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Outcomes from adult implantation, the first 100 patients

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Abstract

We present the outcome of implantation in the first 100 adult patients treated under the Midland Cochlear Implant Programme. All patients were post-lingually deaf with profound or total hearing loss. Performance was tested in lip-reading, implant only and combined lip-reading and implant modes using BKB sentences, connected discourse tracking (CDT) and environmental sound recognition. Assessments were made at nine and 18 months post-implant.

The dominant aetiologies were idiopathic and meningitis. Meningitis was associated with the greatest numbers of ossified cochleas. Forty-three per cent of cases of partial ossification were identified only at surgery. Four per cent of patients became non-users of their devices, however the majority used their implants for more than 12 hours each day. The mean scores at nine months post-implant, in the implant only mode, were for environmental sound recognition 56.7 per cent, for BKB sentences 46.6 per cent (80 per cent of patients scored above 0 per cent) and for CDT 31.2 words per minute (w.p.m.) (62 per cent scored above zero per cent). In the combined lip reading and implant mode the mean scores, at nine months, were for BKB sentences 81.5 per cent and for CDT 65.8 w.p.m. All results were sustained at 18 months.

Patients reported that implantation significantly reduced their hearing handicap. Pre-operative measures of depression were also significantly reduced at nine months post-implant. Results were sustained at 18 months.

Post-operative audiological outcomes in the electrical stimulation only mode correlated significantly with length of profound deafness. Results suggest that performance outcome is also related to the number of active electrodes.

Key words: Cochlear implants; Outcome assessment

Introduction

The Midland Cochlear Implant Programme was established in January 1990 and the first patient implanted in December of that year. By May 1996, 100 patients had received implants. Some 40 of these patients were assessed as part of the Department of Health funded National Programme which was evaluated in 1994 by the Medical Research Council Institute of Hearing Research (Summerfield and Marshall, 1995). Many of the performance tests and questionnaires which formed the process of evaluation for the National Programme have continued in use at the Midland implant centre. By means of a retrospective analysis of the results of these tests this paper presents the outcome of implantation in the first 100 adults implanted on the Midland Cochlear Implant Programme.

Assessment methods

The following performance tests were carried out at nine months [+9] and 18 months [+18] post-implant, administered as described in the MRC main report, (Summerfield and Marshall, 1995) and outlined briefly herein.

Recognition of environmental sounds

A series of 20 recorded common environmental sounds was presented at approximately 70 dB(A), in the soundfield. After each sound patients were asked to report what they thought the sound was. Responses were scored either as completely correct (1 point) or partially correct (½ point) or incorrect/omitted (0 points). Scores over the 20 responses were summed and expressed as a percentage of the maximum attainable score (20 = 100 per cent).

Speech discrimination

This was tested with Bamford-Kowal-Bench (BKB) sentences and connected discourse tracking (CDT). Testing was performed in lip-reading alone (LR), electrical stimulation i.e. implant only (ES) and combined lip-reading and implant (LRES) modes. Performance with lip-reading alone was

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compared with that achieved when lip-reading was supplemented with electrical stimulation. A measure of the improvement score was obtained by subtracting the LR score from the LRES score (LRES-LR). In the BKB sentence test two lists, each containing a total of 50 key words, were presented (audio-visual recording). The average number of key words correctly identified by the patient over the two lists was expressed as a percentage of the maximum attainable score (50 = 100%). The 'loose' scoring method was used, i.e. a word could be scored as correctly identified as long as the rest of the word was correctly reported, even if the ending was incorrect. CDT involved the repetition of spoken text. A story was read to the patient phrase by phrase at a normal conversational level (65–70 dB(A)). After each phrase the patient attempted to repeat the story back verbatim. Two levels of repetition were allowed as described by Summerfield and Marshall (1995). Performance was expressed as the number of words/minute correctly transmitted.

If a patient was unable to attempt the electrical stimulation only part of the test then a score of zero was recorded for the ES mode.

Performance at 18 months was statistically compared with that at nine months using the Student's *t*-test for paired samples. Significance was accepted at $p<0.05$, and $p<0.01$ was considered to be a high level of significance.

Additionally, patients were invited to complete the following questionnaires pre-operatively [Pre] and at nine [+9] and 18 [+18] months post-implant:

Pre-questionnaire. This was completed by all referrals to obtain basic demographic data and details of the patient's hearing loss.

Revised Denver Communication Scale. This provided a measure of the degree to which patients judged themselves to be affected by problems of communication as a result of their deafness. The questionnaire consisted of 25 assertions of problems frequently 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.

