Novel Metrics in Virtual Reality Simulation to Assess Technical Skills in Neurosurgery

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Introduction

Conventional neurosurgical tools do not provide detailed quantitative information that are useful in the objective assessment of a resident's technical skills. Virtual reality (VR) simulators could be excellent systems to quantitatively analyze technical skills and improve our understanding of how and why surgical errors occur. The objective of our research is to demonstrate this potential through design and evaluation of novel validation metrics that can be obtained from the state-of-the-art simulation technology.

Methods

NeuroTouch is a VR simulator that provides the opportunity to assess neurosurgery skills with tactile feedback in virtual reality in controlled laboratory environments. We used NeuroTouch to simulate handling of CUSA when removing tumors with different visual and tactile properties. Novel assessment metrics were developed and used to study individuals with different levels of expertise: 16 staff neurosurgeons and fellows, 15 neurosurgery residents, 84 medical students, and 30 postgraduate students.

Results

Numerous metrics were obtained from the four participant groups. Based on the results, the staff neurosurgeons and fellows obtained the best average scores. The residents obtained better average scores in comparison with the medical students and postgraduate students.
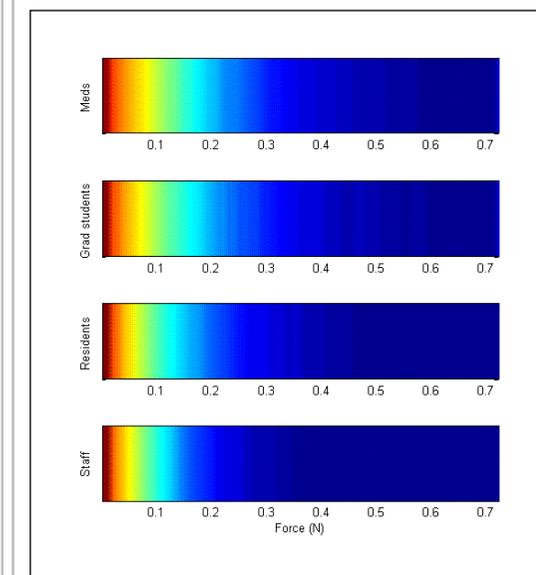
Basic metrics
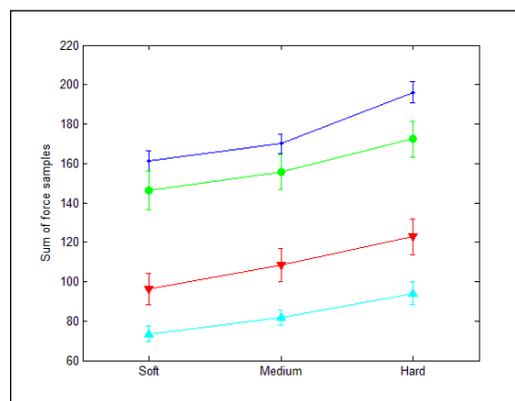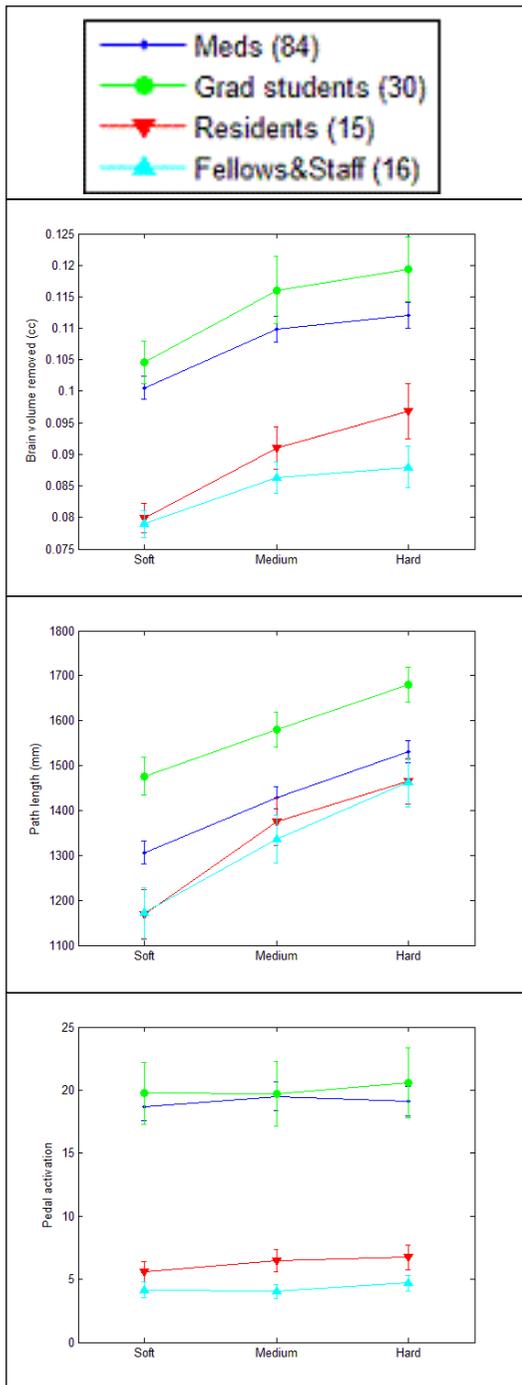
Advanced metrics
Spatial analysis of applied forces

For a resident

For a neurosurgeon
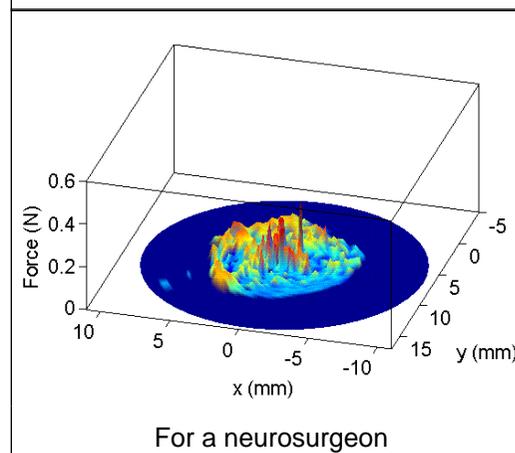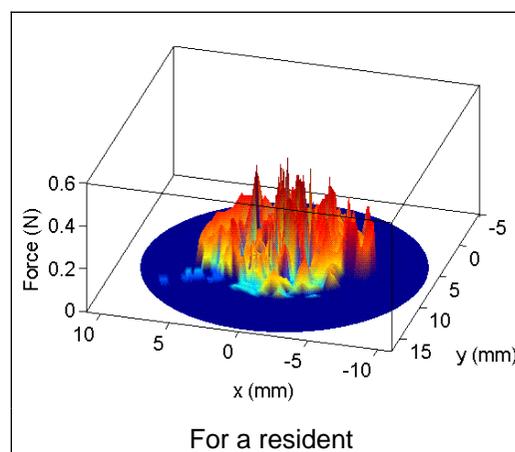
Frequency analysis of applied force

A histogram of the applied forces could shed light on how frequently various force values have been applied by an operator. The range of applied forces is smaller for groups with more neurosurgical experience.

Conclusion

The critical questions that need to be addressed in simulation research include "are we measuring what needs to be measured to advance resident technical learning objectives and can we teach these metrics?" The relevance of the obtained results with neurosurgical expertise establishes preliminary validity for the use of the NeuroTouch simulator and the proposed metrics. Further detailed statistical analysis of advanced simulated metric evaluation systems is essential to advance resident learning.