Virtual neuroendoscopy with haptic force feedback - a new device for neurosurgical training

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Purpose: Development and evaluation of a virtual reality (VR) system for the simulation of endoscopic 3rd ventriculostomy. Next to a design that is as close as possible to the real surgical environment the main focus was placed on the implementation of haptic information.

Method: Different software systems were used for segmentation (Vesuv), modelling (KisMo) and visualization (KISMET). A real hydrocephalic ventricular system was segmented from a high resolution 3D MR dataset. Based on this pattern, a hydrocephalic ventricular system with elastodynamic properties and a complete set of instruments (MINOP, Aesculap) were modelled. Different anatomical structures like vessels, plexus and fornix were modelled separately and integrated into the virtual scene. Haptic information was provided by a commercial force feedback system (PHANTOM 1.0, Sensable Technologies, USA). The operation scene was visualized on a workstation running Windows NT. Both risk structures (no touch areas) and the target at the floor of the IIIrd ventricle were defined. First evaluations of the system were performed with respect to an effect on surgical skill in untrained students.

Results: A configuration of a complex hydrocephalic system with realistic proportions could be modelled. An interactive preparation with force feedback was implemented by coupling real surgical instruments to the PHANTOM. The VR system provides different interactions like axial movement, rotation and angulations of the instruments, cutting, grasping as well as realistic elastodynamic deformations of the ventricle wall. First evaluations proved a reproducible learning effect resulting in a reduction of both unintentional contacts to no touch areas and the required time to reach the target.

Conclusions: VR systems can realistically simulate surgical procedures and may open new perspectives for the neurosurgical training. The integration of haptic information increases the quality of these training systems. The definition of no touch areas and targets and the possibility of automatic registration of both kinetic parameters and the time course of the procedure provide objective criteria for the appreciation of a learning effect.