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 also 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).

Implant use. This questionnaire ascertained for how long the implant was used each day, where and when it was not used, its value as an aid to lip-reading, its effect on tinnitus and the extent to which the patients' expectations of the implant had been recognized (administered nine and 18 months post-implant). A simple measure of quality of life was obtained by asking the patients the following question: 'Has having an implant improved your quality of life?' Four responses were provided – 'enormously', 'greatly', 'slightly' and 'not at all'.

Self assessment of lip-reading ability. Patients were asked to place their lip-reading ability on a five point scale – (1) Barely a lip-reader at all. (2) Below average. (3) Average. (4) Good. (5) Very good. Additionally a close relative or friend was also asked to make an assessment.

Audiometry

Pre-operatively air conduction thresholds were measured in both ears at 0.25, 0.5, 1, 2, 4 and 8 KHz. Hearing levels were summarized as: a) the four frequency average (4FA) based on thresholds at 0.5 KHz, 1 KHz, 2 KHz and 4 KHz b) the three frequency average 1 (3FA1) based on thresholds at 0.5 KHz, 1 KHz and 2 KHz and c) the three frequency average 2 (3FA2) based on thresholds at 1 KHz, 2 KHz and 4 KHz.

Patients who fulfilled the criteria for implant were investigated with high-definition computed axial tomography of the cochleas in order to check the patency of the cochlear ducts.

Characteristics of patients

Of the first 100 patients implanted, 45 were male and 55 female. The mean age at implantation was 49.7 years (SD 16.1) including eight patients over the age of 70. In approximately one third of patients the aetiology of deafness was unknown, 28 patients were deafened as a result of meningitis and 16 through cochlear otosclerosis (Table I).

The average age of onset of profound deafness was 32.6 years (SD 15.6). Figure 1 shows the distribution of ages at which patients became profoundly deaf. One patient was profoundly deafened at the age of five, (aetiology unknown), and there was a fairly even distribution through the second to fifth decade with numbers declining in the older age groups. Almost 30 per cent of patients received their implant within five years of becoming deaf (Figure 2), the mean duration of profound

TABLE I
AETIOLOGIES OF PATIENTS IMPLANTED

Aetiology	Number
Idiopathic	31
Meningitis	28
Otosclerosis	16
Head Injury	4
Genetic	4
Hydrops	4
Measles	2
Syphilis	2
Mastoidectomy	2
Rubella	1
Other*	6

*Sickle cell anaemia, Cogan's syndrome, Autoimmune disease, Sarcoidosis, Noise trauma, Paget's disease.

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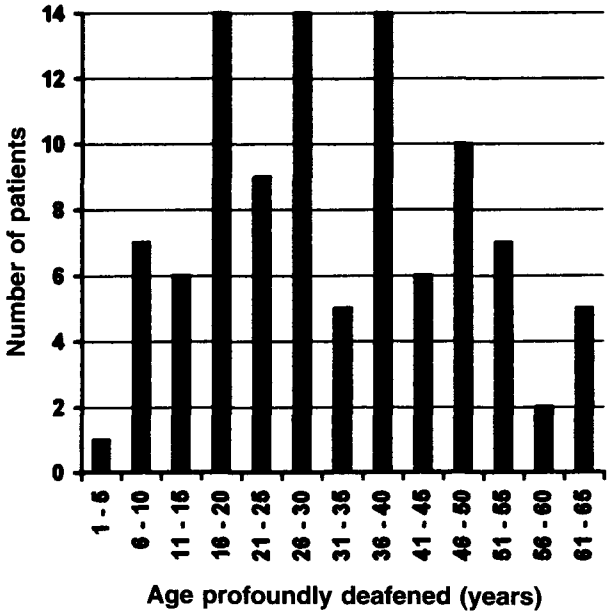

FIG. 1

Distribution in five-year bands of age of onset of profound deafness in the first 100 adult patients implanted.

deafness prior to implantation was 17.2 years (SD 14.5).

Prior to receiving the implant 27 patients had never used a hearing-aid, 33 patients had at some time used a hearing-aid but had stopped using it and 39 patients were using a hearing-aid(s) at the time of referral.

