CURRENT ISSUES IN COCHLEAR IMPLANTATION
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advantages are found when children with average hearing levels greater than about 100 decibels receive implants. Taken together, these data provide a powerful evidence of the achievement of implantation – it is simultaneously associated with savings in the cost of education but with enhanced educational outcomes (see figure 3).

The future and an invitation to participate in research

Professor Summerfield explained that he would shortly move from Nottingham. After 27 years working at the Institute of Hearing Research, he will become the Anniversary Professor of Psychology at the University of York. There, he will be conducting a research programme with three foci: (1) The development of abilities in spatial hearing; (2) improved ways of measuring quality of life in people with impaired hearing; and (3) techniques for training users of implants to improve their skills in speech perception – hopefully resulting in training packages on laptop computers which patients can use in their own home.

Professor Summerfield expressed the hope that members of the association who live in Yorkshire will be willing to participate in this research. Anyone who would like to receive details of what would be involved can contact Professor Summerfield by e-mail at: Quentin.Summerfield@ihr.mrc.ac.uk .

Conclusion

Professor Summerfield concluded his talk by thanking the members of the Association for inviting him to talk, for listening to him, and above all for the support which they have given by participating in research over the last 15 years.

Notes and Bibliography

1. Please contact Quentin.Summerfield@ihr.mrc.ac.uk to obtain details of his research in York and to obtain a copy of the PowerPoint slides which accompanied this talk.
2. A computer programme that implements the statistical equation can be downloaded from www.ihr.mrc.ac.uk by following the links: Research, Prostheses, Optimising outcomes, Actuarial predictions.
3. A paper describing the development and evaluation of the equation will be published by the United Kingdom Cochlear Implant Study Group in the journal Ear and Hearing in the second half of 2004.
4. A paper describing the SSQ Questionnaire was published by Stuart Gatehouse and William Noble in the International Journal of Audiology (2004 Feb;43(2):85-99).
5. Papers reporting the study of hearing-impaired children have been submitted for publication. Summaries can be obtained from Quentin.Summerfield@ihr.mrc.ac.uk .

COMBINED ELECTRIC-ACOUSTIC STIMULATION (EAS)

A Summary of a Presentation by Mr Graham Brickley of MED-EL (UK) Ltd

Thank you very much for asking me to come and talk to you on this very interesting and new development topic of combined electric acoustic stimulation. The key purpose of EAS is to provide hearing-aid support for information that is available at low frequencies in combination with a cochlear implant which will provide electrical stimulation to give high frequency sound information in the same ear.

In the ear it is the organ of Corti, which contains inner and outer hair cells, by which the ear converts sound vibrations into nerve signals for the brain. It is the inner hair cells which are the most important part because they convert the vibration energy into the nerve signal to send up to the brain. The outer hair cells are effectively amplifiers and they boost the vibration levels which excite the inner hair cells.

In a typical audiogram, speech sounds are spread across a wide range of frequencies and at relatively moderate sound levels. Vowel sounds, E, R, U and so on appear louder and more towards the low frequency

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end. High frequency sounds like 'S'are quieter and therefore more easily lost. So with a mild to moderate the degree of hearing loss, you need help to amplify the sounds back into the audible range and with severe to profound hearing loss you need even more help because you won't hear any parts of speech without this. In normal hearing there is a full compliment of outer hair cells. As the outer hair cells are lost so the hearing is reduced down through the mild to moderate degrees of hearing loss. One may still have a full compliment of inner hair cells. When inner hair cells are lost, as can occur in high frequency loss, no amount of amplification through a hearing aid can restore those high frequency sounds.

Figure 1

Now I want to emphasise that the main goal for any treatment is to make all those speech sounds audible. So the goals of EAS (see Figure 1) is to preserve the residual hearing through additional steps during the surgical process to provide acoustic stimulation in the area where residual hearing has been preserved and provide electrical stimulation in the high frequency region. Progress to date is summarised in Figure 2.

