Electrode insertion and positioning with a cochlear implant

A review of clinical evidence and implications for best practice

Cochlea health

There are numerous factors that contribute to a patient's lifetime of hearing with a cochlear implant. Structural preservation and the impact of electrode choice on both short-term and long-term hearing performance are two pivotal components. The importance of cochlea health and modiolar proximity have also been shown to be critical success factors in providing functional benefits to long-term hearing outcomes.[1-3] Additionally, there is ongoing debate about the role of insertion depth on performance outcomes.

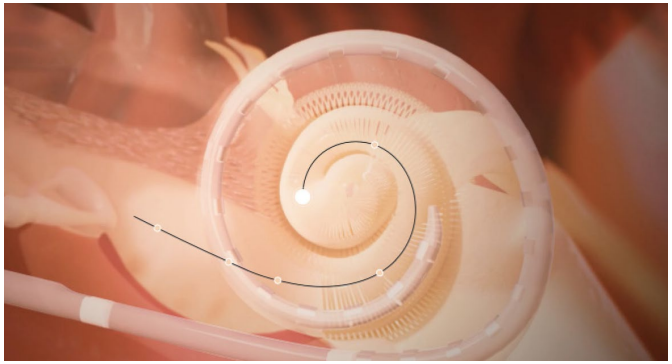
This article will review and compare the impact of electrode insertion depths and positioning to inform electrode choice. Understanding the evidence underpinning these factors will provide confidence in selecting the most appropriate electrode to help deliver a lifetime of hearing performance to patients.

Note: Complex cases, including anatomical abnormalities, may also impact implant selection and are beyond the scope of this article.

Insertion depth

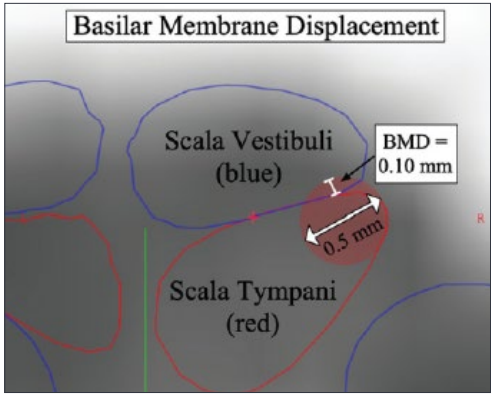
Angular insertion depth (AID) is typically defined as the angle measured from the round window (RW) to the most apical electrode contact. Research shows that there are potential risks and benefits associated with the varying insertion depths which are important to consider when selecting the most suitable electrode to meet the unique needs of the patient.

Full insertion



What does the evidence say?

Several studies indicate that a more shallow insertion depth is associated with better residual hearing preservation.[4,5] Additionally, shorter electrode arrays have been shown to provide a lower risk of cochlea trauma and translocations over longer electrode arrays that result in deeper insertion.[6] This is due to decreasing lateral wall scala tympani height, leading to basilar membrane displacement. Translocations generally occur around 380° and are more common with deeper insertions, with a significant increase in risk beyond 580° of angular insertion depth.[6]



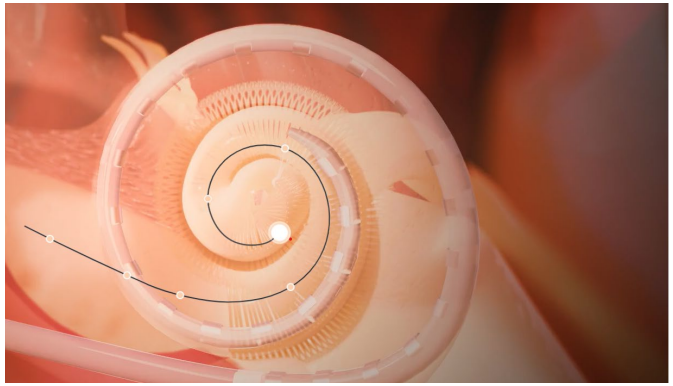
Reference: Morrel et al. (2020).

Additionally, some studies suggest a higher risk of incomplete insertion or electrode migration with lateral wall electrodes.[7-9]

What does this mean?

Whilst there is some variability in electrodes designed for full insertion to suit varying cochlea anatomies and surgical/clinical practices, an insertion depth between 1-1.5 turns (360°- 450°) may minimise the risk of trauma whilst maximising spiral ganglion coverage.[4-6]

Deep insertion



What does the evidence say?