Figure 3 shows the distribution of average hearing levels in 10 dB bands in the better-hearing ear prior to implant. The four frequency average loss was 118 dBHL, 75 per cent of patients had values of 4FA exceeding 110 dBHL and 50 per cent of patients had

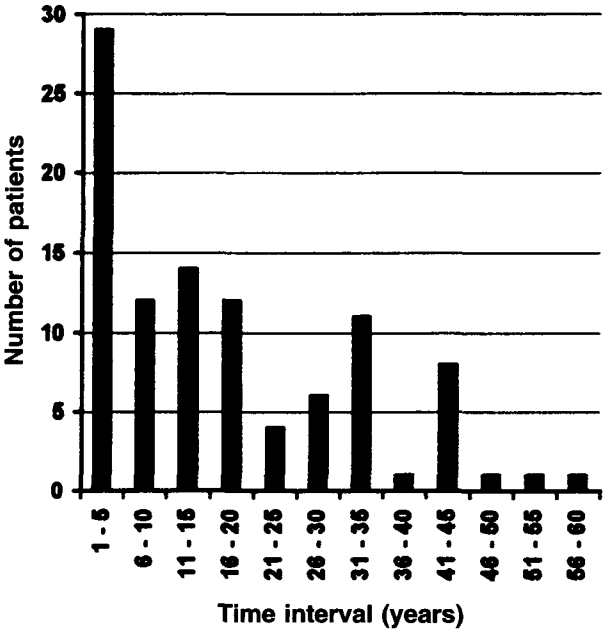

FIG. 2

Distribution in five-year bands in the number of years of profound deafness prior to implantation in the first 100 adult patients implanted.

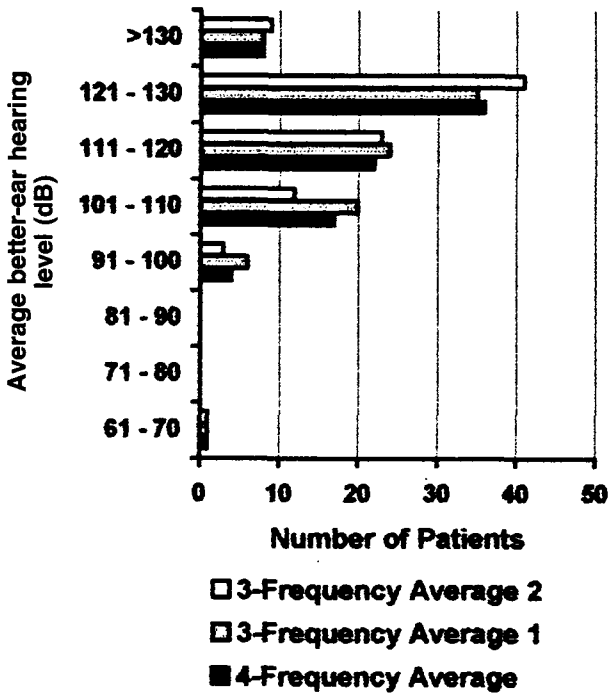

FIG. 3

Distribution of average hearing levels in 10 dB bands in the better hearing ear prior to implant. The 4-frequency average was based on thresholds at 0.5 KHz, 1 KHz, 2 KHz and 4 KHz, the 3-frequency average 1 based on thresholds at 0.5 KHz, 1 KHz and 2 KHz and the 3-frequency average 2 based on thresholds at 1 KHz, 2 KHz and 4 KHz.

values exceeding 120 dBHL. The distribution of figures for the 3FA1 and 3FA2 losses indicated that for most patients the hearing loss was more pronounced at higher frequencies. At the outset of the programme the policy was to implant the worst hearing ear but following the findings of Gantz *et al.* (1993) and Summerfield and Marshall (1995) and in the light of experience gained there was a move to implant the most recently deafened ear in some cases, as one of the most robust predictors of performance outcomes is recency of onset of profound deafness.

Surgical findings

At surgery, electrode insertion was achieved with slight difficulty in nine patients, in one of these patients the cochlea was partially patent. In 13 patients, insertion of the electrode array was achieved with great difficulty, in seven cases this was due to a degree of ossification of the cochlea.

A total of 14 patients had a degree of cochlear ossification: nine were partially patent and five totally obliterated. In six patients partial ossification was identified only during surgery, not having been apparent on high-definition computed axial tomography performed pre-operatively.

The dominant aetiology in cochlear ossification was meningitis. In eight meningitic patients (29 per cent), the cochlea was found to be either partially ossified (four cases) or totally obliterated (four cases).

