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Positioning of the receiver-stimulator for the CI–24M cochlear implant in infants

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Abstract

A new cochlear implant (CI–24M) has recently been released by Cochlear Ltd. The shape and size of the receiver-stimulator differs from that of the CI–22M. Infants as young as one year of age are now receiving cochlear implants. We have examined the likely effect of skull growth following the implantation of a CI-24M cochlear implant in an infant of this age.

Key words: Cochlear implant; Skull; Growth

Introduction

The Nucleus 22 electrode cochlear implant (CI–22M) has been implanted in almost 7000 children worldwide (Cochlear Ltd, Australia, personal communication). The introduction of a new device with two extracochlear electrodes (CI–24M) may give improved performance by means of different modes and faster rates of stimulation. However, the receiver-stimulator of the CI–24M differs in shape from that of the CI–22M. In particular, the section containing the receiver coil and magnet is larger with a maximum diameter of 33 mm.

With increasing experience, it has become clear that the outcome of congenitally deaf children is better the younger that they are implanted (Dowell *et al.*, 1995). There has therefore been a move to implant children at younger ages. The CI–24M receiver-stimulator was designed to allow it to be implanted in a six-month-old infant (Clark, 1997). The youngest child to be implanted in the New South Wales cochlear implant program was 12-months-old at the time of implantation. Consequently, it is very important that the effect of skull growth is considered when deciding on the placement of the receiver-stimulator.

We have therefore undertaken a study to predict the position of the receiver-stimulator in relation to the skull at various ages after implantation of a child of one year of age.

Materials and methods

A CI–24M receiver-stimulator was placed at an appropriate position for implantation on the skull of a one-year-old child. The centre of the anterior section was sited on an imaginary line drawn from the posterosuperior margin of the bony ear canal at an angle of 45 degrees to the orbitomeatal line (the Frankfurt plane). Its position on this line was determined such that the well drilled to accommodate the device would lie on the temporal bone adjacent to the temporoparietal suture line.

Figures 1A and 2A show the device in different orientations. In Figure 1, the device has been positioned so that the section containing the receiver coil and magnet lies adjacent to the parieto-occipital suture line. This suture line marks the inferior limit of the subperiosteal pocket created for the receiver-stimulator when using a linear postaural incision (Gibson *et al.*, 1995). Figure 2 shows the position of the device when placed vertically. The position and orientation of the receiver-stimulator in relation to the temporo-parietal suture line of the one-year-old child was noted and used to determine the expected position in relation to the skull of children of three, five, seven, nine and 11 years of age (Figures 1B–F and 2B–F).

Measurements taken from these skulls indicate that the distance between the postero-superior margin of the bony ear canal and the site of the receiver-stimulator is 10 mm greater in the 11-year-old compared to the one-year-old.

Discussion

Several points need to be taken into account when considering the placement of the CI–24M receiver-stimulator on the skull of infants. Firstly, it should be placed sufficiently posteriorly so that it does not interfere with the placement of the microphone or ear-level speech processor, which has recently been

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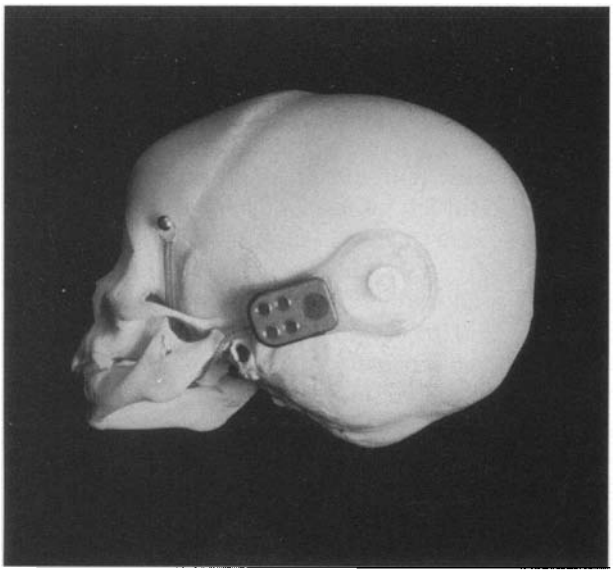
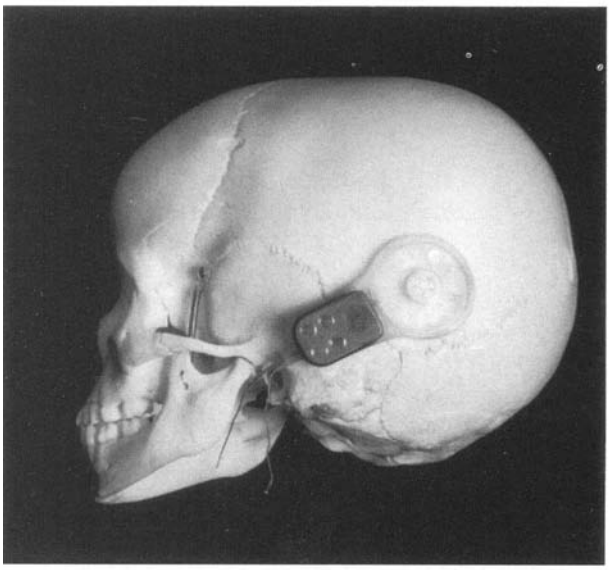


