Cochlear implantations in Northern Ireland: An overview of the first five years

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Accepted 12 March 1999

SUMMARY
During the last few years cochlear implantation (CI) has made remarkable progress, developing from a mere research tool to a viable clinical application. The Centre for CI in the Northern Ireland was established in 1992 and has since been a provider of this new technology for rehabilitation of profoundly deaf patients in the region. Although individual performance with a cochlear implant cannot be predicted accurately, the overall success of CI can no longer be denied. Seventy one patients, 37 adults and 34 children, have received implants over the first five years of the Northern Ireland cochlear implant programme, which is located at the Belfast City Hospital. The complication rates and the post-implantation outcome of this centre compare favourably with other major centres which undertake the procedure. This paper aims to highlight the patient selection criteria, surgery, post-CI outcome, clinical and research developments within our centre, and future prospects of this recent modality of treatment.

INTRODUCTION
Experiments by Volta were the first recorded attempts at electrical stimulation of the auditory system. More recent efforts at electrical stimulation of the auditory nerve began in 1957 by Djourno and Eryies.1 In 1964 Blair Simmons working at California placed a 6-electrode array in the modiolus of a human volunteer.2 At the same time clinical prototypes developed into clinically applicable devices and then in 1984, the US food and drug administration (FDA) approved the use of the House-3M single-channel implant system for routine clinical use. This was followed by the approval of Nucleus 22-channel implant for adults in 1985 and then for children in 1990. In the United Kingdom a clinical programme at University College Hospital, London was established in 1984. The Royal National institute for the Deaf developed the UCH/RNID single-channel implant and the Department of Health sponsored programmes in selected centres in 1990. At present over 15,000 CIs have been done world wide.

A multichannel cochlear implant consists of two parts, a receiver stimulator implanted in the temporal bone consisting of a receiver coil with an electrode array inserted into the cochlea, and an external device. The three main components of the external device are the microphone, speech processor and a transmitter coil conveying signals from the processor across the skin to the electrode array (Fig 1). The microphone picks up sounds and transfers them to the speech processor. These sound signals are analysed and converted to a form suitable for transmission by the processor. In most devices these transformed signals reach the electrodes by radio-frequency transmission from the transmitter coil resting on the head to the implanted receiver coil.

Profound deafness in the majority of cases results from damage to the sensory cells in the ‘Organ of Corti’ in the inner ear, due to various causes. CI helps this group of patients since it bypasses the damaged part of the auditory pathway and stimulates the surviving spiral ganglion cells directly with electrical signals. Early CI systems were mostly single-channel; with the advent of

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Methods

One hundred and eighty nine patients were referred to the CI centre during the first five year period from 1992 to 1997, for consideration of a cochlear implant. A preliminary screening based on the guidelines mentioned in Table I was carried out to exclude those who would not benefit much from the cochlear implant programme. According to our protocol, following screening each patient has a routine ENT examination. Audiological tests are performed to confirm profound bilateral sensorineural hearing loss, without useful residual hearing even with the use of an optimal hearing aid. A high resolution computerised tomogram (HRCT) is also performed to establish patency of the cochlea. Additionally magnetic resonance imaging (MRI) scan and promontory stimulation tests are performed to assess the integrity of the auditory pathways in selected cases. These

TABLE II
Age range of patients implanted

| Age group (years) | Total |
|-------------------|-------|
| 0-5               | 16    |
| 6-10              | 17    |
| 11-20             | 3     |
| 21-40             | 6     |
| 41-50             | 14    |
| 51-60             | 9     |
| >60               | 6     |

TABLE III
Aetiology of deafness

| Aetiology            | Total |
|----------------------|-------|
| Congenital           | 31    |
| Meningitis           | 10    |
| Head injury          | 9     |
| Ototoxicity          | 2     |
| Meniere’s syndrome   | 2     |
| Accoustic Neuroma    | 1     |
| Idiopathic           | 16    |

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investigations help to confirm the indications for CI as well as determining the most suitable ear for surgery. In this study a review of the case notes of all the seventy-one patients who received an implant during this period was carried out. With the exception of one case surgery for all the patients was carried out by one principal surgeon.

Data regarding age and aetiology of deafness of the study group are shown in Tables II and III respectively.

Surgery
Hypotensive general anaesthesia is widely used for CI surgery in adults and children. A few adult patients considered to have “high risk” for hypotensive general anaesthesia have been successfully implanted by employing a local anaesthetic protocol developed in our centre. Following a standard skin preparation a postauricular curvilinear incision measuring about 7 cm is placed. An anteriorly based musculoperiosteal flap is raised to provide cover for the implant. The next step is to perform a cortical mastoidectomy and posterior tympanotomy to gain access to the round window region. The part of the device to be implanted is placed in a bony recess drilled over the squamous temporal area. The opening into the cochlea (cochleostomy) is performed through the promontory anterior to the round window niche. The electrode array passes through the posterior tympanotomy into the middle ear and then into the cochlea through the cochleostomy. An intra-operative assessment of stapedial reflex is used to test the device in all paediatric cases. The implant is secured in place and the wound is closed in layers. A digital x-ray image is taken post-operatively to confirm good positioning of the implant. As a rule patients go home the day after surgery.