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TABLE II
ANALYSIS OF ENV SCORES (% CORRECT) AT 9 AND 18 MONTHS POST-IMPLANT

ENV	9 Months	18 Months
N	89	39
X	56.7	57.1
SD	22.4	23.5
Min	7.5	12.5
Max	95	100

(Mean difference between 9 and 18 months = +0.66, $p>0.05$)

In one patient, total obliteration of the cochlea necessitated the implantation of a Medel single channel device. Three patients received a Nucleus 20+2 device, the remainder received the Nucleus 22 channel system.

Electrode data

Patients with a non-patent cochlea were functioning with an average of 11.8 (SD 6.0) active electrodes at nine months post-implant compared with 18.1 (SD 2.8) active electrodes in patients with a patent cochlea.

Performance tests – results

In theory all 100 patients should have received a nine month follow-up evaluation and 76 an 18 month evaluation. However missing data points occurred for a number of reasons: failure to attend the follow-up sessions despite reminders; failure to return the questionnaire; questionnaire incomplete; non-use of the device.

Non-use of the device

Non-use of the device was recorded for four patients at the nine- and 18-month post-implant assessments. One patient died prior to switch-on, for reasons unrelated to the implantation. One patient had been undergoing treatment for severe depression for some time. Another non-user was a 42-year-old female who experienced no stimulation at switch-on of her implant, perceived minimal stimulation at three months and reverted to total loss of stimulation at nine months. The fourth non-user developed an iatrogenic cholesteatoma in the implanted ear. During surgery for the treatment of this an implant wire was cut necessitating re-implantation of the implant in the other ear. Subsequently this patient became a non-user due to reduced benefit, due (it is believed) to the fact that the ear had a much longer duration of deafness. The patient has now opted to undergo re-implantation in the same ear as originally implanted.

Analysis of ENV scores

At the nine-month post-implant assessment the overall mean recognition of environmental sounds was 56.7 per cent correct (Table II). Scores covered a wide range from 7.5 per cent to 95 per cent correct. Over two-thirds of patients who performed this test achieved a score of 50 per cent or greater. Repeat testing at 18 months revealed an overall mean score of 57.1 per cent correct. Statistical analysis of paired data demonstrated no significant improvement with time ($p>0.05$).

Analysis of BKB scores

On testing at nine months post-implant, patients significantly improved their scores by an average of 41.8 per cent when tested with their implant and lip-reading compared to lip-reading alone ($p<0.01$) (Table IIIa). Individually 95 per cent of patients improved their score and so demonstrated some benefit with the implant. Almost one quarter of patients achieved the maximum possible score in the combined condition.

Eighty per cent of patients scored above 0 per cent in the test with electrical stimulation alone. Just over one half of patients (54 per cent) had better hearing-only scores than lip-reading scores.

Statistical analysis of paired data for +9 and +18 month test sessions revealed a small but significant improvement with time in scores for lip-reading only and electrical stimulation only test modes (Table IIIb). This did not translate to an improvement in combined scores (LRES).

TABLE III
PERFORMANCE ON THE BKB SENTENCE TEST

a) Analysis of BKB scores (% correct) at 9 and 18 months post-implant

BKB	9 months				18 months			
	LR	LRES	ES	LRES – LR	LR	LRES	ES	LRES – LR
N:	86	85	87	85	40	38	40	38
X:	39.7	81.5	46.6	41.8	49.9	88.0	43.1	36.9
SD:	22.5	25.5	36.0	23.6	21.9	17.8	35.2	19.5
Min:	0	6	0	−8	0	18	0	−4
Max:	84	100	100	98	86	100	94	88

b) Analysis of change in BKB scores (% correct)

Group	N	Mean difference	Student's t
LR (+9 & +18)	38	3.3	$p<0.05$
LRES (+9 & +18)	36	2.6	$p>0.05$
ES (+9 & +18)	39	1.9	$p<0.05$
LRES – LR (+9 & +18)	36	–0.9	$p>0.05$

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TABLE IV
PERFORMANCE ON CONNECTED DISCOURSE TRACKING

a) Analysis of CDT scores at 9 and 18 months post-implant

CDT	9 months				18 months			
	LR	LRES	ES	LRES – LR	LR	LRES	ES	LRES – LR
N:	73	82	82	73	37	45	45	37
X:	40.6	65.8	31.2	26.5	38.8	65.4	32.2	26.7
SD:	15.4	20.5	30.2	15.0	15.4	19.4	26.2	15.6
Min:	0	21	0	−6	9	22	0	1
Max:	73	111	110	71	69	113	82	64

b) Analysis of change in CDT scores (words/min)