On the depth of the electrode insertion, the

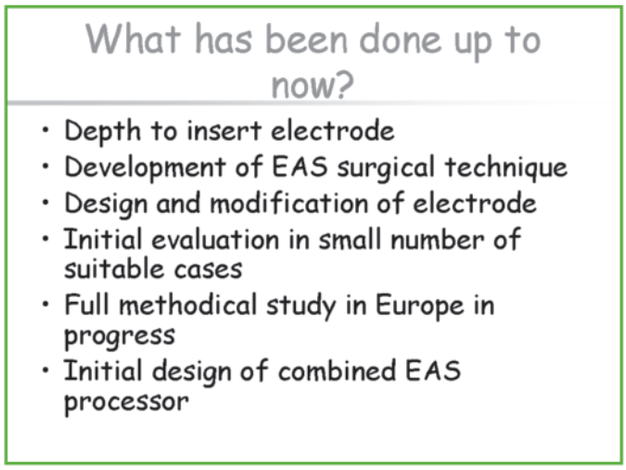

Figure 2

normal device is inserted a full two or slightly more turns about 30 mm into the cochlear to stimulate the full length of it. For EAS the decision has to be made as to what depth the electrode should be inserted, if it is to provide high frequency information, and there is a map which allows one to correspond the depth of insertion to frequency (see figure 3). We know that a depth of 15 mm

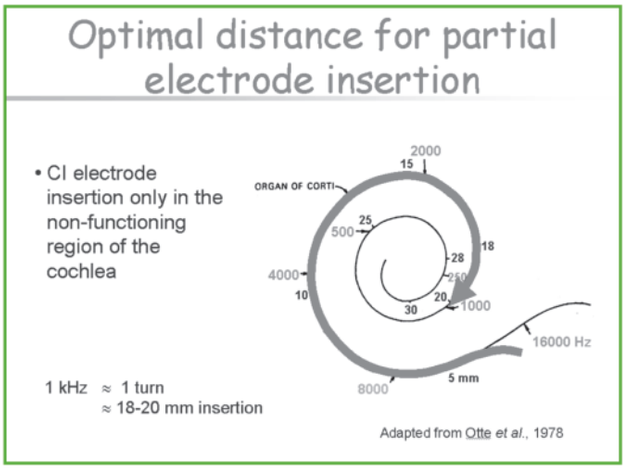

Figure 3

corresponds to 2000 hertz, the region of the normal cochlear, 1000 corresponds to about one full turn or 20 mm. How deep should it be inserted for EAS? There are various possibilities. It could be fully inserted covering both functioning and non-functioning regions or, to provide only high frequency information, partially into only the non-functioning region, a very limited insertion or even placed just outside the cochlear.

There is some evidence we can call on to help to judge what should be the best depth for insertion of the electrode from a research study looking into simulations of the depth of insertion. Overall, the evidence is that deeper insertion and close tonotopic matching to the normal cochlear is better for providing electrical stimulation in EAS. But one of the risks of course of inserting an electrode into the cochlear is that from the resulting trauma some hearing won't be preserved and that is obviously not desirable. However further research has established that there is no real difference according to the depth of insertion on the result for hearing preservation. So just to conclude, the longer insertion depth is suitable and desirable for EAS but that depth should be limited to the non-functioning region of the cochlear and the prerequisite is an electrode design that is capable of one full turn without damage to the cochlear, the membrane of the cochlear and that deeper insertion does not automatically increase the risk. That means that the optimal distance will be around one full turn for up to around the 1 kHz point.

The next step was to decide on the development of surgical technique which aims to preserve the residual hearing. The needs of the surgical technique are to minimise disturbance to the hydromechanics of the cochlear; to minimise damage whilst the electrode is being inserted and minimise damage due to the trauma of drilling the acoustic entry. Secondly, as far as possible

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COMBINED ELECTRIC-ACOUSTIC STIMULATION *continued from page 5*

the surgeon aims to avoid inflammatory reactions within the cochlear which may be due to contamination of the cochlear with by-products of the surgical technique. This aim is to reduce fibrous tissue growth inside the cochlear which would limit the mechanical abilities of the cochlear to still transmit the acoustic signal.

Initially an electrode was designed by MED-EL for medium spacing which conveys the electrodes over about 21 mm that is designed to be inserted up to that distance in the cochlear. This is a small volume electrode in which the volume taken up by the electrode is only 20% of the volume of one of the three fluid-filled cavities of the cochlear. That means that it conserves the inner ear fluid and that helps to maintain the hair cell function.

