Quantitative rigidity and tremor evaluation using accelerometer during deep brain stimulation surgery - a preliminary study

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Introduction: Deep brain stimulation (DBS) is a common neurosurgical procedure for relieving movement related disorders such as Parkinson's disease. DBS presents uncertainties associated with suboptimal target selection, partially due to incomplete knowledge of the optimal stimulation site in the brain and suboptimal exploitation of the intra-operatively obtained patient data in general. Our aim was to evaluate the feasibility to objectively assess clinical effects obtained during intraoperative test stimulation based on acceleration measurements.

Methods: Two patients referred for bilateral DBS-implantation for the treatment of Parkinson's disease were included in the study. For one patient, rigidity was evaluated by fixing a 3-axis accelerometer on the neurologist's wrist during intraoperative test stimulation. While the intensity of stimulation current was increased, the neurologist continuously moved the patient's wrist to determine the moment of and the amplitude at rigidity release ("stimulation threshold"). For the other patient, tremor was evaluated by fixing the accelerometer on the patient's wrist during stimulation. In this case, the neurologist evaluated the stimulation threshold based on visual examination of variation in tremor. In both cases, for each test stimulation position, different mathematical features were determined and statistically compared a) for the time period before reaching the stimulation threshold identified by the neurologist and b) after reaching the threshold. We then statistically identified the stimulation thresholds that would have been chosen based on the acceleration signal alone and compared them to the ones subjectively identified by the neurologist.

Results: A statistical significant change in rigidity ($p<0.01$) could be identified for signal entropy, energy and standard deviation. The signal energy seemed to be the most sensible parameter showing a higher percentage change compared to the initial clinical state. The stimulation threshold identified based on the acceleration signal was in most cases lower than the subjectively determined one.

Conclusion: The present study has demonstrated the feasibility to perform rigidity and tremor assessments from the acceleration signal of the wrist. The stimulation threshold was confirmed by the acceleration measurements, and it seems that the measurements were more sensitive than the neurologist's evaluation. Results have to be confirmed by a larger clinical study, currently in progress.