Intracochlear potential prediction accounting for bone conductivity uncertainty

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ABSTRACT

Cochlear implantation (CI) outcomes are highly influenced by patient-specific factors such as cochlear anatomy [1]. These factors do not only include geometrical aspects, but also material properties of the tissues. Concretely, electrical properties of the bone, which surrounds the cochlea, have an influence in CI outcomes since the current delivered by the implant is propagated through the bone. However, bone is the tissue with the widest range of material properties all over the body - depending on its localization and type - and the literature has reported bone conductivity values that range from 650 to 26.000 ohm·cm. Furthermore, determining electrical properties of bone is a challenging process and even unfeasible for in-vivo experiments. This uncertainty regarding to bone electrical properties can lead to wrong computational results of the potential field, and therefore wrong predictions provided to the clinicians. The objective of this work is to assess the effect of bone conductivity uncertainty in the outcomes of CI computational analyses on patient-specific models. In order to do so, we use a developed automatic framework for the generation of computational models of the inner ear [2]. It involves a statistical shape model built from high-resolution human microCT images, an algorithm for virtual insertion of the implant and an automatic finite element mesh generation. The framework allow us to obtain a final mesh of the implanted inner ear of the patient. By uncertainty quantification methods, such as Multi-Level MonteCarlo, we statistically explore the distribution of bone conductivity values, treated here as an uncertain input variable [3]. Electrical finite element simulations are carried out to compute the intracochlear potential, created by the electrodes activated, that will stimulate the closer nerve fibers. The results of this study will help to better understand how bone properties affect the electrical stimulation delivered by the implant. Furthermore, we can provide statistical characterization of the outcome that the patient may present after CI.

References

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