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Patient-Specific Electrode Array Selection for Cochlear Implantation

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Introduction

Patient-specific CI electrode array selection has to take account for the cochlear morphology and residual hearing situation. A preoperative estimation of the cochlear duct length (CDL) may avoid over/under-insertions during implantation.

This work aims to provide an equation that estimates the CDL for a given cochlear diameter (*A*) and for an intended angular insertion depth (θ).

Methods

- 15 human petrous bone specimens with implanted arrays (Med-El Flex28/Standard, Fig. 1)

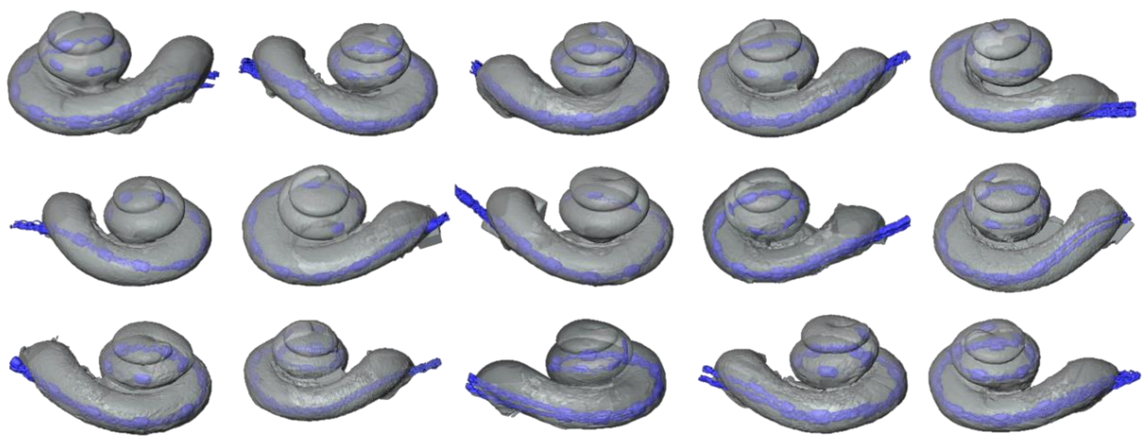


Fig. 1: MicroCT generated surface models of 15 human cochleae with implanted CI electrode arrays

- High-resolution microCT imaging (18 µm isotropic)
- Assessment of the cochlear diameter and the cochlear duct length (Fig. 2)
- Parametric fitting of logarithmic function [1]

$$CDL_{OC} = p_1 \cdot A \cdot \ln\left(1 + \frac{\theta}{p_2}\right)$$

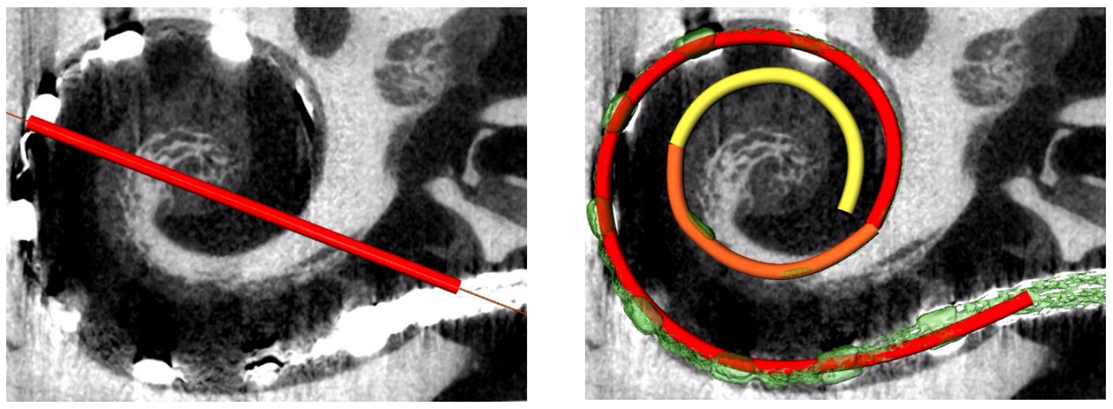
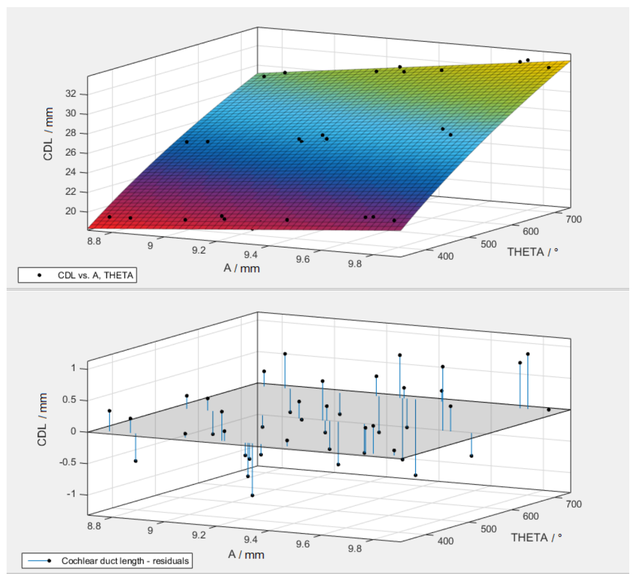