Group	N	Mean difference	Student's *t*
LR (+9 & +18)	29	5	$p<0.05$
LRES (+9 & +18)	40	6.9	$p<0.01$
ES (+9 & +18)	40	10.8	$p<0.01$
LRES – LR (+9 & +18)	28	–0.6	$p>0.05$

Analysis of CDT scores

Table IVa shows the analysis of CDT scores at nine and 18 months post-implant. At nine months the mean transmission in the LRES condition was 66 w.p.m. Twenty of the 82 patients tested (24 per cent) achieved scores greater than 80 w.p.m. This performance approaches the results achieved by normal hearing adults detailed in the MRC Main Report (Summerfield and Marshall, 1995). All but one patient showed an improvement in their score when tested with their implant and lip-reading compared to lip-reading alone, the average increase in transmission rate was 26.5 w.p.m. Fifty-one patients (62 per cent) scored greater than 0 in the ES alone mode and 38 patients (46 per cent) scored greater than 30 w.p.m. which is probably the minimal level of performance which translates into a practically useful ability to converse in every day life. For patients who attempted the test in both LR and ES modes (n = 73) the majority had better lip-reading scores than hearing-only scores (n = 43).

Little change was observed in the mean scores at 18 months. However, an analysis of paired data LRES scores revealed a significant improvement of +6.9 w.p.m. at 18 months compared with nine months (Table IVb).

Analysis of the questionnaires

Implant use

Information regarding implant use at nine months post-implant was recorded for 71 patients. As detailed above three patients were elective 'non-users'. The majority of patients (59) were 'full users' of their devices i.e. ⩾12 hours use per day. Nine patients were 'partial users' of their devices i.e. 1–11 hours use per day. The mean daily use for patients using their devices at +9 and +18 months was 14 hours. Patients were most likely to avoid using the implant in noisy situations. Those detailed were: pub; disco; heavy traffic; very windy weather; using machinery such as a drill or vacuum cleaner.

Measures of depression

Two measures of depression were obtained: Depress (Q) derived from the administration of a questionnaire and Depress (F) where the patient had to match his mood to one of eight cartoon faces. In both cases higher values indicated greater depression.

The mean level of self reported depression prior to implant was 3.89 (Depress Q) and 3.90 (Depress F) (Table Va). Depress (Q) scores exceeded 5.5 in 28 per cent of patients. These patients would therefore be classified as clinically depressed. Bird *et al.* (1987) determined that a criterion value of Depress (Q) between five and six optimally segregated cases of clinical depression from normals in their sample. At the nine month post-operative stage, both measures

TABLE V
SELF-REPORTED DEPRESSION SCORES

a) Analysis of DEPRESS (Q) and DEPRESS (F)

	Pre-Implant	9 months	18 months
Depress (Q)			
N:	65	83	36
X:	3.89	2.27	2.47
SD:	3.10	2.60	2.72
Min:	0	0	0
Max:	12	10	11
Depress (F)			
N:	63	81	35
X:	3.90	2.63	2.91
SD:	1.32	1.22	1.29
Min:	1	1	1
Max:	8	5	7

b) Analysis of DEPRESS (Q) and DEPRESS (F)

Group	N	Mean difference	Student's *t*
Depress (Q)			
Pre & +9	53	–1.40	$p<0.01$
Pre & +18	31	–1.32	$p<0.01$
+9 & +18	30	+0.50	$p>0.05$
Depress (F)			
Pre & +9	49	–1.49	$p<0.01$
Pre & +18	29	–0.90	$p<0.05$
+9 & +18	28	+0.11	$p>0.05$

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TABLE VI
ANALYSIS OF REVNED SCORES

	Pre-Implant	9 Months	18 Months
N:	67	78	34
X:	4.1	5.7	5.7
SD:	1.8	2.0	2.2
Min:	0.9	0.8	0.13
Max:	8.1	9.5	9.3

Analysis of change of REVNED mean difference:

Pre and +9	+2.3	$p<0.01$
Pre and +18	+1.4	$p<0.01$
+9 and +18	–0.53	$p>0.05$

of depression were significantly reduced compared with the pre-operative state (Table Vb). Depress (Q) scores of nine patients (11 per cent) exceeded 5.5 – five of these patients had been clinically depressed pre-operatively, two were new cases and for two patients no pre-operative data was obtained.

Eighteen months following implantation depression scores were significantly reduced compared to pre-operative scores (Table Vb), however, there was no further improvement over the nine month post-operative scores. Four patients (11 per cent) fell into the clinically depressed category, three of which had been clinically depressed prior to receiving the implant.

