Cochlear implants in children; the value of cochleostomy seals in the prevention of labyrinthitis following pneumococcal otitis media


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Cochlea implantation at an early age is important in rehabilitating profoundly hearing impaired children. Given the incidence of pneumococcal otitis media in young children, there has been concern that cochlear implantation could increase the possibility of otitis media, leading to labyrinthitis, in this age group. Clinical experience has not indicated an increase in the frequency of otitis media and labyrinthitis in implanted adults or children over two years. However, labyrinthitis has occurred in implanted animals with otitis media. In order to assess the impact of cochlear implants on the occurrence of labyrinthitis, pneumococcal otitis media was induced in 21 kittens. Thirty-two kitten cochleas were implanted, of which 9 had a fascial graft and 9 a Gelfoam® graft. Nine control cochleas were unimplanted. Labyrinthitis occurred in 44% of unimplanted controls. 50% of implanted ungrafted cochleas, and 6% of implanted grafted cochleas. There was no statistically significant difference between the incidence of labyrinthitis in the implanted cochleas and the unimplanted controls. However there was a statistically significant difference between the ungrafted and grafted cochleas, but not between the two types of graft.

Cochlear implantation has become established in children as a means of rehabilitation of profound hearing loss (Dawson et al 1992). Early implantation has been shown to be important in order to gain the maximum benefit for both hearing and speech development. One potential hazard of cochlear implantation is the spread of infection from the middle ear to the cochlea via the electrode tract. This is of particular concern in young children because of their susceptibility to otitis media (Ingvarson et al 1990). Suppurative labyrinthitis could lead to loss of auditory neurons (Clark et al 1975, 1977), as well as intracranial complications (Schuknecht 1974). Fibrosis or new bone formation can lead to a loss of implant function (Clark et al 1988).

Clinical experience thus far indicates that there has been no increase in the frequency or severity of otitis media and labyrinthitis in implanted adults or children over the age of two (Cohen et al 1991). However, labyrinthitis has occurred in implanted animals with otitis media. Efforts have been made to develop sealing methods to protect the cochlea at the electrode entry site (Clark et al 1984). Animal models of otitis media with Staphylococcus aureus (Brennan et al 1985) and Streptococcus pyogenes (Cranswick et al 1987) were developed. These showed, even without grafting, that the healed round window membrane and a fibrous tissue sheath would resist the spread of infection to the cochlea. However, labyrinthitis was most likely to develop soon after implantation before the seal had adequately formed. A preliminary study with pneumococcal otitis showed that labyrinthitis occurred in recently implanted ears, with widespread loss of neurons (Berkowitz et al 1987). A more detailed study was required in order to follow this and is reported in detail elsewhere (Dahm et al 1994).

Materials and Methods

Twenty-one two month old cats were used in the formal study (Dahm et al 1994). Thirty-two ears were implanted...
under general anaesthesia with scala tympani electrode arrays, and nine were left unimplanted as controls. The array was inserted about 4mm into the scala tympani via the round window. Strict asepsis was observed and ampicillin was given at the time of surgery. The electrode array was similar to that of the Cochlear Pty Limited human implant, but with five electrode bands so that it was suitable for the cat.

In 14 implanted ears, no graft was applied to the incised round window membrane. Twelve were included in the study, as the electrode fell out in one ear and another became infected prior to the inoculation. Nine of the implanted ears were grafted with fascia and the other nine with Gelfoam®. Only seven of the Gelfoam® grafted ears could be included, as two developed pre-inoculation infection which resulted in severe labyrinthitis.

Eight weeks after the initial surgery, each ear was carefully reopened and inoculated with a virulent strain of Streptococcus pneumoniae which had been obtained from a child with meningitis. Gelfoam® was used to fill the middle ear and block the Eustachian tube, so that the organism would be retained and encouraged to multiply. The nine control ears were inoculated in a similar way. The animals were carefully observed for evidence of any adverse effects, such as otorrhea, but none occurred and no treatment was required.