FIG. 1A

CI-24M receiver stimulator positioned on the skull of a 12-month-old infant adjacent to the parieto-occipital suture line.



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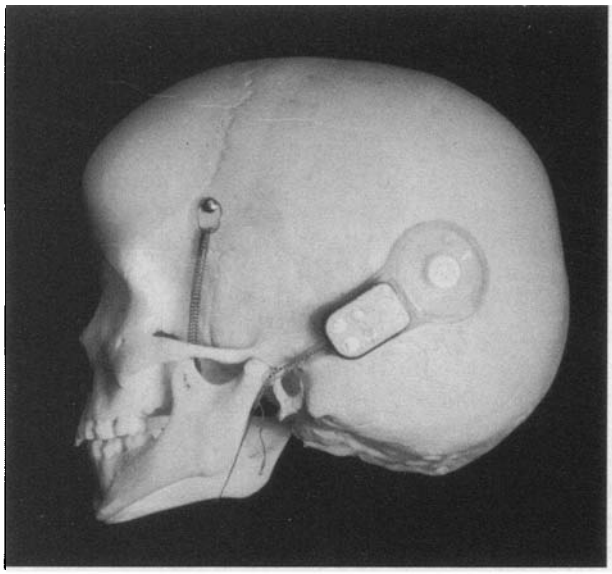

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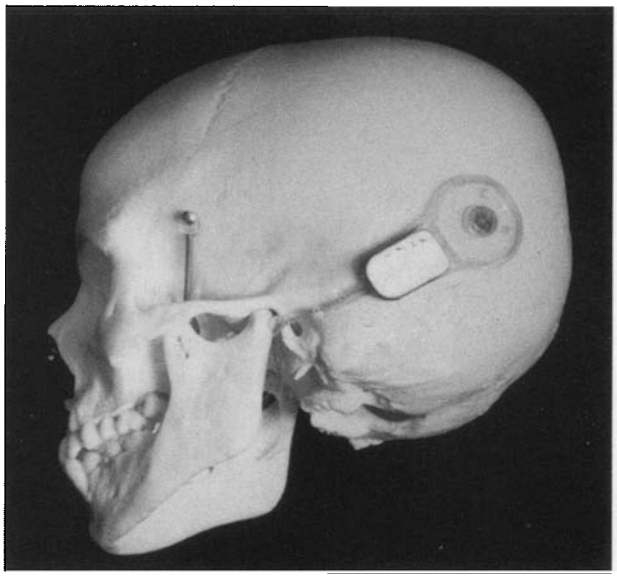

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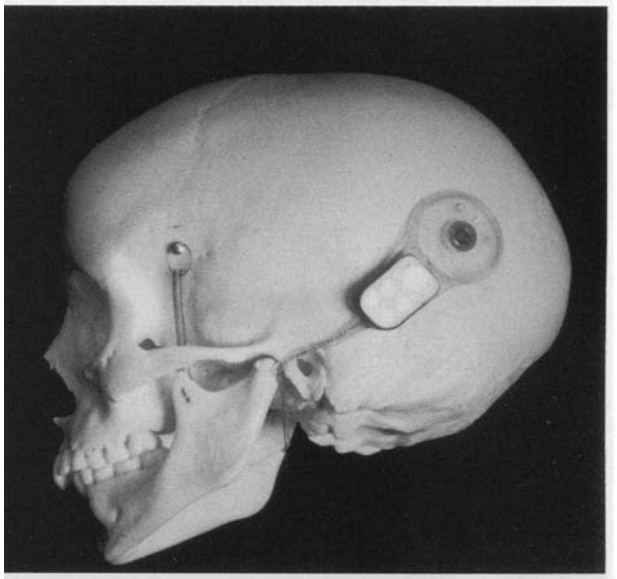