Hearing handicap

The revised Denver communication scale was administered pre-operatively and at nine and 18 months post-implant to obtain a measure of hearing handicap (REVNED) (Table VI). The higher the score the less a patient judged themselves to be afflicted by problems of communication as a result of their deafness. Hearing handicap was reduced significantly by the nine month stage, 86 per cent of patients who completed the pre- and +9-questionnaire reported a reduction in hearing handicap. Eighteen months following implantation hearing handicap was significantly reduced compared to the pre-operative state, however there was no further improvement over the nine month post-operative scores.

Meeting expectations

As part of the implant use questionnaire patients were asked if their expectations regarding the performance of the implant in a number of areas had been met – as an aid to lip-reading; recognition of environmental sounds; alleviating tinnitus and improving speech. The results nine months after implantation are shown in Figure 4 (n = 80). In all areas, apart from alleviating tinnitus, the majority of respondents felt that the implant had fully met or exceeded their expectations. For an average of 14 per cent of patients, expectations in these areas had not been fully met. However by 18 months this figure had fallen to 9.7 per cent. Ninety per cent of patients experienced tinnitus pre-operatively in one or both ears. At nine months post-implant, 52 per cent of respondents declared that having the implant had not fully met their expectations in alleviating tinnitus, by 18 months this figure had fallen to 43 per cent.

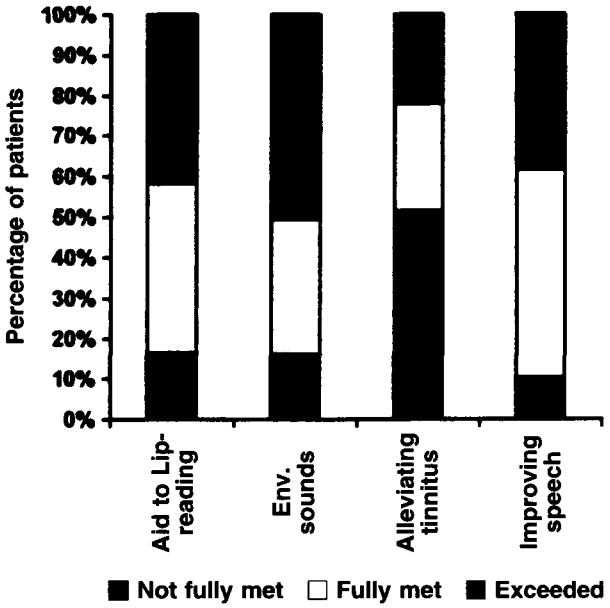

FIG. 4
Patients were asked if their expectations regarding the performance of the implant in a number of areas had been met. Distribution of responses (% of patients) at the nine-months post-operative stage.

As part of the Implant Use Questionnaire patients were also asked 'Has having an implant improved the quality of your life'. At +9 months 45 per cent responded 'Enormously', 41 per cent responded 'Greatly', 12 per cent said 'Slightly' and two per cent said 'Not at all' (n = 81).

Self assessment of lip reading ability

Analysis of paired data from pre-implant and nine months post-implant sessions (n = 58) revealed that the majority of patients (44) felt that their lip-reading ability had improved following their experience with the implant. Eleven patients reported an improvement of two points on the self-assessment of lip-reading ability scale and 23 patients an improvement of one point on the scale. In seven cases the self-reported improvement was not confirmed by a third party. Five patients felt that their lip-reading ability had deteriorated. By 18 months the majority of patients (75 per cent) reported no further change over their nine month score.

Predictors and correlates of outcome

Table VII compares the performance of patients functioning with fewer than 15 active electrodes with that of patients functioning with 15 or more active electrodes on auditory performance tests at nine months post-implant. For the BKB and CDT tests both the ES and LRES figures are shown. On all tests patients with fewer than 15 active electrodes achieved, on average, lower scores. This difference was most marked for the electrical stimulation (ES) alone scores.

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TABLE VII
THE EFFECT OF NUMBER OF USABLE ELECTRODES UPON PERFORMANCE WITH THE COCHLEAR IMPLANT

No. active electrodes	Mean ENV score & correct (SD)	Mean BKB score % correct (SD)		Mean CDT score words per minute (SD)	
		ES	LRES	ES	LRES
≥15	59 (21)	50 (36)	86 (21)	35 (31)	68 (20)
<15	49 (24)	30 (34)	64 (35)	14 (20)	57 (19)

Two composite measures of performance outcome were calculated: CPES was the average of three hearing only scores obtained at nine months post-implant – BKB, CDT and ENV.

