

: CSem Π **ARTORG CENTER Evoked Potential Energy of Bipolar Stimulation** BIOMEDICAL ENGINEERING RESEARCH

E. M. Calvo¹, D. Ferrario¹, J. Ansó², T. Wyss³, K. Gavaghan², Ph. Renevey¹, O. Chételat¹

²ARTORG, University of Bern ³ISTB, University of Bern ¹CSEM SA

Introduction

Cochlear implantation (CI) operations are very delicate and require precise mapping of the zone under operation, usually performed with µCT scan. Recent studies [1,2] have proved the feasibility to implement image guided CI. However, the proximity of the facial nerve (0.1 to 1.2 mm) during the drilling process is a challenge for the navigation system since an error can potentially damage the FN and could result in postoperative facial paresis. The goal of this study is to evaluate the potential of EMG-based neuromonitoring as a safety mechanism for identification and preservation of the facial nerve (FN).

To this aim, a dedicated Facial Nerve Monitoring (FNM) was designed integrating, a novel multi-anode stimulation probe, a configurable relay, a linear isolated stimulator, and measurements of two EMG channels and electrical impedance.

An in-vivo animal study was performed on 5 sheep with several trajectories planned with preoperative CT imaging. For each trajectory, 5 pre-defined depths were drilled close to the FN. At each depth the drill was swapped with the probe and the stimulation protocol applied (Figure 2). The proposed stimulation protocol [3,4] consisted of ten different current levels (0.1 to 3 mA) and 5 different pulse widths (50, 100, 150, 250, 500 us) for each of the cathode-



Data Analysis

Results

We analyzed the signal of the evoked potential of the EMG response as well as its relationship with the parameters of the input stimulations (pulse duration and amplitude). Our hypothesis is that an important feature like the energy of the EMG response to a positive non-saturated stimulation bears a correlation with the distance between the probe and the FN, or that a related feature could be used to alert the operator when approaching an unsafe zone (<0.3 mm).

Based on the EMG signal, the energy response is calculated at all drilling positions during the procedure. A map of the energy response for a given distance and cathode/anode pair (or monopolar) has been created. Each of these maps contains in each pixel the energy response information for each combination of stimulation pulse duration and amplitude (see Figure 2).

Results in Figure 3 show a discernable difference between the responses of the bipolar stimulation at the closest cathode-anode₁ (CA1) with respect to the monopolar stimulation. The confinement of the CA1 electric field provides a lower response at a further distance from the nerve (0.74mm), in comparison to the monopolar stimulation. However, for closer distances energy maps of both stimulations bear a higher resemblance. This difference in the energy maps calculated for all the sheep experiments is currently being analyzed to find statistically significant correlations between these energy maps and the distance to the nerve.





Figure 2: Block diagram of the features extraction and algorithm overview pipeline

Rue Jaquet-Droz 1

pulse duration

T +41 32 720 5111

Figure 3: Energy of evoked potentials for the monopolar and closest Cathode-Anode Pair (CA1) at several distances for Sheep1, Trajectory 7.

+41 32 720 5700

References

CSEM SA

[1] Ansó, J. et al., Feasibility of Using EMG for Early Detection of the Facial Nerve During Robotic Direct Cochlear Access, Otol. Neurotol., vol. 35, no. 3, pp. 545–54, Mar. 2014. [2] Bell B., et al., In Vitro Accuracy Evaluation of Image-Guided Robot System for Direct Cochlear Access., Otol. Neurotol., vol. 34, pp. 1284–1290, Aug. 2013. [3] Neuburger et al., Electric nerve stimulation in relation to impulse strength. A quantitative study of the distance of the electrode point to the nerve, Anaesthesist. 2001 Mar;50(3):181-6. [4] Urmey, W. F., Use of Sequential Electrical Nerve Stimuli (SENS) for Location of the Sciatic Nerve and Lumbar Plexus, Regional Anesthesia and Pain Medicine, Vol. 31, No.5, Sep-Oct 2006 [5] Ansó, J. et al., Facial nerve Preservation Using EMG during Minimally Invasive Cochlear Implantation, Journal of the Association for Research in Otolaryngology, submitted.

CH-2002 Neuchâtel