Results
The outcome of all the adults and children implanted during the first five year period was assessed. In adults the Benkowal Bamford (BKB) sentence tests were used to assess speech perception. Routinely assessments are carried out at 1, 9 and 24 month intervals post-operatively. Of the 37 adults implanted one patient was lost for follow up and another patient died due to unrelated causes before the 9 month assessment. Figure 2 shows the mean results of the remaining 35 adults implanted.

Unlike the standardised tests available for the assessment of post-lingually deaf adults implanted, testing of the pre-lingually deaf children implanted is more difficult and complex. Early post-implant assessment of children initially concentrates on detection of environmental sound followed by the identification of the sound source. Parental report is a valuable source of information during this listening period. Discrimination of environmental sounds is assessed before the child progresses to speech sounds. As the children make further progress, tests on comprehension and expression can be undertaken. The children are assessed after a period of 3 and 6 months and then at 1, 2, 3 and 5 years according to the test involved. All the children in the study group developed environmental sound awareness and a variable degree of sound discrimination. A significant number of children achieved comprehension of spoken language and expressive language development. These results are in agreement with the study by Moog and Geers who concluded that “Evidence from our longitudinal study of pre-lingually deafened children using cochlear implants in the oral education programme at the central institute for the deaf indicates that the expectations [expressed in the proposition that implants should be used to help deaf children to learn to talk] have a great deal of validity”.

DISCUSSION
The role of CI for the rehabilitation of the profoundly deaf is now established beyond doubt. All the prospective candidates can be grouped under four categories, namely pre- or post-
lingually deaf adults or children. Previous experience has revealed that post-lingually deaf adults perform better following CI than pre-lingually deaf adults. Therefore pre-lingually deaf adults are not considered to be suitable candidates for CI. In the case of children the post-CI progress between pre- and post-lingually deaf children is less pronounced. This raises the issue of the upper age limit for a successful implantation in the pre-lingually deaf children. In our series of CI in the older children (>7 years) promising results have been obtained in the areas of auditory perception and expressive language development.

In the earlier days of CI, placement of the device necessitated elevation of large scalp flap. This approach resulted in a significant number of flap-related complications sometimes associated with implant extrusion. To overcome this without compromising the results, a much smaller post-auricular curvilinear incision was adapted in our centre in 1994. This approach helped to avoid the psychological trauma of partial head shave especially in children, and resulted in more rapid healing of the surgical incision with good cosmetic result.

The report by the MRC institute of Hearing Research on the evaluation of the national cochlear implant programme confirmed that the occurrence of major complications was acceptably low. In our series of 71 cases, only one case needed removal of the implant. A child suffering from KID (keratosis, ichthyosis and deafness) syndrome had partial extrusion of the implant which necessitated explanation. In one adult case, only partial insertion of the electrode array was possible due to obliterated cochlea. Functioning of the implant was poor and it had to be explanted. Successful reimplantation was performed in the other ear which resulted in optimum functioning of the device and satisfactory results. Slippage of the electrode occurred in one case on the first post-operative day. Exploration of the mastoid and re-positioning of the implant resulted in a successful outcome. Of the minor complications, one case had a non-healing wound over the implant site secondary to trauma, and another case developed a cyst in the incision scar. The first case was managed by wound debridement and resuturing, while the second case had an excision biopsy of the cyst which was reported as keloid. Both these cases had an uneventful recovery. The successful outcome of surgery is dependent on a number of factors, one of the most important being the correct placement of the electrode array. To assess this post-operatively the digital radiography technique is used. In contrast to the plain x-ray and CT scan this produces a clearer image at a much reduced radiation dose to the patient. Although the digital imaging technique was being utilised in some disciplines of medicine, its role in imaging post-CI patients was developed in our Centre in collaboration with the department of radiology at Belfast City Hospital.

Implantation of the device is only the first step for a patient entering into the CI programme. The next two important phases are the rehabilitation and maintenance. A month following implantation initial tuning and “switch on” of the device is performed. Initially the patients make regular visits to ensure good functioning and optimal tuning of the device to meet individual needs. Professional help in the form of speech and hearing therapy is given to improve communication skills. This phase which lasts about a year in adults is much prolonged in children, and lasts at least 3 years. This is followed by the maintenance phase which lasts as long as the device is being used by the patient. Routinely, 6 monthly visits for adults and 3 to 6 monthly visits for children are arranged.

CONCLUSION

In the present era of ‘evidence based medicine’, for a health technology to be concluded as beneficial it must be supported by outcome data. The main report by the MRC Institute of hearing research on the evaluation of the national cochlear implant programme in the UK confirms with relevant data the benefits of CI for the rehabilitation of deaf patients. All the 71 patients in this study developed environmental sound awareness and a variable degree of expressive language and speech discrimination. CI research is developing rapidly, presently an ‘ear level’ multi-channel processor is available similar in appearance to a behind-the-ear hearing aid. As further progress is made and we edge towards the millennium, it is hoped that a completely implantable device with improved speech processing technology will soon be available.

ACKNOWLEDGEMENTS

The authors thank Mr J E T Byrne, consultant otolaryngologist for his advice and comments, also Ms Brannigan for her help with data collection. Thanks also go to the staff of Regional Cochlear Implant Centre, Belfast for their valuable help in this study.

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