Rehabilitation strategies for adult cochlear implant users

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SUMMARY
This paper summarizes open-set speech perception results using audition alone for a large group of adult Nucleus cochlear implant users in Melbourne. The results show wide variation in performance but significant improvement over the years from 1982 to 1995. Analysis of these results shows that speech processor developments have made the major contribution to this improvement over this time. Recent results for patients using the SPECTRA-SPEAK processor show that most subjects obtain good speech perception within six months of implantation and the need for intensive auditory training is minimal for many of these patients. Postoperative care should encourage consistent device use by providing opportunities for success and providing long term technical support for implant users. In some cases, including elderly patients, those with long term profound deafness, and those with special needs, there will still be a need for additional rehabilitation and auditory training support.

INTRODUCTION
The clinical application of cochlear implants as a treatment for acquired profound hearing loss in adults began in the 1970s with simple single channel devices. After considerable preliminary research, the Nucleus multiple electrode cochlear prosthesis began clinical trials in Melbourne in 1982 (Dowell et al, 1985) and world-wide clinical application accelerated in 1985 following the approval by the U.S.A. Food and Drug Administration for use of the device in adult patients. Approximately 8,000 profoundly hearing-impaired adults have been implanted with the Nucleus device since that time.
Until recently, the internal electronics of the Nucleus implant have remained largely unchanged but there have been three major changes in the signal coding performed by the external speech processor. These changes have been driven on the one hand by improvements in electronics technology and on the other by the desire to provide better speech understanding for patients. Early applications of cochlear implants were seen largely as providing an aid to lipreading for profoundly hearing-impaired people, and rehabilitation programs emphasised this aspect. Evaluation of speech perception also played a role in rehabilitation programs. These changes have been driven on the one hand by improvements in electronics technology and on the other by the desire to provide better speech understanding for profoundly hearing-impaired people, and rehabilitation programs emphasised this aspect. Evaluation of speech perception also played a role in rehabilitation programs.

However, as results improved and implant users gained experience with the device, the motivation was strong for implant users to be able to communicate via telephone. The evaluation of speech perception for implant users has also moved away from lipreading assessment towards more open-set assessments using the device alone. The evaluation of speech perception for implant users is complex, with benefit to communication with lipreading still remaining a primary goal of cochlear implantation. This paper will review and summarise the changes in speech perception performance that have occurred over the last 15 years for adult implant users and discuss the implications of these findings in relation to rehabilitation strategies.

MATERIALS AND METHODS

For profoundly deaf adults who undergo cochlear implantation in Melbourne at the Royal Victorian Eye and Ear Hospital, there has been regular assessment of speech perception skills following initial rehabilitation program. This is approximately six months after surgery in most cases. The battery of tests used has changed somewhat over the years with some of the lipreading assessments and simple closed-set tests being phased out in favour of additional open-set assessments. All patients have received open-set sentence testing using the CID everyday sentence test. This allows us to open-set sentence testing using the CID everyday sentence test. This allows us to evaluate the rate of learning and the rate of which of learning takes place. Data will also be presented for a selection of 37 patients implanted in Melbourne between 1982 and 1995 who had completed their six month postoperative assessment. In addition to the six month postoperative evaluations, all adult patients are reviewed at the Cochlear Implant Clinic regularly. This review includes speech perception assessment providing additional long-term follow-up data for those patients. The most recent assessments on the CID sentence test were also obtained for the same group of adults identified above, except for those who were deceased or no longer lived in Melbourne (n=35). All patients used the Nucleus multiple channel cochlear prosthesis but the signal coding scheme varied depending on when they were implanted and whether they had upgraded to the latest speech processor at the time of testing. For the six month postoperative data, patients implanted between 1982 and 1985 used the WSP2-FOF2 speech processor (Dowell et al., 1985), those implanted between 1985 and 1989 used the WSP3-FOF1 processor (Dowell et al., 1987), those implanted between 1989 and 1994 used the MSF-MULTIPERA processor (Skinner et al., 1991, Dowell et al., 1992) and those in 1994 and 1995 used the SPECTRA-SPEAK processor (Hollow et al., 1995).

In addition to the six month and long term follow-up results, recently implanted patients using the SPECTRA-SPEAK processor have been tested more regularly during their postoperative rehabilitation program using the CID sentence test to attempt to show the areas at which learning takes place. Data will also be presented for a selection of these patients.

