Optimization of deep brain stimulation surgery for Parkinson’s disease with quantitative rigidity evaluation
Ashesh Shah, Jerome Coste, Jean-Jacques Lemaire, Etan Taub, Raphael Guzman, Erik Schkommodau, Simone Hemm-Ode

To cite this version:

HAL Id: hal-01865490
https://hal-clermont-univ.archives-ouvertes.fr/hal-01865490
Submitted on 31 Aug 2018

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers. L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Background
Deep brain stimulation (DBS) is now a widely accepted surgical treatment for Parkinson’s disease (PD). Electrodes are implanted in the patient’s brain after intraoperative test stimulation. Changes in parkinsonian rigidity during test stimulation are detected by an evaluator, usually a neurologist, by identifying changes in the resistance of the patient’s arm to a passive movement. We hypothesized that at the moment of reduction in rigidity, the speed with which the evaluator moves the patient’s arms increases and that this change and its amplitude can be detected with an acceleration sensor. The aim of the present study was to test this hypothesis by collecting data during DBS surgery. Furthermore, to know more about the optimal stimulation target, these quantitative data were categorized based on the anatomical location of the electrode during test stimulation.

Methods
- Clinical study (University Hospital in Clermont-Ferrand): 9 rigidity patients undergoing DBS surgery
- Preoperative manual outlining of sub-thalamic nucleus (STN) and its anatomic neighbors was done using iPlan (Brainlab, Feldkirchen, Germany, Figs 1A and B) and the target point was selected.
- Intraoperative microelectrode recording (MER) and test stimulations (Figs 1C and 1D) were performed.
- Maximum reduction in rigidity during passive movements and the corresponding amplitude (best clinical amplitude, BCA) were noted for all positions.
- 188 test stimulations in total.
- One anatomical structure was attributed to every 188 evaluations were distributed in 5 structures: 2 in Substantia Nigra, 3 in zona incerta (ZI) and Fields of Forel (FF).
- Results of Wilcoxon 2 sided rank test showed that BQAs were significantly lower in rigidity that were identified (best quantitative amplitude, BQA, Fig 3).
- BQA and BCA were compared using Wilcoxon 2 sided rank test.
- Data were grouped based on the anatomical location of the electrode during test stimulation.
- Data filtering and statistical feature extraction preceded normalization of features to baseline recordings.
- Effective stimulation amplitudes inducing a reduction in rigidity were identified (best quantitative amplitude, BQA, Fig 3).
- BQA and BCA were compared using Wilcoxon 2 sided rank test.
- Data were grouped based on the anatomical location in which the electrode was present during test stimulation for a particular position.
- Average BCA, Average BQA and number of side effect occurrences were compared for the STN, zona incerta (ZI) and Fields of Forel (FF).

Results
- Out of the 188 test stimulations, 138 evaluations were used for comparison between BCA and BQA. For 14 evaluations none of the thresholds were found, for 30 evaluations no BQA were found and for 6 evaluations no BQA were found.
- Results of Wilcoxon 2 sided rank test showed that BQAs were significantly lower than BCA (p<0.001, Fig 4).
- The 138 evaluations were distributed in 5 structures: 2 in Substantia Nigra, 3 in Thalamus, 27 in FF, 26 in ZI and 80 in STN.
- STN had the lower average values for BCA and BQA, but highest occurrences of side-effects. The comparison with FF and ZI can be seen in Figure 5.

Discussion
- The additional acceleration measurements during the surgery did not increase operation time or the patient’s discomfort.
- Higher sensitivity when using the accelerometer recording system; effective stimulation amplitudes were found for 33 additional test stimulations.
- Conventionally targeted STN requires the lowest stimulation amplitude to reduce rigidity, but has significantly higher chances of side effect occurrence. The Fields of Forel have slightly higher stimulation amplitudes but have much lower chance of causing side effects.
- Sufficient baseline data is necessary for proper identification of BQAs.
- There is an inherent subjective component in the acceleration analysis because the evaluation is done by the neurologist.

Conclusion
- Changes in rigidity of PD patients can be quantified during passive movements by measuring data from the evaluator.
- Acceleration measurements confirm the subjective evaluation, but they seem to be more sensitive (Fig 4).
- STN may not be the most efficacious target structure. The patient may benefit from an electrode placed closer to the Fields of Forel.

Acknowledgements
This research has been supported by the Swiss National Science Foundation (SNSF) and the Germaine de Stael program of the Swiss Academy of Engineering Sciences (SATW).

References

Dr. Simone Hemm-Odeo
T +41 61 4674-796
Contact: F +41 61 4674-701
simone.hemm@fhnw.ch

Ashish Shah
T +41 61 4674-413
ashish.shah@fhnw.ch

Dr. Jerome Coste
T +33 4 73 751 002
jerome.coste@u-douai.fr