CPLRES was the average of two scores obtained when electrical stimulation was combined with lip-reading at nine months post-implant – BKB and CDT. Product-moment coefficients of correlation were computed between these two outcome measures and a number of variables (Table VIII).

Three variables correlated significantly with the CPES score, namely the number of years of profound deafness, the portion of a patient's life for which they had been profoundly deaf (Durage) and the Depress (F) score at nine months post-implant. Only the Depress (F) score at nine months post-implant and the number of active electrodes correlated significantly with the CPLRES score.

Age at implantation did not correlate significantly with either composite score.

Discussion

In the main, the results presented for this single centre study concord with those of the multi-centre study evaluated by Summerfield and Marshall (1995).

Non-use of the device was recorded in four per cent of cases (elected non-use three per cent, non-use due to death unrelated to the implant one per cent). No single factor characterized the patients who elected to become non-users, cases were spread evenly throughout the cohort of patients studied. One patient lacked the motivation to wear the device due to severe depression and this could not have been predicted prior to implant. Two patients became non-users due to lack of auditory sensation. One of these patients had become deaf as a result of contracting meningitis and had also suffered additional neurological sequelae. A partially patent cochlea was encountered at surgery and the patient was functioning with only two active electrodes.

TABLE VIII
COEFFICIENTS OF CORRELATION BETWEEN PREDICTORS AND OUTCOMES

Variable	N	Mean	SD	r CPES
Age at Implant	79	50.59	16.31	–0.17
Age at which deafened	79	32.33	16.49	+0.14
No. years of deafness	79	18.28	14.99	–0.34*
DURAGE	79	35.52	26.35	–0.32*
REVNED (Pre)	52	4.07	1.90	–0.03
REVNED (+9)	68	5.83	2.10	+0.25
DEPRESS (F) (Pre)	50	3.94	1.32	+0.10
DEPRESS (F) (+9)	70	2.53	1.16	–0.34*
DEPRESS (Q) (Pre)	51	4.04	3.25	–0.05
DEPRESS (Q) (+9)	72	2.04	2.41	–0.12
Number Active Electrodes (+9)	78	18.49	7.93	+0.09

Variable	N	Mean	SD	r CPLRES
Age at Implant	78	50.41	16.53	–0.27
Age at which deafened	78	32.10	16.47	–0.16
No. years of deafness	78	18.29	15.10	–0.12
DURAGE	78	35.53	26.51	–0.03
REVNED (Pre)	51	4.04	1.89	–0.02
REVNED (+9)	69	5.78	2.11	+0.17
DEPRESS (F) (Pre)	49	3.92	1.32	+0.17
DEPRESS (F) (+9)	70	2.59	1.18	–0.32*
DEPRESS (Q) (Pre)	49	3.84	3.14	+0.04
DEPRESS (Q) (+9)	72	2.14	2.55	–0.09
Number Active Electrodes (+9)	77	17.71	3.40	+0.30*

CPES – Composite measure of performance. Average of three scores with electrical stimulation alone: BKB, CDT, ENV at 9 months post-implant. CPLRES – Composite measure of performance. Average of two scores with electrical stimulation and lip reading: BKB and CDT at 9 months post-implant. DURAGE – Portion of a patient's life that they have been profoundly deafened. r – Product-moment coefficients of correlation between the variables and the outcome measure.
*$p<0.01$

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Research suggests that performance is poor with one or two active channels but can rapidly improve when increased to four (Brill and Hochmair, 1997; Fishman *et al.*, 1997). Certainly we have experienced an excellent result in one post-meningitic deafened adult whose cochlea was totally obliterated and is functioning with six active electrodes. In the other non-user a medical and surgical complication necessitated re-implantation in the other ear. Subsequently there was no obvious reason for the lack of benefit. The patient had a history of short duration of deafness and no other disability.

In their report Summerfield and Marshall (1995) concluded that the rate of non-use of three to five per cent, they reported, was acceptable during the introduction of multi-channel cochlear implantation to the National Health Service. It was suggested this figure should improve as teams gained further experience in providing the service (evidence from the United States suggests that rate of non-use may be as low as one per cent). A further 42 patients have been implanted (to October 1997) on the Midland Cochlear Implant Programme. At present only one of these patients is currently a non-user.

