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Multi-channel cochlear implantation in patients with a post-traumatic sensorineural hearing loss

A. MOORE, B.SC., I. M. CHESHIRE, PH.D.

Abstract

There are few accounts of cochlear implantation in adults with post-traumatic sensorineural hearing loss. We report our experience with multichannel implantation in three such patients.

Two patients experienced no cognitive or communication deficits as a result of their head injury. At nine months post-implant, compared with our experience of non-head-injured implantees, these patients achieved average or above average scores on audiological performance tests.

The third patient presented with cognitive, behavioural and communicative deficits. The level of improvement achieved by this patient, when lip-reading was supplemented with electrical stimulation, in both BKB sentence and connected discourse tracking (CDT) tests was comparable with that of the non-head-injured group. However, his absolute performance at nine months post-implant was well below average. Performance at 18 months on BKB sentences and environmental sound recognition showed little change, and was again well below average, however his score on CDT with lip-reading and electrical stimulation improved considerably and was similar to the average achieved by the non-head-injured group. The major difficulties experienced with this patient were increasing depression and low implant use. Considerably more time was spent in the assessment and rehabilitation of this patient and involved liaison with a number of other agencies. When considering such patients for cochlear implantation it is strongly recommended that these additional requirements are taken into account.

Key words: Hearing loss, sensorineural; Head injuries; Cochlear implants

Introduction

There are few accounts of cochlear implantation in patients with a post-traumatic sensorineural hearing loss (Coligado *et al.*, 1993). Of the first 100 adult patients implanted on the Midland Cochlear Implant Programme, four patients suffered a profound sensorineural hearing loss following a fracture to the skull. One patient experienced additional cognitive, behavioural and communication difficulties. This paper details our assessment and rehabilitation experience with three of these patients with reference to the other agencies involved in their management (the fourth patient has not yet completed the full nine month post-operative assessment). By means of a retrospective analysis of audiological and questionnaire results, the outcome of implantation in these patients is compared with that in other adult, non-head-injured patients.

Patients and methods

Patients

Of the three patients who suffered a post-traumatic sensorineural hearing loss, two experienced no additional difficulties (patients A and B) They were both 64-years-old at the time of implantation, male, and had been profoundly deaf for 16 and two years. The third patient in this group (patient C), also male, was 29-years-old when implanted and had been profoundly deaf for two years following a road traffic accident when he sustained a fracture to the base of his skull. On pre-assessment he was found to possess a number of communication and cognitive deficits (Table I). He demonstrated a verbal expressive dysphasia. Conversational skills such as turn-taking, maintenance of the topic and use of appropriate language were impaired, as were non-verbal

TABLE I

COMMUNICATION AND COGNITIVE DEFICITS IN PATIENT C

Communication deficits	Cognitive deficits	Behavioural problems
• Verbal expressive dysphasia	• Reduced attention and concentration	• Variable mood
• Impaired conversational skills	• Slowed information processing	• Verbal aggression
• Impaired non-verbal communication		

From the Midland Cochlear Implant Programme, Department of Otolaryngology, University Hospital Birmingham, Queen Elizabeth Hospital, Edgbaston, Birmingham, UK.

aspects of communication most notably eye contact and facial expression. He was often distracted and lacked concentration. His rate of understanding was slow, due to a reduced rate of information processing. His ability to follow spoken language was also impaired by limited lip-reading skills. He was subject to mood swings, being easily frustrated and occasionally becoming verbally aggressive. Despite these difficulties this patient was found to be suitable for cochlear implantation. It was felt that the implant would alleviate communication difficulties and frustration resulting from his profound deafness. His cognitive and communication deficits resulting from the brain injury did not exclude him from implantation. His expectations were realistic and he was receiving a high degree of support from his partner.

Assessment methods

Objective measures of outcome were obtained from standardized auditory and speech perception tests performed at nine and 18 months post-implant and administered as described (Summerfield and Marshall, 1995). Patients were assessed by:

(1) Bamford-Kowal-Bench (BKB) sentences were presented via audio tape in the sound alone condition (ES), using lip-reading alone (LR) and using sound plus lip-reading (ES + LR). This test involved the correct identification of key words in sentences, performance was expressed as a percentage of the maximum attainable score, 50 = 100 per cent.

(2) The University College hospital test of environmental sound recognition in which a series of 20 recorded common environmental sounds was presented. The number of sounds correctly identified was summed and expressed as a percentage of the maximum attainable score, 20 = 100 per cent.

