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Does the Intracochlear Position of an Electrode Array Impact Performance?

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BACKGROUND
Cochlear implants (CI) restore hearing by stimulating spiral ganglion neurons via multichannel electrodes inserted into the cochlea. Many types of electrode arrays have been developed and fall into three categories based on intracochlear position: perimodiolar (PM), lateral wall (LW), and midscala (MS) electrodes. PM electrodes are designed to hug the medial wall to reduce the distance between the cochlea and the spiral ganglion neurons and typically do not coil around the apex. LW electrodes are designed to remain laterally in the scala tympani, with longer array options capable of reaching the apex. MS electrodes are a new type of electrode designed to remain in the middle of the scala tympani, thereby avoiding contact with either the medial or lateral walls to decrease trauma and fibrosis. It has been hypothesized that PM electrodes may have improved hearing performance and longer battery life given their closer proximity to the spiral ganglion. With less electrical current needed to stimulate the spiral ganglion neurons at each electrode position, PM electrodes theoretically should offer improved speech discrimination. When considering electrode type, however, the surgeon must also consider other factors that vary based on electrode type, such as insertional trauma, development of intracochlear fibrosis, transcalar positioning, battery life, and extrusion rates. This article summarizes the major advantages and disadvantages of these electrodes to help guide this decision.

LITERATURE REVIEW
Since the development of PM electrodes, many studies have compared their design and performance with LW electrodes. A recent study by O’Connell et al. retrospectively looked at 184 patients (220 implants; mean age at time of CI 60.2 years) and showed that electrode type was predictive of scala position, with LW electrodes successfully placed in the scala tympani in 95.6% of patients compared to significantly lower rates for PM (48.7%) and MS electrodes (42.9%).1 Electrode placement completely within the scala tympani minimizes trauma to the surrounding structures because accidental translocation into the scala vestibuli damages the basilar and, potentially, Reissner’s membranes and the organ of Corti. Given the intracochlear trauma caused by interscalar translocation of the electrode arrays, the authors concluded that LW electrodes are likely the superior choice to PM. Their MS group was too small to draw conclusions.

Other studies have specifically compared which electrode type is better at preserving low-frequency hearing. Wanna et al. performed a retrospective study of 196 patients (225 implants, mean age at time of CI 63.7 years) looking at hearing preservation, which they defined as a postoperative air-conduction threshold ≤ 80 dB hearing loss (HL) at 250 Hz.2 They found that LW electrodes were more likely to preserve functional hearing when compared to PM electrodes at both short-term (2–3 weeks postoperative) and long-term (>1 year postoperative) follow-up. Although MS electrodes had 3.4 times higher odds of hearing preservation when compared to PM arrays in the short term, there was no significant difference between these two in the long term. The authors suggested that at least part of the reason for improved hearing preservation was that LW electrodes are more likely to remain within the scala tympani, causing less trauma.

Studies have also looked at outcomes in pediatric populations. Gordin et al. performed a prospective nonrandomized control trial involving 115 children to look for differences in performance between the Nucleus 24M straight array (LW), the PM Nucleus 24RC Contour, and the PM Nucleus 24RE with stylet insertion (Cochlear Ltd., Sydney, Australia).3 Children implanted with the 24RE PM
array had significantly lower electrophysiological thresholds and higher speech perception scores compared to the other two groups, which the authors concluded could be due to closer modiolar proximity. Jeong et al. looked at eight children who had bilateral CIs with a PM array on one side and a LW array on the other. Overall, the electrically evoked compound action potential, threshold level, and comfort level were lower for cochleae with PM electrodes; however, the dynamic range was wider in cochleae implanted with LW electrodes. Interestingly, based on postoperative radiographic imaging due to different insertion techniques, the basal electrodes of PM arrays were farther from the modiolus compared to LW arrays. Although three children reported slightly reduced (improved) battery consumption with PM electrodes, the battery life was not different enough to provide a practical advantage between the two.

Other groups have looked at electrode selection in specific types of cases, such as otosclerosis, where the side effect of facial nerve stimulation is more common. Matterson et al. performed a retrospective study looking at 59 adults with profound postlingual sensorineural hearing loss (SNHL) caused by otosclerosis who were implanted with a Nucleus straight LW (n = 35) or Contour PM (n = 29) electrode array (Cochlear). None of the patients with PM electrodes experienced facial stimulation, whereas 14 of 35 with LW CIs experienced facial stimulation during mapping.

BEST PRACTICE
Clinical presentation must drive electrode choice. LW electrodes have improved hearing preservation compared to PM, likely due to decreased entry into scala vestibuli; therefore, LW electrodes should be favored in hearing preservation cases. For adults with profound SNHL, data are still lacking to support one electrode type over another. For those looking for the lowest threshold levels, PM electrodes may be the best option, although more studies are needed to determine whether this translates into improved speech discrimination. In the pediatric population, the decision can be more complicated. Although PM electrodes can result in lower thresholds and improved word recognition, revision surgery is more likely over the lifetime of these patients, making LW electrodes an attractive choice because more force is required to remove PM than LW electrodes. For advanced otosclerosis causing SNHL, PM electrodes should be chosen to minimize risk of facial nerve stimulation postoperatively. Inner ear malformations require special attention to the type of deformity. More data are needed to see how MS electrodes compare in these outcomes. No single type of electrode array is suitable for all scenarios; however, as the criteria for cochlear implantation continues to expand and include more adults with residual hearing, the current trend to minimize insertion trauma and preserve hearing has led to increased popularity of the LW electrode. Other factors such as electrode length, stiffness, and insertion speed should be investigated further and may also prove to be important determinants to overall outcomes in addition to the designed intracochlear position of the electrode array.

LEVEL OF EVIDENCE
One study was a prospective nonrandomized control trial (Gordin et al.; level 2). One study retrospectively reviewed a prospectively acquired database (O’Connell et al.; level 3). Three studies consisted of retrospective cohorts (Jeong, Matterson, Wanna; level 4).

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BIBLIOGRAPHY