Fig. 2: CDL measurement using microCT images of a left human cochlea: the diameter of the cochlea (left) and the cochlear duct length (right).

Results

The following parameters were found after fitting (Fig. 3):



p_1 = 2.43
p_2 = 248°

Goodness of fit (n=15):
- r^2 = 0.988
- RMS-Error = 0.495 mm
- Residuals within ± 1 mm

Fig. 3: Data points, fitted surface (top), and residuals (bottom)

Figure 4 shows the CDL for a cochlea with a diameter of 7.0, 8.5, and 10.0 mm.

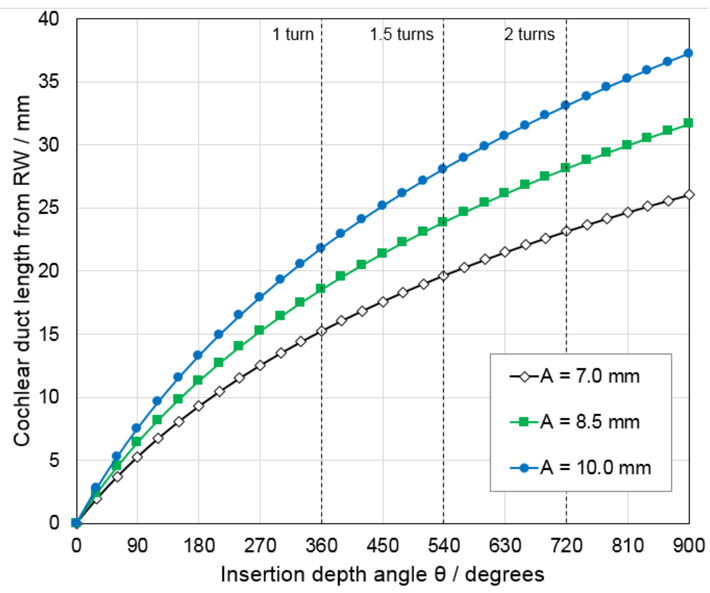


Fig. 4: CDL as a function of angular insertion depth for different cochlear diameters

Discussion

Evaluation of the fitting residuals suggests that the CDL at a given angular insertion depth can be estimated with ± 1 mm accuracy. The estimated values lie within the distribution reported in literature [2-4].

Conclusion

The derived equation could be used in the future as tool for the surgeon to enable preoperative CI electrode array selection, accounting for the patient's anatomy and residual hearing.

References

[1] Escude et al.: The size of the cochlea and predictions of insertion depth angles for cochlear implant electrodes. Audiol Neurotol 11 (2006)
[2] Hardy M: The length of the organ of Corti in man. Am J Anat 62 (1938)
[3] Lee J et al.: Depth of Electrode Insertion and Postoperative Performance in Humans with Cochlear Implants: A Histopathologic Study. Audiol Neurotol 15 (2010)
[4] Avci E et al.: Variations in Microanatomy of the Human Cochlea. J Comp Neurol Epub (2014)

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