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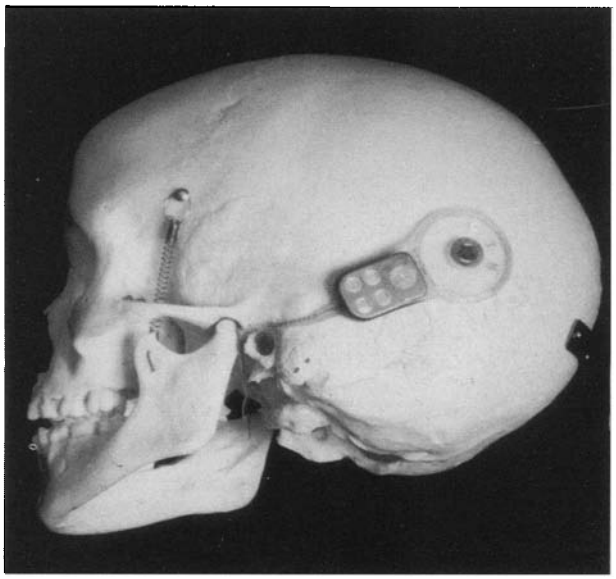

FIG. 1B–F

Predicted position of CI-24M receiver-stimulator shown in Figure 1A at three, five, seven, nine and 11 years of age.

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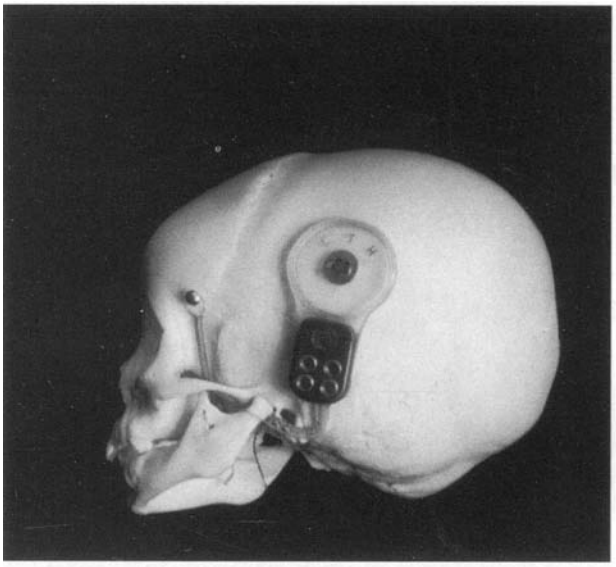
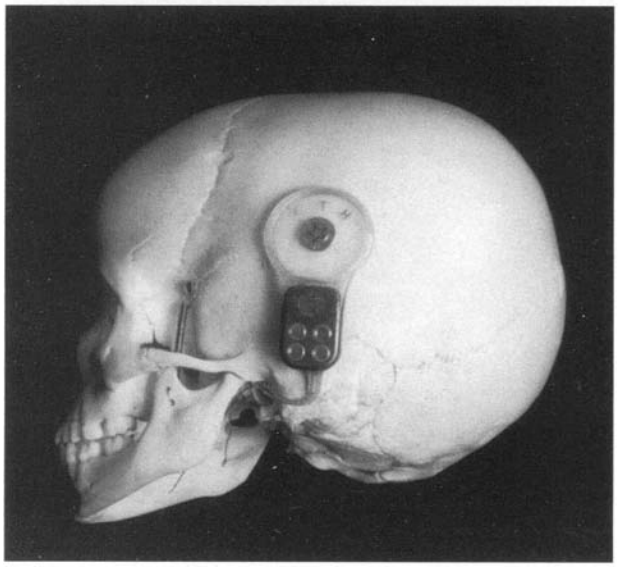


FIG. 2A
CI–24M receiver stimulator positioned on the skull of a 12-month-old infant in a vertical orientation.