Whilst some studies may suggest a potential positive correlation between insertion depth and improved audiological outcomes, this benefit is not conclusive. [10-14] This is due to the impact of other simultaneous predictors within these studies. Additionally, research shows the potential benefits may plateau beyond 360°.[5]

In contrast, other robust studies have shown a negative correlation between increasing angular insertion depth and speech recognition due to varying factors such as those outlined in the risks below.[4,5] The most important to highlight is the largest cohort study (n=484) showing a significant negative effect of deeper angular insertion with regard to speech discrimination.[5]

Due to the lack of conclusive evidence surrounding potential benefits of deeper electrode insertion or the use of longer electrode arrays, it is important to understand the potential risks.

What does this mean?

1. Scala translocation

- Lateral height of scala tympani reduces significantly beyond 450°, increasing the risk of trauma to lateral structures or translocation with lateral wall electrodes.[15,16]
- Higher prevalence of translocation than shallower insertions, with evidence showing a marked increase in risk above 580°.[17]

2. Cochlea trauma

- Forces on the lateral wall increase significantly beyond 360-450°, increasing the risk of trauma to the delicate structures of the cochlea.[15,16]
- Diminishing benefits given the increased risk of trauma with lateral wall electrodes to the basilar membrane/ cochlea structures.[18]
- Risk of pitch confusion and diminished speech recognition due to cross-channel stimulation.[5,18]

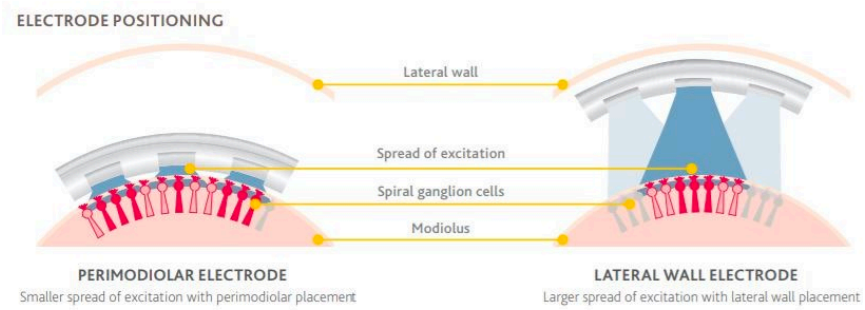
3. Basal buckling

- With the increase in insertion force required to drive a lateral wall electrode deeper into the cochlea, there is an increased risk of kinking of these electrodes. This occurs when the force required for insertion overwhelms the basal strength of the electrode.[19]

† The Hearing Zone is approximately 400-450 degrees into the cochlear, which has been determined from peer review articles. Stakhovskaya O, Bonham BH, Sridhar D, Leake P. Frequency Map for the Human Cochlear Spiral Ganglion. JARO. 2007 8:220-223 and Ariyasu L, Galey FR, Hilsinger R, Jr., Byl FM. Computer-generated three dimensional reconstruction of the cochlea. Otolaryngology Head Neck Surgery. 1989; 100(2):87-91.

Perimodiolar electrode positioning

In addition to electrode insertion depth, another factor to consider is electrode placement. With the Slim Modiolar Electrode the placement of the electrode close to the modiolar wall offers many key benefits, including:



- Consistent scala tympani placement
- Avoids contact with the lateral wall (near zero insertion forces)[26], reducing both acute and long-term trauma to the structures of the lateral wall, further supporting cochlea health and ongoing hearing outcomes.[3, 20-22]
- Equivalent angular insertion depth with a significantly shorter electrode length compared to that of a lateral wall electrode, requiring nearly half the volume of electrode and resulting in less perilymph disruption and foreign body reaction.[23-25]

	Lateral Wall		Slim Modiolar
	Full Insertion (up to 450°)†	**Deep Insertion (beyond 450°)†**	**Perimodiolar Positioning**
Audiological outcome benefit	✓	Variable	✓
Minimise acute cochlea trauma	Variable	×	✓
Long-term cochlea health	✓	×	✓
Spiral ganglion coverage	✓	✓	✓
Scala tympani placement	✓	Variable	✓

Key takeaways

There are a number of factors that need to be considered when choosing the optimal electrode for each patient, including their individual anatomy and hearing outcome goals.[27] Additionally, methods that preserve cochlea structures can significantly impact hearing preservation.[28]

Further studies and clinical investigations are needed to clarify the relationship of angular insertion depth and speech perception outcomes.

The most recent evidence suggests it is important to balance any theoretical benefit with the potential risks. Thus, it is imperative to prioritise optimal placement, perimodiolar electrode positioning, and minimising cochlea trauma when deciding on an electrode and surgical approach to support cochlea health and deliver a lifetime of hearing performance.

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