(3) Connected discourse tracking (CDT) involved the repetition of spoken text. A story was read to the patient phrase by phrase. After each phrase the patient attempted to repeat the story back word for word. Two levels of repetition were allowed as described by Summerfield and Marshall (1995). Performance was expressed as the number of words/minute correctly transmitted. This test was performed in the ES, LR and ES + LR modes. (If a patient did not attempt the electrical stimulation only part of the test then a score of zero was recorded for the ES mode).

Subjective measures of outcome were obtained from questionnaires administered pre-operatively and at nine and 18 months post-implant. These included:

Revised Denver communication scale This was a measure of the degree to which patients judged themselves to be afflicted by problems of communication as a result of their deafness. The questionnaire consisted of 25 assertions of problems caused by hearing impairment. Respondents indicated their degree of agreement with each assertion on a five-point scale which ranged from 'strongly disagree' (scored 1) to 'strongly agree' (scored 5). Values over the 25 assertions were summed and converted to a number in the range 0–10 by subtracting 25 and then dividing by 15.

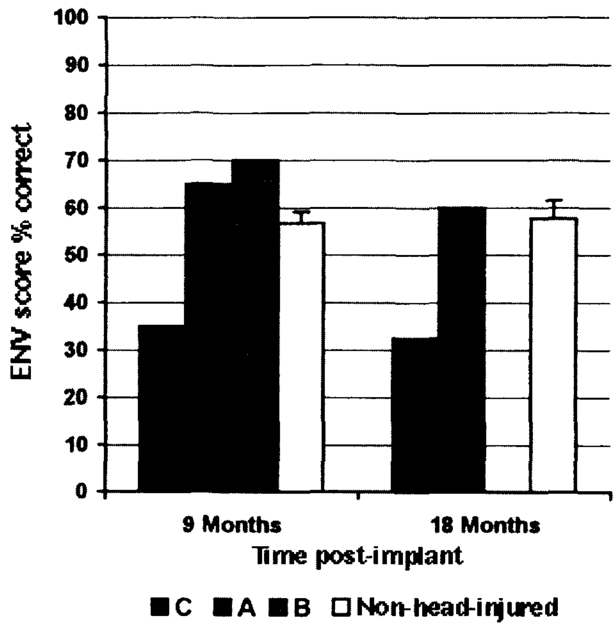

FIG. 1

Accuracy of identification of environmental sounds (% correct) at the nine and 18-months post-operative stage. Performance for head-injured patients A, B and C (no result for patient B at +18 months) and mean performance for non-head-injured patients.

Self-rating of depression scale Two measures of depression were obtained. 1) Patients were asked to indicate which of a series of eight cartoon faces best matched their mood, on a scale of 1–8 where higher values indicated greater depression. This score was termed Depress (F). 2) Patients were asked to complete the self-rating of depression scale described by Bird *et al.* (1987). Scores to 12 questions were summed giving a total score in the range 0–12 where higher values indicated greater depression. This score was termed Depress (Q).

Results for the head injured patients were compared with those for non-head-injured patients using standard scores. The number of non-head-injured patients was between 60 and 64 at the pre-operative assessment, between 78 and 86 at the nine months post-implant assessment and between 32 and 43 at the 18 months post-implant assessment, depending on the test.

Results

Auditory and speech perception results

At nine months post-implant the average score achieved by the non-head-injured group on the environmental sound recognition test was 57 per cent. Patients A and B scored well above this average, with counts of 65 per cent and 70 per cent correct respectively (Figure 1). On word recognition in BKB sentences, the non-head-injured group correctly identified an average of 82 per cent of the key words when the implant was supplemented with lip-reading, an improvement of 42 per cent over the