Overall in this study 43 per cent of cases of partial ossification of the cochlea were identified only during surgery while the pre-operative computerized tomography (CT) findings were normal. The majority of these were in patients with an aetiology of meningitis. Profant *et al.* (1997) found that in most cases of obliterated cochlea the pre-operative CT finding was normal while Truy *et al.* (1997), using high resolution computerized tomography (HRCT), reported that in 7.4 per cent of cases of some obliteration the HRCT had been interpreted as normal. Frau *et al.* (1994) report that out of 32 cases of partial ossification 11 (34 per cent) were identified only during surgery (report by attending radiologists). Magnetic resonance imaging (MRI) has proved more sensitive in detecting cases where there is some degree of cochlear ossification (Truy *et al.*, 1997). However, given the increased expense incurred with MRI it may be worth limiting this investigation to patients with an aetiology of meningitis.

The average score of 56.7 per cent correct at +9 months on recognition of common environmental sounds is very similar to that reported by other groups (Summerfield and Marshall, 1995).

Given the 'live voice' presentation nature of the CDT test the score achieved will be influenced in part by the character of the speaker. In this analysis of the first 100 implantees, patients were assessed by one of three specialist speech and language therapists. Whilst a detailed comparison of results with other cochlear implant centres is therefore not appropriate the broad similarity of the test permits a comparison of trends. The mean scores at nine months post-implant presented in this report are very similar to those reported by Van Dijk *et al.* (1995) concerning data obtained after 12 months of implant use. We observed a wide range of scores in all modes tested and for all but one patient the combined conditions of lip-reading and electrical stimulation produced the best result. As also observed by Strauβ-Schier *et al.* (1995) there were a small number of patients whose hearing only and combined rates were almost equal (<10 w.p.m. difference). For the majority of patients lip-reading only scores were better than hearing only scores at both nine and 18 months post-implant. Strauβ-Schier *et al.* (1995) in their study of 90 patients with at least three years experience with the Nucleus cochlear implant observed the opposite – the majority of patients had better hearing only scores than lip-reading only scores. Whilst the mean hearing only scores are very similar, the German group report much poorer lip-reading only rates, almost half those observed in our study. Unlike the post-lingually deaf subjects in a study by Hinderink *et al.* (1995), who all achieved speech recognition in the auditory alone mode, this was achieved by 62 per cent of our patients. We observed a significant improvement in LRES scores at +18 months compared with +9 months. This was probably attributable to the significant improvement in LR only and ES only scores from nine to 18 months since there was no significant difference in LRES-LR scoring. Whilst the majority of patients felt that their lip-reading ability had improved by the +9 assessment, the majority reported no further change at +18 months over their nine-month score.

Analysis of the BKB sentence test results indicated that the implants assisted the patients to lip-read words in sentences. Eighty per cent of patients achieved scores of greater than 0 per cent in the electrical stimulation alone condition. This is appreciably higher than the figure of 50 per cent reported in the multicentre study (Summerfield and Marshall, 1995). If patients who did not attempt the ES only part of the test are excluded from the analysis, then the mean score at the +9 months assessment was 53.4 per cent (SD 33.6 per cent, n = 76), again much higher than the mean score of 35 per cent reported in the multicentre study, but similar to that reported by Gray *et al.* (1995), (for 15 patients each with 18 months experience of the Ineraid four-channel intracochlear implant), of 47 per cent in the implant only mode. We observed a small but significant improvement with time in scores for lip reading only and electrical stimulation only test modes. This did not translate to an improvement in combined scores (LRES) and suggests that these improvements were achieved in patients who had already scored maximum or near maximum combined scores at nine months.

Unlike the National multicentre study (Summerfield and Marshall, 1995), the two measures of depression displayed significant improvements between the pre-operative and nine-month post-operative stages and between the pre-operative and 18-month post-operative stages. However, we observed a much higher rate of clinically depressed subjects prior to implantation i.e. patients whose depress (Q) scores exceeded 5.5.

The average value of REVNED for patients increased from 4.1 pre-operatively to 5.7 at the +9 and +18 month assessments. The post-operative judgments were close to those of patients with mild to moderate hearing losses before fitting with hearing aids (Summerfield and Marshall 1995; Schow and Nerbonne, 1980).

As demonstrated in previous studies (Gantz *et al.*, 1993; Summerfield and Marshall, 1995), the post-operative ability of patients to identify speech and environmental sounds using electrical stimulation alone correlated significantly with the length of profound deafness. Unlike the multicentre study (Summerfield and Marshall, 1995), this relationship did not extend to the lip-reading supplemented with electrical stimulation condition. This study also suggests that variance in performance outcome may be related to the number of active electrodes.

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