One week after inoculation the animals were anaesthetized, the ears opened, observed for pus and swabbed for bacteria. The animals were then given a lethal dose of phenobarbitone and perfused with fixative and the temporal bones removed. The cochleas were trimmed and decalcified after the electrodes were carefully removed. They were then embedded, sectioned, and stained for light microscopy. The seven day interval was chosen as the effects of inner ear inflammation would still be in the acute phase and thus could be distinguished from infection at the time of implantation. Each cochlea was checked for evidence of an electrode tract and one was discarded as no tract was seen. Otitis media, serous, suppurative and resolved labyrinthitis were noted. Other features were new bone formation, neuronal loss, hydrops and structural damage. The effects of the relevant factors on outcome were evaluated statistically using Fischer’s exact test.

**Results**

Pus was present in all 41 middle ears. Only 37 ears were available for detailed study, as three had widespread chronic inflammation and in one case the electrode had slipped out. This had occurred prior to inoculation. Thirty-five ears had histological evidence of otitis media. Streptococcus pneumoniae was cultured in 24, as well as Staphylococcus epidermidis in one and Gram negative rods in two cases.

The 37 available cochleas consisted of nine controls, twelve ungrafted implants, nine fascia and seven Gelfoam® grafted implants. Eleven showed evidence of serous or suppurative labyrinthitis. Four of the nine controls (44%), six of the 12 ungrafted implants (50%), one of the nine fascia (11%) and none of the Gelfoam® grafted implants (0%) were affected (Table 1) (Dahm et al 1994).

The statistical analysis showed no significant difference between the implanted ungrafted cochleas and the unimplanted controls in the rate of labyrinthitis (p=0.24; two tailed test). There was, however, a significant difference between the implanted grafted cochleas and those left ungrafted (p=0.03; two tailed test). There was no difference between the types of graft used.

There was also no relationship between the positive growth of pneumococci or histological signs of otitis media and labyrinthitis in the controls or grafted cochleas.

**Discussion**

A number of interesting points came out of this study. The first is the susceptibility of cats with pneumococcal otitis media to labyrinthitis, as indicated by a 44% rate in the unimplanted control animals. This organism, its toxins or associated inflammatory mediators, can penetrate the normal cat round window membrane (Franz et al 1984). There was a similar rate in the implanted unsealed cochleas (50%), so that the unreinforced healed round window membrane resembles the natural one. There was a clear benefit from grafting of the electrode entry site at the round window, with a rate of 11% for fascia and 0% with Gelfoam®. There was no statistical difference between the two types of graft and histologically both appeared as thick fibrous tissue. The Gelfoam® was completely replaced by fibrous tissue in eight weeks, and therefore provided protection once the fibrous tissue had become established.

Gelfoam®, however, may have drawbacks in the shorter term as a cochleostomy graft. It is a favourable medium for the growth of bacteria, and it should be noted

**Table 1**

<table>
<thead>
<tr>
<th>Description of cochleas</th>
<th>Incidence of bullae swabbed</th>
<th>Pneumococci positive</th>
<th>Incidence of labyrinthitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unimplanted control</td>
<td>9</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Implanted-ungrafted</td>
<td>12</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Implanted-grafted with fascia</td>
<td>9</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Implanted-grafted with Gelfoam®</td>
<td>7</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>37</td>
<td>24</td>
<td>6</td>
</tr>
</tbody>
</table>

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that two of the three cochleas excluded from the study because of pre-inoculation labyrinthitis came from the Gelfoam® grafted group.

**Conclusion**

This study is consistent with the clinical experience that there has not been an increased incidence of labyrinthitis with cochlear implant surgery. It is, however, a major complication and any means of preventing it is important. Therefore, it is strongly recommended that the electrode entry site in cochlear implantation be sealed with fascia or similar fibrous tissue.

**References**


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Dahm, M. C.; Webb, R. L.; Clark, Graeme M.; Franz, B. K-H.; Shepherd, R. K.; Burton, M. J.; ROBINS-BROWNE, R.

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