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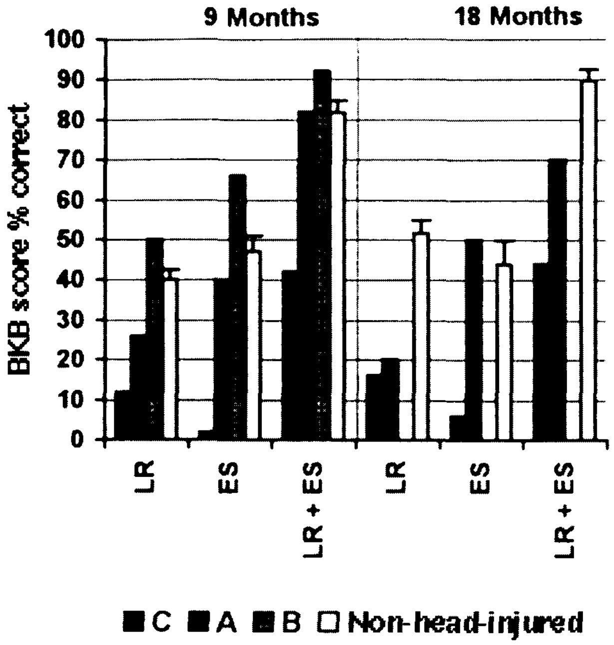

FIG. 2

Accuracy of identification (% correct) of words in sentences from the BKB test at the nine and 18-months post-operative stage. Performance for head-injured patients A, B, and C (no result for patient B at +18 months) and mean performance for non-head-injured patients.

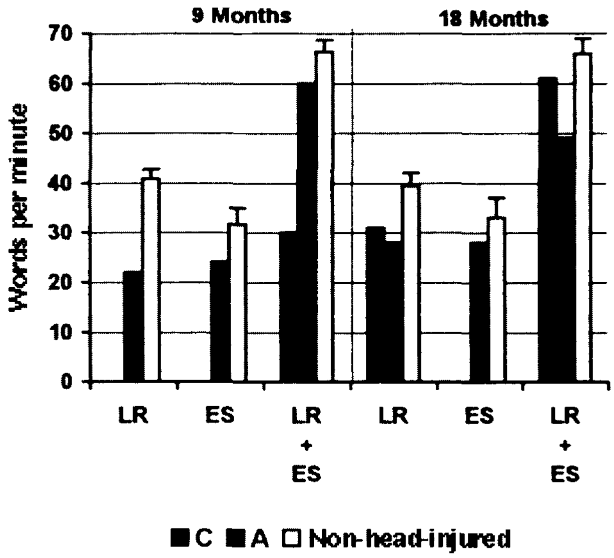

FIG. 3

The number of words per minute correctly transmitted on connected discourse tracking test at the nine and 18-months post-operative stage. Performance for head-injured patients A and C (patient B did not perform the test) and mean performance for non-head-injured patients.

lip-reading alone condition. Average or above average scores were recorded for patients A and B, 82 per cent and 92 per cent respectively (Figure 2). The connected discourse tracking score in the lip reading and implant mode for patient A was 60 words per minute, an increase of 38 over the lip-reading alone condition. This was only slightly below the non-head-injured group average of 66 (Figure 3).

Results were sustained at 18 months for the non-head-injured group. Similarly for patients A and B comparable results were recorded at 18 months on BKB sentences and environmental sound recognition. Performance on connected discourse tracking fell slightly for patient A.

The scores achieved by the two head-injured patients, with no additional cognitive, behavioural or additional communication deficits, on all tests, fell within the area achieved by 95 per cent of the non-head injured population.

Prior to surgery, the third head-injured patient (C) found lip-reading difficult and relied heavily on written messages. Pre-operatively on CDT he scored 26 words per minute, unaided. At nine months post-implant the patient correctly identified an average of 12 per cent of the key words on BKB sentences in the lip-reading alone condition (Figure 2). When supplemented with electrical stimulation this score increased to 42 per cent. He achieved 30 words per minute on CDT in the ES + LR mode, at nine months CDT was not attempted in the implant alone or lip-reading alone modes (Figure 3). Scores at nine months post-implant were approximately half those achieved by the non-head-injured group. At 18 months his performance on BKB sentences in all modes remained essentially unchanged. His performance on CDT in the LR and ES mode doubled to 60 words per minute and was comparable with the non-head-injured group. His performance on recognition of environmental sounds was below the average scored by the non-head-injured group at nine months and did not show any improvement by 18 months (Figure 1).

An examination of the results achieved by patient C showed that the score he achieved on BKB sentences in the LR and ES mode, at 18 months post-implant, fell outside the area achieved by 99 per cent of the non-head-injured group respectively. His score on CDT in the LR and ES mode at nine months fell outside the area achieved by 95 per cent of the non-head-injured group.

