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Promontory stimulation following labyrinthectomy

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Abstract
Promontory stimulation testing was carried out on a series of ten patients who had undergone osseous labyrinthectomy. The thresholds, discomfort levels and dynamic ranges were found to be comparable with a series of ten patients who have subsequently been successfully implanted with the Nucleus 22 channel cochlear implant. These findings suggest that cochlear implantation might be possible in a labyrinthectomized ear.

Introduction

Labyrinthectomy is an accepted and effective method of abolishing vertigo arising in an ear which no longer has any useful hearing. The commonest indication for it is probably end stage Menière's disease, although the realization that that condition may ultimately afflict both ears in up to 50 per cent of sufferers has made most surgeons conservative about its use. Nevertheless there are unfortunate patients who have had the operation performed in what appeared to be unilateral disease only for the remaining hearing to deteriorate rapidly due to the subsequent appearance of Menière's disease in the second ear. Histological examination of the temporal bones of patients who have undergone labyrinthectomy has indicated that despite considerable loss of the membranous elements, there may be a near normal population of surviving ganglion cells. These findings suggest that there might be residual neural elements in the labyrinthectomized ear capable of electrical stimulation by an intracochlear prosthesis. Electrical stimulation of the promontory is employed in many centres to assess the survival of neural elements which it is hoped may be stimulated by a cochlear implant. This paper describes the results of the promontory stimulation test in a series of patients who had undergone total osseous labyrinthectomy, and compares them with a group of patients who have been implanted with the Nucleus 22 channel intracochlear implant at Manchester Royal Infirmary.

Materials and methods

Ten patients had had labyrinthectomy performed. Of these nine suffered from Menière's disease and had vertigo which persisted despite saccus surgery. One patient had constant imbalance following an unsuccessful stapedectomy. In none of the ears was there any useful hearing. The ages of patients were 38–70. The control group comprised the first ten patients to receive prostheses (Nucleus 22 channel) in the Manchester Royal Infirmary/University of Manchester Cochlear Implant Programme which was established in June 1988. The aetiology of the deafness in this group was meningitis (two patients), failed stapedectomy (two patients), autoimmune disease (two patients) and idiopathic (four patients).

Promontory stimulation was carried out using a transtympanic needle electrode inserted through the tympanic membrane and sited close to the round window. Anaesthesia of the drum was achieved using the topical anaesthetic, EMLA cream (Timms *et al.*, 1988). The reference electrode was positioned on the forehead. Half second bursts of square wave electrical stimuli were delivered to the promontory. The frequency of the stimulus was adjustable between 50 Hz and 800 Hz, and the stimulus intensity could be varied between zero and 500 μA in 1 μA steps. At each frequency, the intensity was gradually increased until the stimulus could be perceived as sound. It was also assessed by asking the patient to indicate when a decreasing suprathreshold stimulus was no longer audible. The latter technique tends to yield a lower threshold. The recorded threshold was taken as the mean of the ascending and descending thresholds. The authenticity of the observations was confirmed by asking the patient to tap out the rhythm of the stimulus, and by test retest reliability. At the upper end of the dynamic range the patient was asked to indicate the point at which the stimulus just started to become unpleasant. The threshold of auditory sensation (T) the discomfort level (P) and the dynamic range (DR) were measured at all frequencies of stimulation in all patients.

Results

In the implant group of patients, worthwhile dynamic ranges were obtained in 10/10 at 50 Hz and at 100 Hz, in 9/10 at 200 Hz, in 7/10 at 400 Hz and in 3/10 at 800 Hz. In the labyrinthectomy group, worthwhile dynamic ranges were obtained in 10/10 at 50 Hz and at 100 Hz, in 6/10 at 200 Hz, in 3/10 at 400 Hz and in 1/10 at 800 Hz. The data are summarized in Table 1 and Figures 1 and 2. Details

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TABLE I

THRESHOLD (T) AND PAIN (P) VALUES AND DYNAMIC RANGES (DR) IN LABYRINTHECTOMY AND COCHLEAR IMPLANT SUBJECTS (µA)