RESULTS

Figure 1 shows the results for all 107 adult patients at their six month postoperative evaluation on the CID open-set sentence test. Figure 2 shows the distribution of scores for the same data. From inspection of the data, it is clear that there has been improvement over time in speech perception performance. It is also evident that there are large variations in performance across the lipreading assessment. This set of results was analysed using multiple linear regression using a number of possible predictive factors (Blenney et al., 1992). This analysis suggested that changes in speech processing have had a highly significant effect on performance, and that patients with a shorter duration of profound
deafness and younger patients tend to perform slightly better. The mean scores for patients grouped by speech processor were 16% for WSP2-F0F2 (n=16), 36% for WSP3-F0F1F2 (n=40), 56% for MSP-MULTIPEAK (n=32) and 78% for SPECTRA-SPEAK (n=11).

Figure 3 shows the recent results for the CID sentence test for 81 of the patients shown in Figure 1. Figure 4 shows the distribution of scores and can be compared directly with Figure 2. It is clear that the overall performance of the group is better for the recent data than for the six month postoperative data. One possible reason for this is that many of the patients have gained further experience with the prosthesis enhancing their ability to understand speech. In addition, many of the patients have upgraded to the newer speech processors which, as shown above, provide significant improvements in speech perception. When the recent scores were grouped by processor type the mean results were 38% for WSP3-F0F1F2 (n=6), 59% for MSP-MULTIPEAK (n=41) and 82% for SPECTRA-SPEAK (n=34). There were no patients still using the original F0F2 coding scheme. It is immediately clear that the main factor in the improvement from the postoperative to recent data is the improvement in speech processing. The mean results grouped by speech processor are similar for both sets of data. If there were a strong experience effect we would expect that the mean scores for the recent data would be significantly higher than those for the six month postoperative data given the same speech processor. This is not the case and suggests that the speech processing improvements have been more important than experience alone in improving speech perception. To put this another way, the recent results appear to be significantly better mainly because there are larger proportions of the patients using the advanced speech coding schemes.

Figure 5 shows results on the CID open-set sentence test over the immediate postoperative period for five adults using the SPECTRA-SPEAK speech processor. Note the different rates of improvement and that most of the patients appear to have reached a maximum level of performance for this task by the six month point.

Figure 3

Open-set sentence scores for adult postlingually deaf patients implanted with the Nucleus cochlear prosthesis in Melbourne between 1982 and 1995. Scores were obtained in 1994 or 1995.

Figure 4

Distribution of open-set sentence scores for adult postlingually deaf patients implanted with the Nucleus cochlear prosthesis in Melbourne between 1982 and 1995. Scores were obtained in 1994 or 1995.

Figure 5

Open-set sentence scores for five adults using the Nucleus cochlear prosthesis with the SPECTRA-SPEAK speech processor during the immediate postoperative period. Scores were obtained at 2 weeks, 4 weeks, 12 weeks and 24 weeks postoperative.

DISCUSSION

The open-set speech perception results presented here show that cochlear implantation is now able to provide useful comprehension of everyday speech for adult patients using audition alone. The expectation should now be that adult cochlear implant users can develop adequate telephone communication skills with appropriate training. Analysis of these results has shown significant improvement over time. The main factor in this
improvement has been changes to signal coding schemes. Additional factors that have been shown to be important are the duration of deafness, age and experience with the device, but all to a relatively minor extent. In isolated cases, surgical difficulties such as extensive ossification of the cochlea, or neurological deficits such as frontal lobe damage in head trauma, can lead to unsatisfactory results. Fortunately, in the large majority of cases, good speech perception is now achieved after a relatively short postoperative period. There are a number of implications for rehabilitation of adult patients that follow from these results. Perhaps of prime importance is technical support to implant users. As more patients are obtaining better performance, so the reliance on the implant for vocational and social activities increases. The technical support in terms of device programming and maintenance is a long-term, important consideration in planning a clinical service for implanted patients. Due to the need for at least six months experience with the device to obtain optimum benefit, the initial postoperative care should aim to maximise use of the device while providing encouragement, support and opportunities for success. For many patients, the amount of rehabilitation required apart from the technical support is minimal as long as they have a clear mechanism for obtaining long-term follow-up when they encounter problems. For others, including older patients, those with long-term deafness and those with additional deficits, a larger amount of rehabilitation time may be necessary to ensure optimum benefit. With the improvement in results there has also been a change in the criteria for implantation with many more patients with useful residual hearing now considering the procedure. These patients present new challenges including the careful assessment of residual hearing and the use of the implant in conjunction with hearing aids. These patients are likely to be more demanding as they are not reliant on the implant to the same extent as totally deaf patients. In summary, multichannel cochlear implants are able to provide useful speech perception without lipreading in the majority of postlingually hearing-impaired adult patients. The emphasis of postoperative care needs to be on providing technical support over the long term, and establishing consistent use of the device. For many patients, long-term additional rehabilitation will be unnecessary, once they integrate use of the device into their daily life.

REFERENCES


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