The second stage is producing a refined design of more flexible electrode and this is the new technology which is currently in evaluation. Its principal benefit is that it requires 40 to 50 percent less force during insertion. It leads to less insertion trauma and has greater mechanical flexibility. This FLEX electrode is anticipated to be completed evaluation and be introduced in EAS surgery in the next few months.

Now, in terms of clinical experience the EAS technique was developed in Frankfurt. They have been implanting using this technique for the last 4 to 5 years. Using 18 to 20mm insertion depths, they have shown that patients who had long term stability up to 4 years, have all experienced an improvement in speech understanding using the implant alone compared with their hearing aid alone, even if the hearing was not preserved.

Who might be an EAS candidate? Generally EAS candidates are not conventional on today's criteria, they would seem to have too much hearing. They do have severe to profound hearing loss in the high frequency but only mild to moderate loss in the lower frequencies. They should have stable and not progressive hearing loss, but they must have also limited speech perception and need to have above a minimal speech intelligible so as to make it worthwhile trying to preserve those low frequencies. Of course and it is under debate as to how much hearing they should have and perhaps we could get a contribution by using the odds ratio calculations from IHR (see page 2) to help decide on candidacy for this.

In terms of results most EAS candidates have preserved hearing after implantation. Both in monosyllable tests and speech discrimination in noise, the combination effect of EAS showed better performance than the hearing aid alone (eg average score for 7 cases, monosyllables: 8%, HA alone: 58%, CI alone 73% EAS). So for the future. There is a formal clinical investigation under way in Europe and one of the UK centres (St Thomas' Hospital) is participating in that. The results are expected in the next six to 12 months. These will help to determine new standards for extending the candidacy for cochlear implants to suitable candidates.

There is continuing work on programming the combined signal between hearing-aid and cochlear implant. A decision has to be made on the best crossover frequency so that one can limit the hearing-aid to only providing information below and the implant any information above that frequency. And there is on- going work into designing a combined speech processor. Med-El expects to release such a device in the next 12 months. (See Figure 4)

So finally we feel that combined EAS provides great promise for the future as a treatment for appropriate patients who have significant residual hearing but limited benefit from hearing aids. (See figure 5)

I would like to acknowledge the University of Frankfurt who have done the majority of this work that I have been reporting here. There is further information on the Med-El website at www.medel.com should you wish to find out more.

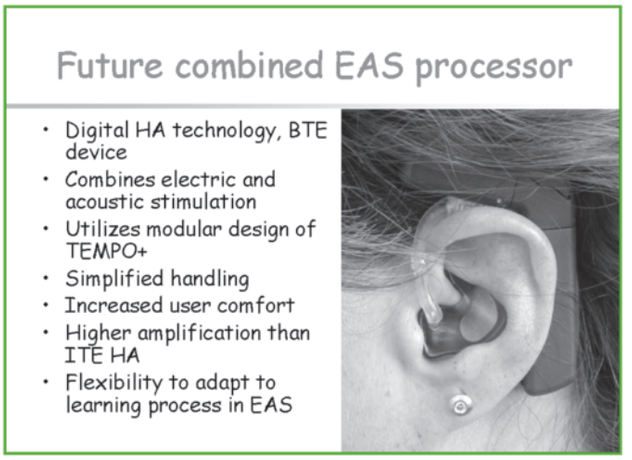

Figure 4

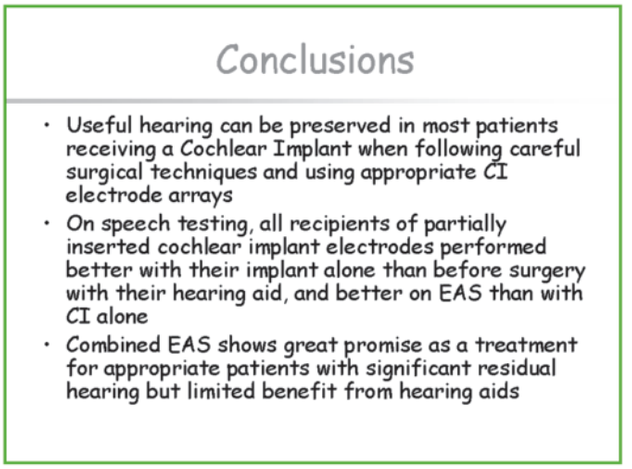

Figure 5

DIARY DATE

13th November Winter Forum at Citylodge, Nottingham