Experience using intraoperative 3D ultrasound in conjunction with preoperative MRI in brain tumor surgery

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ABSTRACT

Objectives
Our group has developed a prototype neuronavigation system that combines the detailed preoperative anatomical information of MRI with the low cost and real-time advantages of ultrasound. The system includes a tracked 2D ultrasound probe, which enables acquiring a series of images that can then be reconstructed in 3D. The 3D ultrasound can then be viewed in parallel or superimposed on the preoperative MRI. When necessary, automatic correction of the ultrasound/MRI misalignment is also possible. The goal of this study was to determine the usefulness of such a system for brain tumor surgery.

Methods
The system was tested in a series of 18 brain tumor surgeries including both low grade and high grade gliomas. Ultrasound was acquired at two time points: 1) on the dura to compare tumor appearance from MRI to ultrasound and, 2) at the end of resection for residual tumor evaluation.

Results
All tumor types were visible on ultrasound as hyperechoic (bright) masses with easily identifiable cystic and solid components. Tumor size was generally similar, but tumor appearance occasionally differed. Imaging the first 5-10 mm below the dura was difficult. For that reason and because of tracking limitations, it was not always possible to image the entire tumor with ultrasound. The quality of the images obtained at the end of surgery to assess the extent of tumor resection was better acquired on dura than directly within the resection cavity. We also found that hemostatic agents created a bright imaging artifact that prevented accurate visualization beyond the agent.

Conclusion
Tracked ultrasound can help visualize tumor differences with the preoperative MRI, correct for misalignment due to intraoperative brain shift and facilitate residual tumor evaluation. When compared to conventional ultrasound, tracked 3D ultrasound enables point-to-point correlation with preoperative MRI that facilitates ultrasound image interpretation and understanding of real-time intraoperative anatomy.