Questionnaire results

At nine months post-implant patients A and B showed a reduction in self reported depression compared to the pre-operative state (Figure 4). This reduction was sustained with little change at 18 months, at which point the scores were below the average recorded by the non-head-injured group, which showed a similar pattern of decline over time. Patient C at nine months post-implant also showed a reduction in self-reported depression compared to the pre-operative state. However at 18 months levels had risen considerably such that his Depress (F) score and Depress (Q) score fell outside the area achieved by 95 per cent and 99 per cent of the non-head-injured group respectively. The Depress (Q) score of 11 indicated a state of clinical depression for this patient (Bird *et al.*, 1987).

The revised Denver communication scale was administered pre-operatively and at the nine and 18 months post-implant to obtain a measure of hearing handicap (REVNED). The higher the score

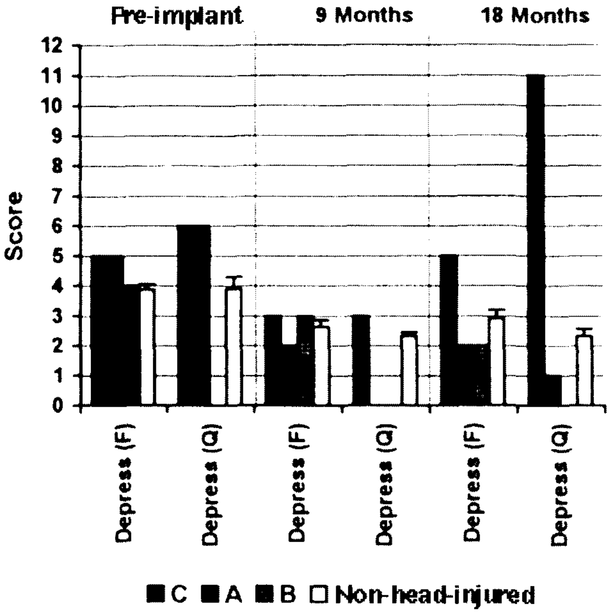

FIG. 4

Levels of self-reported depression pre-operatively and at the nine and 18-months post-operative stage. Higher values indicate greater depression. Level for head-injured patients A, B and C and mean performance for non-head-injured patients.

the less a patient judged themselves to be afflicted by problems of communication as a result of their deafness. For all head-injured patients there was an increase in the score at nine months post-implant compared to the pre-operative state (Figure 5). At 18 months patient B showed a further increase while patients A and C declined, in the case of patient C this was to below the pre-operative score. All scores at all time points for the head-injuried patients fell within the area achieved by 95 per cent of the non-head-injured group.

Implant use

Patients A and B were using their implant for approximately 15 hours each day at nine and 18 months post-implant. This was similar to the average of 14 hours recorded for the non-head-injured group. Patient C recorded 14 hours at nine months however by 18 months was wearing his implant for between zero and eight hours.

Contact time

The total time for assessment and rehabilitation of the head-injured patients by the speech and language therapist, over the first two years, was calculated. The two head-injured patients with no additional difficulties required 18 hours. Patient C required considerably more contact time with a total of 69 hours. The average contact time required by non-head-injured patients, matched for age and length of profound deafness with patient C, was 12 hours.

Discussion

Compared to the non-head-injured group the two patients who experienced no additional difficulties as a result of their head injury (A and B), achieved average or above average scores on environmental sound recognition, BKB sentences and connected discourse tracking. Similar patterns of scoring were also seen for self reported measures of depression and hearing handicap.

In addition to the hearing loss, patient C experienced cognitive, behavioural and communication difficulties as a result of his head injury. Compared to the non-head-injured group his absolute performance at nine months post-implant on standardized auditory and speech perception tests was well below average. Performance at 18 months on BKB sentences and environmental sound recognition showed little change, and was again well below average, however his score on CDT in the LR and ES mode improved considerably and was similar to the average achieved by the non-head-injured group. Relative to lip-reading alone patient C gained considerable benefit with the implant. The level of improvement achieved by this patient, when lip-reading was supplemented with electrical stimulation, in both BKB sentence and CDT tests was comparable with that of the non-head-injured group.

