Comparison of two alternative material approaches applied in a straight cochlear implant, a numerical study

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Abstract. Cochlear implant is the unique device able to replace the function of the hair cells, they bypass the malfunctioning auditory periphery and directly stimulate the auditory nerve. However, there are some risks associated with its insertion, mainly due its rigidity and size. This study intends to research ways of reducing the intracochlear damage using different implants design with two alternative material approaches.

Introduction

A cochlear implant is a safe and reliable electronic device for adult and children with severe to profound hearing loss. It can be considered a composite, consisting of an array of platinum contacts and wires (platinum-iridium 90/10) embedded in a silicone carrier material [1].

In children, the correction of hearing losses is crucial, since it allows the development of a spoken language. The age of implantation has been shown to be an important factor that allows for good outcomes in children, as the central auditory pathways present the maximum plasticity to sound stimulation during the sensitive period of the first 3.5 and 4 years of age [2]. However, cochlear implantation in the first age was associated with significantly steeper rate increases in comprehension and expression, as mentioned by Tajudeen et al. [3].

The insertion of the cochlear implant in the cochlea is a difficult process, due to the curvature of the bony labyrinth. On the present study, a finite element analysis will be conducted in order to simulate the insertion of the cochlear implant in a coiled human cochlea obtained through MRI - magnetic resonance imaging. Since the wires arrangement inside the electrode array plays an important role in the electrode flexibility, different wires arrangement will be studied in order to optimize the electrode and obtain a good adaptation to the cochlea curvature. Two different approaches will be used to model the implant material behavior. In the first approach, a homogenized hyperelastic material will be assumed for the cochlear implant matrix. On the second approach, the cochlear implant will be considered as a elastic matrix. Both approaches were reinforced with metal wires.

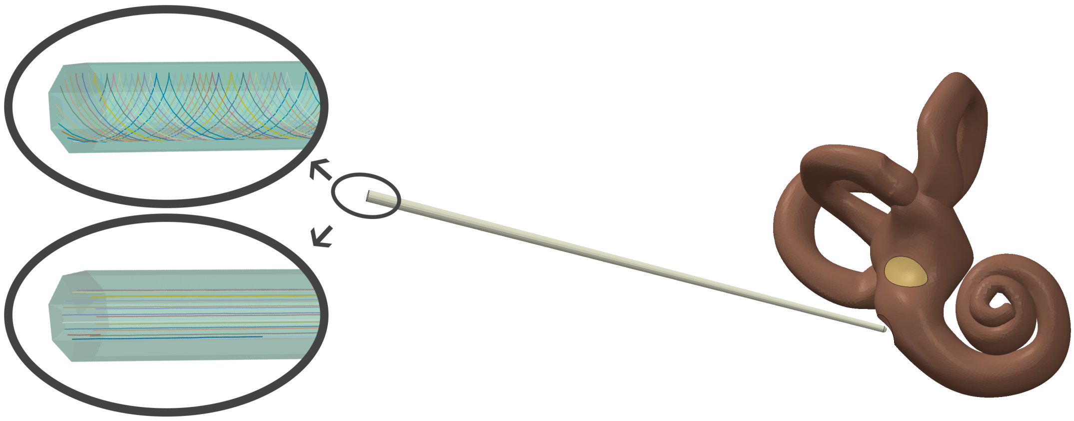

Figure 1: Finite element model of the human cochlea and a straight cochlear implant with two different wire arrangement.

Results and discussion

The evolution of the insertion force during the implantation, throughout the various steps associated with the cochlear insertion, will be obtained for both approaches. The study of the wires arrangement will allow decrease the electrode's stiffness and consequently the intracochlear damage, thus preserving the patient's residual hearing. Preliminary numerical results showed that both the insertion force and the contact pressure are affected by the wire arrangement. The comparison of the insertion force between both material approaches showed similar behaviors.

References

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