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Background:
Deep brain stimulation (DBS) is a common neurosurgical treatment for the tremor of Parkinson's disease, essential tremor, and tremor of other causes. The outcome depends on optimal placement of the permanently implanted electrode. Many centers perform DBS surgery under local anesthesia in order to confirm the therapeutic effect with intraoperative stimulation testing. Visual inspection—the method generally used to rate changes in tremor during stimulation testing – is subjective, and its accuracy depends on the evaluator's experience [1]. This study presents the results of quantitatively estimating improvement in tremor during intraoperative stimulation tests in 15 patients. In addition, its influence on identifying the final position of the permanently implanted electrode is described.

Method:
We designed a 3D acceleration sensor system that is attached to the patient's forearm during surgery [2]. During intraoperative stimulation tests, at each different position, accelerometric data are synchronously recorded with the changing stimulation current amplitude. The method was applied in 15 DBS procedures in 2 centers (University Hospital Bern, Switzerland & University Hospital Clermont-Ferrand, France); the data were analyzed offline to assess improvements in tremor and to identify tremor-suppressing stimulation current-amplitudes. For correlation analysis, the quantitatively and visually determined improvements in tremor were categorized into: no improvement, low improvement, average improvement, high improvement and tremor arrest. The quantitatively identified tremor-suppressing current amplitudes were compared to those identified by visual inspection, in order to determine the influence these findings would have had on the position chosen for permanent electrode implantation if they had been used for intraoperative decision-making. As this was a purely observational study, the accelerometric measurements were not, in fact, allowed to alter the surgical procedures in any way.

Results:

A total of 359 evaluations were available for a comparison of the improvement in tremor identified by accelerometry vs. visual inspection. Of these evaluations, 156 (43.5%) were assigned the same categorie by both methods; 296 (82.5%) fell in the same or neighboring categories; and 63 (17.5%) were at least 2 categories apart. The quantitatively identified tremor-suppressing current-amplitudes were significantly lower than the visually identified ones (1.13 ± 0.8 mA vs. 1.7 ± 0.8 mA [mean ± SD]). Of the 26 finally chosen positions for permanent lead implantation, 15 would have been different had the accelerometric data been considered.

Discussion and Conclusion:

The improvement of tremor brought about by test stimulation was rated in the same category by visual inspection and by quantitative measurement (accelerometry) in only 43.5% of the evaluations that we made in this study. In some of the evaluations where there was only mild tremor at baseline, the stimulation-induced improvement in tremor was classified by visual inspection as tremor arrest, while accelerometry revealed a very mild residual tremor. This fact explains many of the instances in which the tremor ratings obtained by the two methods were only 1 category apart, but it cannot account for the 17.5% of evaluations that were 2 or more categories apart. The quantitative assessment of tremor as performed here yields different findings from assessment by visual inspection alone. The tremor-suppressing stimulation current-amplitudes are lower, and this, in turn, can often affect the chosen site for permanent electrode implantation. Thus, quantitative tremor assessment can affect, and perhaps improve, targeting in DBS without altering the routine surgical procedure. This tentative conclusion awaits confirmation by further studies. Moreover, aside from its potential direct clinical utility, quantitative tremor assessment DBS surgery might be a useful adjunct to the clinical testing of new types of DBS electrode

References

1 Griffiths RI, et al: Automated assessment of bradykinesia and dyskinesia in Parkinson's disease. J Parkinson's disease 2012;2:47–55.
2 Shah A, et al: A method to quantitatively evaluate changes in tremor during deep brain stimulation surgery. 6th International IEEE/EMBS Conference on Neural Engineering, 2013;1202–1205.