.

The percentage of significant losses in group B cases who were over 50 years of age was 26·7 per cent.

Discussion

These figures accord fairly well with those of Smyth and Hassard (1978), who found that the over-50 age group, combined with types B and C pre-operative BC, increased the risk of post-operative cochlear loss.

This study demonstrates that the shape of the BC curve is highly important. Curve 6, the descending audiometric curve, produced a high percentage (43 per cent) of post-opeative cochlear losses.

This failure rate is far higher than for the other types of BC curves, and there is a strong case to be made for avoiding an operation in this type of ear.

Furthermore, analysis of the BC curves in the unoperated ears of these cases showed that all the failures had a type 6 curve in the other ear, whereas all the successes had curves 4, 5 or 7 in the other ear.

The cochlear risk group can therefore be further defined as patients with bilateral type 6 curves, 100 per cent of these giving significant loss.

The nature of the curve makes it most likely to lie within group B or C, and most patients will be over 50 years of age, since the average age for the curve is 59 years.

The current assumption is that poor cochlear reserve is due either to vascular factors or cochlear otosclerosis, or both. In the type 6 curve, the deficiency appears to start from 0·5 KHz, affecting subsequent frequencies progressively more towards the higher tones.

In all the other curves, the lower frequencies have a flat loss, and in curve 5, despite a sudden high frequency fall-off, results are not significantly worse statistically.

Schuknecht (1967) stated that the descending audiometric curve is found in old age, otosclerosis, and chronic suppurative otitis media.

Wright (1972) reported that the only consistent change in the inner ear with this curve is abnormality of the spiral ligament, and that this appears to predispose to rupture of the cochlear duct.

In the otosclerotic inner ear, the spiral ligament shows loss of cellularity and deposition of a layer of collagen occurring adjacent to the otosclerotic focus (Schuknecht, 1974).

The above histopathology is very unlikely to be part of a spectrum of degeneration through curves 4, 5 or 7, since high frequency hearing loss, especially of an abrupt nature, corresponds well with hair cell and

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supporting cell loss in the Organ of Corti in the basal turn of the cochlea (Schuknecht, 1974).

This study demonstrates that the descending audiometric curve, especially when present in both ears, has a high risk of cochlear damage at stapedectomy. The most likely explanation is that rupture of the cochlear duct occurs due to the pressure changes during operation.

Conclusions

Significant post-stapedectomy cochlear deficit is associated with the following factors in an uncomplicated operation:

(1) The age of the patient.
(2) A pre-operative bone conduction loss, averaged over 0·25, 0·5, 1·0 and 2·0 KHz, of 20 db or more.
(3) A left-to-right sloping bone conduction curve (descending audiometric curve), especially where there is a similar curve in the other ear.

Acknowledgements

I wish to thank the ENT Consultants at the Royal United Hospital, Bath, for allowing me to use their patients for this study. My thanks are also due to Mr. Anthony Hughes for checking the statistics.

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