		Labyrinthectomy	Implant
50Hz	T	0.4–23.0 µA (Mean = 7.4)	0.7– 7.0 µA (Mean = 3.2)
	P	4.2–100 µA (Mean = 29.6)	3.2–38.0 µA (Mean = 15.2)
	DR	3.6–77.0 µA (Mean = 22.2)	2.5–34.5 µA (Mean = 12.0)
100 Hz	T	1.8–35.0 µA (Mean = 12.8)	0.9–14.5 µA (Mean = 5.2)
	P	4.6–175 µA (Mean = 44.3)	5.4–48.0 µA (Mean = 18.2)
	DR	2.2–140 µA (Mean = 31.5)	3.3–39.0 µA (Mean = 13.0)
200 Hz	T	4.8–50.0 µA (Mean = 23.6)	3.7–62.5 µA (Mean = 16.2)
	P	9.7–75.0 µA (Mean = 46.0)	8.4–94.0 µA (Mean = 25.7)
	DR	1.4–47.0 µA (Mean = 22.4)	3.0–34.1 µA (Mean = 9.5)

are given for test frequencies 50 Hz, 100 Hz and 200 Hz only. At 400 Hz and 800 Hz the number of patients was felt to be too small to be of significance. There is a suggestion that the mean threshold values in the labyrinthectomy group may be greater than in the implant group at 50 Hz, 100 Hz and 200 Hz, and that the dynamic ranges may be wider in the labyrinthectomy group at those frequencies. The range of values is however so great that the significance of these findings must remain in some doubt.

Discussion

These results indicate that in every labyrinthectomized ear tested there was good evidence of functional survival of electrically stimulable neural tissue. Both the labyrinthectomized and the implanted groups exhibited a similar pattern of psycho-physical response, with a progressive elevation of threshold and of pain levels, and narrowing of the dynamic range with increasing stimulus frequency (Figs. 1 & 2). Chen *et al.* (1987) describe the histological findings in four labyrinthectomized temporal bones. The salient finding was that all four bones showed survival of ganglion cells, the neural element that many investigators feel is stimulated by the cochlear implant. The authors suggested that these findings gave support to the hope that cochlear implantation in the labyrinthectomized ear might be feasible. The current study sought to investigate survival of function as opposed to structure and the results lend support to the view that, assuming all other selection criteria to be satisfactory, the patient with a labyrinthectomy might be expected to benefit from a cochlear implant. Levine (1989) has recently described a case in which a partial labyrinthectomy had to be carried out in order that an intracochlear device could be introduced into the inner ear, after which all 22 channels functioned well.

The promontory stimulation test is used in most cochlear implant centres as a means of assessing the survival of neural elements capable of being stimulated by an electrical prosthesis. The value of the test and its limitations are not universally agreed, but most teams engaged in this work include it in their selection protocols. The House group, however, have ceased to employ the test as they have been able to achieve good results from implantation in patients who failed to respond on promontory stimulation (House and Berliner, 1986). At the other extreme, some workers attach much greater prognostic value to the test. Burian and the Vienna group (Burian *et al.*, 1986) employ it to assess the temporal processing abilities of the ear, by determining the temporal difference limen (TDL: the smallest detectable increase in duration of a stimulus burst) and feel that a TDL of less than 100 msec for a 125 Hz stimulus is a good prognostic sign for performance with the implant. Other workers have studied gap detection (*i.e.* the shortest interval between stimuli that the patient can identify). The consensus of opinion, however, would suggest that TDL and gap detection techniques give equivocal results, and most centres using the promontory stimulation test regard it simply as a 'go/no go' technique. Ryan (1989) has confirmed the suggestion of others that round window stimulation using a ball electrode may be a more reliable technique and has suggested that in the event of promontory stimulation failing to yield a response, the test should be repeated