It was evident that, following the implant, patient C continued to experience difficulties attributable to his head injury and his performance on the auditory and speech perception tests was thought to have been adversely affected by a number of other factors. Duration of use of the implant was extremely variable such that the implant was not worn consistently during the period of assessment. By 18

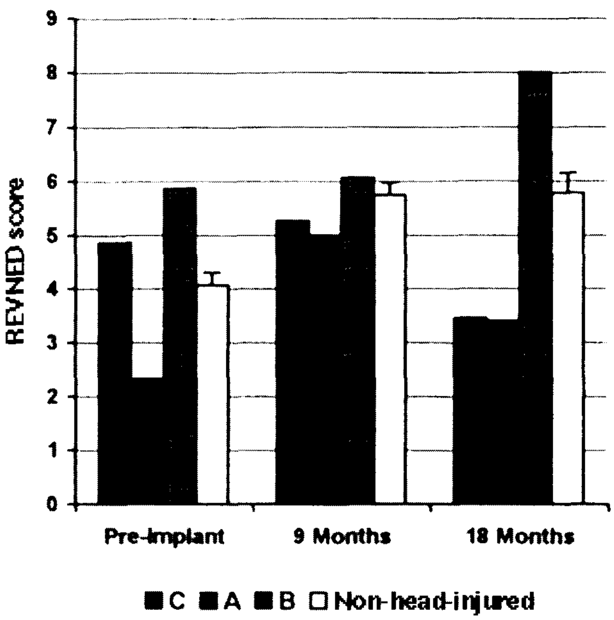

FIG. 5

Level of self-reported hearing handicap pre-operatively and at the nine and 18-months post-operative stage. Higher values indicate lower self-reported hearing handicap. Level for head-injured patients A, B and C and mean performance for non-head-injured patients.

TABLE II
HEALTH CARE WORKERS INVOLVED IN THE MANAGEMENT OF PATIENT C

Pre-implantation	Post-implantation
• Specialist Speech and Language Therapist	• Specialist Speech and Language Therapist
• Occupational Therapist (Head-Injury)	• Speech and Language Therapy Assistant
• Clinical Psychologist (Head-Injury)	• Social Worker
• Psychiatrist for Deaf People	• Psychiatrist for Deaf People
	• Occupational Psychologist
	• Social Skills Tutor

months, implant use had fallen to between zero and eight hours per day. This patient had limited opportunities for interaction due to greatly reduced social contact. There were also periods of time when the implant was not used. As the time post-implant increased the patient suffered with increasing depression. This is thought to have influenced the patient's attitude toward and willingness to wear the implant. The depression was linked to a difficulty in accepting the residual problems associated with the head injury and the inability to return to his previous social and employment status. A return to useful and stimulating employment was extremely important to this patient, however, his employment status since the implant has not altered. Following his implant the patient also experienced considerable social and family difficulties. Although expectations of the implant appeared realistic prior to implantation his depression was also linked to a realisation that his communication skills would continue to be problematic and not be fully resolved by the implant.

Considerably more time was required for assessment and rehabilitation of patient C compared with the average for non-head-injured patients matched for age and length of profound deafness. This involved assessment of language comprehension and expression, written language, general communication ability and lip-reading as well as speech and voice skills. His management also required extensive liaison with other health care workers including a clinical psychologist and occupational therapist (Table II). This was extremely time consuming.

Our experience with this patient highlighted a number of aspects that must be taken into account when considering head-injured patients with additional cognitive, behavioural and communication difficulties for implantation. Detailed assessment of the patients speech and language and communication skills is required to establish the level of impairment that was the result of the head injury and that which could be assigned to the hearing loss. This will assist in establishing realistic expectations of the implant given that the communication difficulties attributable to the head injury may continue to present considerable difficulties following implantation. Assessment and rehabilitation of these patients is extensive and requires implementation of a range of speech and language therapy skills. Liaison with a speech and language therapist who specializes in head-injured patients is essential as is that with clinical psychologists who can provide essential information on changes in personality, behaviour and cognition resulting from the head injury.

Following implantation many aspects of communication therapy may be employed with such patients. Intensive auditory training may be carried out alongside work on conversational skills, verbal expression language therapy, social skills and non-verbal communication. Monitoring all aspects of the communication skills during assessment is necessary to evaluate the extent of recovery following the trauma. In addition, counselling is required to help the patient adjust both to the hearing impairment and to communication difficulties associated with brain injury.

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Address for correspondence:
Miss Alison Moore,
Specialist Speech and Language Therapist,
Hearing Assessment and Rehabilitation Centre,
Selly Oak Hospital,
Raddlebarn Road,
Selly Oak,
Birmingham,
West Midlands B29 6JD.

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