A Versatile Optical Neuronavigator System for Intraoperative MRI

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Introduction

Recently, intraoperative MRI has become a useful part of image-guided brain tumor surgery. Since continuous scanning is not usually required in open surgery, and the surgery itself is ergonomically better outside most scanners, a simple procedure for registering intraoperative images to the patient is required. To facilitate patient positioning inside and outside the scanner, an optical navigation system equipped with fast registration capability was developed.

Material and Methods

A dedicated open 0.23 T Proview MRI scanner has been fitted with a modified Path 200 optical navigator system (Marconi Medical Systems, Cleveland OH, USA). The latter comprised an IR camera and trackers rigidly attached to the scanner, headholder and surgical tools. The navigation software transferred registration from the scanner to the headholder each time the patient was moved out of the magnet after imaging (1). The degradation of optical registration accuracy was found to be < 1.6 mm with 99% confidence level due to the transfer. The present scanner could be shut off during the surgical phase, allowing for ultrasound imaging and neurophysiological monitoring. Scanner reactivation took 6 minutes.

Typically, a large 3D MR image set with 3mm slices was first acquired. Outside the scanner, the principle of the common axis for tool registration (2) was applied to obtain multiplanar reconstructed MR images that were calculated relative to the relavent tool axis, i.e. in two planes along the tool axis and at the desired level in the perpendicular plane. Thus, the navigator system has been used in seven brain tumor resections to track the position of three types of surgical tools each fitted with optical trackers: A simple pointer (used for showing anatomical landmarks and tumor remnants), an ultrasound imaging transducer (for comparing real-time ultrasound and intraoperative MRI images, and for reducing the number of MRI imaging sessions during each case), and a cortical stimulator probe (for stimulation of critical areas in awake craniotomy).

Results

The pointer could be used in all cases as needed to find residual tumor indicated by intraoperative MRI. The navigator pointer was also used to confirm the preoperative surgical plan in two cases. In addition to precise craniotomy, selection of the appropriate sulcus or fissure for microsurgical exposition of the tumor was possible. Ultrasound (US) imaging provided a means to detect brain shift that would otherwise degrade navigation results. US was used in all cases to follow the approach to and resection of the tumor, and was aligned with the corresponding reconstructed intraoperative MR images in the last case. Color Doppler imaging in the same case displayed important blood vessels in the surgical volume. Navigation with the stimulator probe augmented the procedure when operating near the sensorimotor area. That is, the stimulation probe was guided towards to those regions which were detected to be active in the previously acquired functional MR images. Specially, the sensorimotor regions of the right arm and side were intraoperatively mapped in the DNET patient (Table 1.). Intraoperative MRI -assisted neuronavigation contributed to successful tumor management in all cases.

Implication

The present versatile navigation system serves to maximize the usefulness of intraoperative MRI, making the latter a necessary part of image-guided tumor surgery.

References