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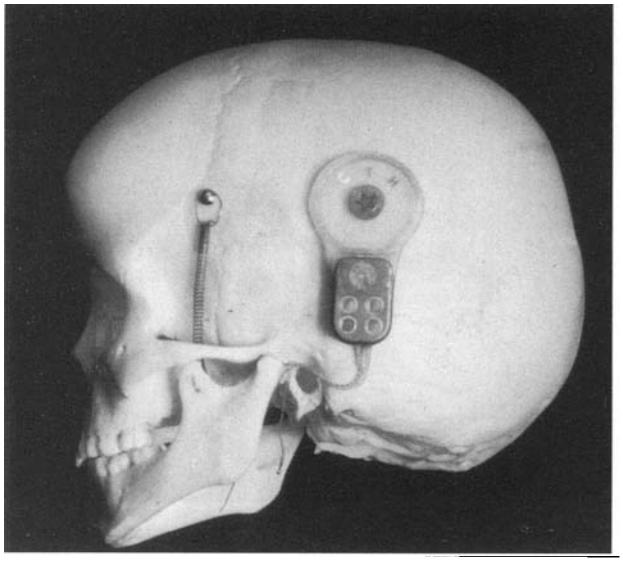

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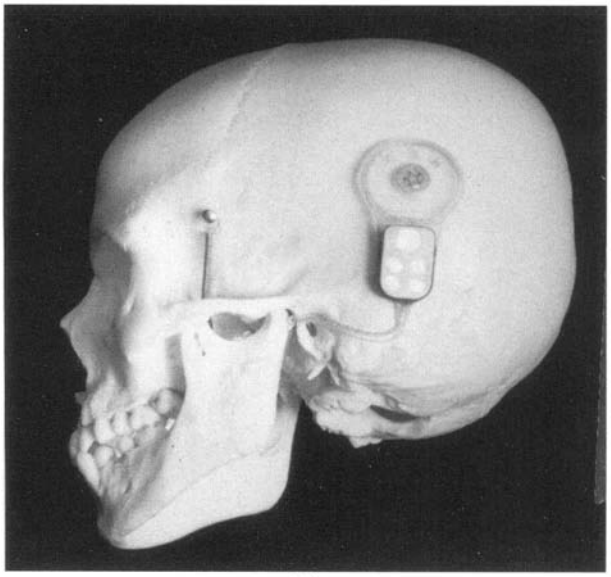

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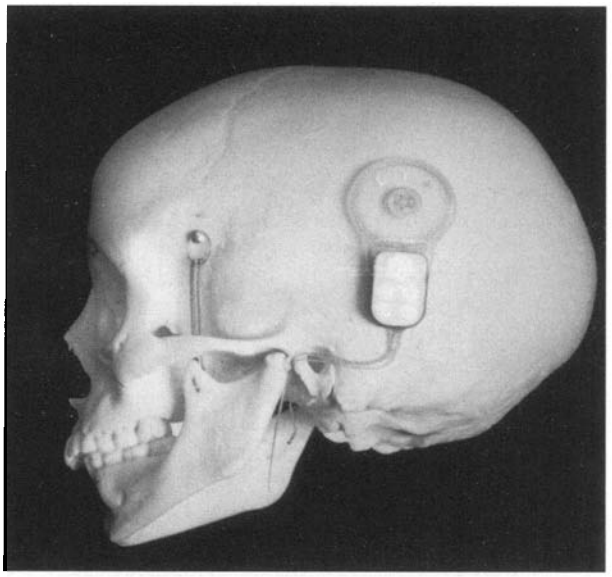

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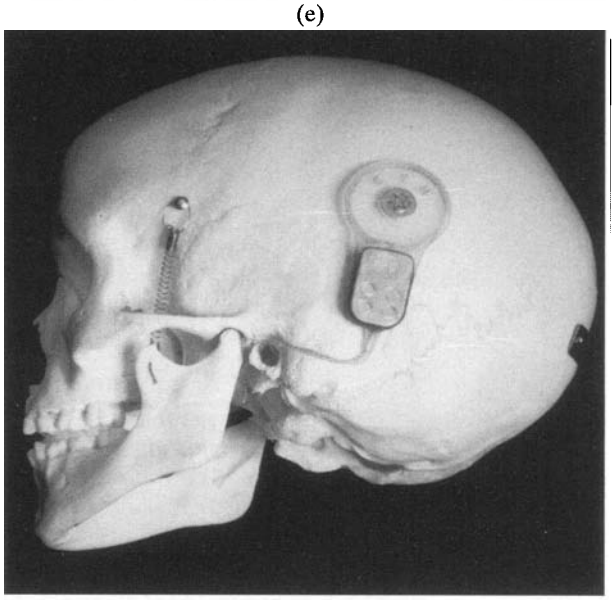