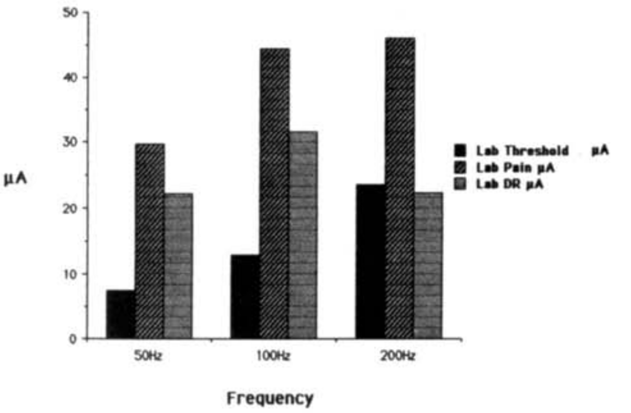

FIG. 1

Threshold and pain values and dynamic ranges at different stimulation frequencies in labyrinthectomy subjects (µA).

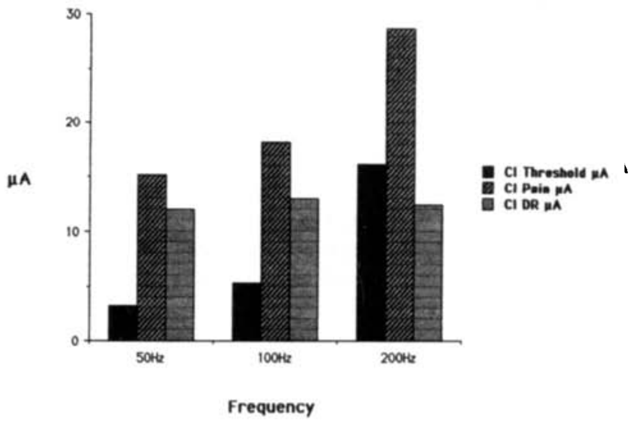

FIG. 2

Threshold and pain values and dynamic ranges at different stimulation frequencies in cochlear implant subjects (µA).

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using round window stimulation. In Manchester, there has been a cochlear implant programme running since June 1988 during which time 21 patients have been implanted with the Nucleus 22 channel device. The promontory stimulation test has been used as part of the selection protocol, and patients who have failed to perceive sound on electrical stimulation have been excluded from the programme.

Because of the uncertain role of the test as a quantitative predictor of residual neural function, some caution must be exercised in interpreting the figures presented in this paper, especially when one considers the wide range of values within each group. It appears nevertheless that the labyrinthectomy group do less well than the implant group at higher stimulation frequencies. (200 Hz, 400 Hz and 800 Hz). This could, however, be because those patients chosen for implantation so far have been those with the best performance across the frequency range. If one regards the test as no more than a means of determining the presence or absence of stimulable elements, then the results of this study suggest that cochlear implantation may have a role to play in the rehabilitation of certain totally deaf and labyrinthectomized patients.

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Key words: Labyrinthectomy; Promontory stimulation

References

Burian, K., Hochmair-Desoyer, I. J., Eisenwort, B. (1986) The Vienna cochlear implant program. *Otolaryngologic Clinics of North America*, **19(2):** 313–328.

Chen, D. A., Rizer, F. M., Linthicum, F. H. (1987) House Ear Institute Research Bulletin, Vol. 1, No. 7: 7.

House, W. F., Berliner, K. I. (1986) Safety and efficacy of the House/3M cochlear implant in profoundly deaf adults. *Otolaryngologic Clinics of North America*, **19(2):** 275–286.

Levine, S. C. (1989) A complex case of cochlear implant electrode plac ement. *American Journal of Otology*, **10:** 477–480.

Ryan, R. M. (1989) Acute round window stimulation for cochlear implant assessment. Cochlear implant: Acquisitions and Controversies. (Fraysse, B., ed.) Cochlear AG: Basel, 161–163.

Timms, M. S., O'Malley, S., Keith, A. O. (1988) Experience with a new topical anaesthetic in otology. *Clinical Otolaryngology*, **13:** 485–490.

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