FIG. 2B-F
Predicted position of CI–24M receiver-stimulator shown in Figure 2A at three, five, seven, nine and 11 years of age.

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released. If it is placed too anteriorly, it may prevent the microphone or ear-level speech processor from sitting comfortably behind the ear. At worst this may cause pressure necrosis of the skin over the receiver-stimulator (Hoffman and Cohen, 1993).

Various studies have shown that growth of the temporal bone is maximal during the first two years of life but continues into teenage years (O'Donoghue *et al.* 1986; Simms and Neely, 1989; Dahm *et al.*, 1993). Dahm *et al.* (1993) found that the distance from the round window to the sinodural angle increases by 11.6 mm between the neonate and the adult. O'Donoghue *et al.* (1986) have suggested that the electrode array should have a redundancy of up to 30 mm to allow for skull growth and prevent the electrode array from extruding from the cochlea. The effect of skull growth is less the closer that the receiver-stimulator is positioned to the mastoid cavity.

There has been some concern that the insertion of a cochlear implant might interfere with skull growth. Growth of the bones of the skull occurs by the formation of new bone at suture lines. It has been suggested that trauma or surgical procedures might cause osseous bridges across suture lines which would affect subsequent skull growth (Simms and Neely, 1989). However, experimental work in monkeys has shown no effect on skull growth when a bed for the receiver-stimulator was created across a suture line (Xu *et al.*, 1993).

As a consequence of the small size of the mastoid bone in young infants the bed for the receiver-stimulator must be placed more superiorly than in older children and adults. Xu *et al.* (1993) have suggested that the optimal placement for the receiver-stimulator is where the mastoid, parietal and occipital bones meet at the asterion. However, we feel that it is preferable to avoid placing the bed for the receiver-stimulator across a suture line if possible. We suggest that the bed is drilled on the temporal bone adjacent to the temporo-parietal suture line as demonstrated in Figures 1A and 2A.

As the antenna of the CI–24M is longer and wider than that of the CI-22M, it is necessary to rotate the package more superiorly (Clark *et al.*, 1995). This affects not only the position of the receiver-stimulator in relation to the skull, but also in relation to the incision used. The size of the incision or flap is determined by the size of the receiver-stimulator, and not by the size of the child's skull. If a flap is raised, this must extend almost to the vertex if the package is orientated vertically as shown in Figure 2. Using a linear postaural incision, as described by Gibson *et al.* (1995), a vertical orientation of the package is undesirable as this would entail the incision lying over the entire length of the receiver-stimulator. We recommend that the receiver-stimulator is placed in a sub-periosteal pocket posterior to the line of the incision in as horizontal an orientation as possible. As the pocket is limited inferiorly by the parieto-occipital suture line, the antenna lies adjacent to this suture line, as shown in Figure 1A. The tension of the periosteum and overlying tissues helps to support the package in position.

Aside from surgical considerations, the orientation of the package determines the position of the antenna and therefore the position of the head coil when the implant is in use. If the package is placed vertically, the head coil must be attached more superiorly. This is less acceptable cosmetically and may prove to be a problem with the short cable to the head coil from the bottom of the ear level speech processor. Whether using a flap or linear incision, we believe that the more horizontal orientation shown in Figure 1 is preferable to the vertical orientation shown in Figure 2.

Conclusion

We have investigated the likely effect of skull growth on the position of the CI–24M receiver-stimulator after implantation in a one-year-old infant. We believe that the well for the package should be placed adjacent to the temporo-parietal suture line on a line drawn from the postero-superior margin of the bony ear canal at an angle of 45 degrees to the orbitomeatal plane. The package should be orientated as horizontally as possible, such that the antenna lies adjacent to the parieto-occipital suture line.

Acknowledgement

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