Impact of Fiber Tracking on Neurosurgery Using an Intra-operative 3.0T MR System

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Introduction Diffusion Tensor Imaging (DTI) provides 3D knowledge of white matter tracts, fiber tracking and their relationship to surgical pathology. Image quality and definition is dependent on magnetic and gradient field strengths. The importance of prior knowledge of the white matter fiber tracts in relation to surgical lesion remains vital in the education of neurosurgical trainees.

Learning Objectives 1) To understand the importance of white matter tract anatomy in surgical dissection, 2) To appreciate how DTI helps in surgical planning and education.

Methods In 2009, a 3T intra-operative MR imaging (iMRI) system (Siemens, Erlangen Germany) was installed at the University of Calgary (1). This prospective study is based on 177 patients in whom DTI was acquired after anesthesia and patient positioning, prior to surgery. Axial DTI (20 diffusion direction) were acquired with 230mm field of view, 1.8X1.8X4 mm voxel size, 25 axial slices, 4-mm slice thickness, TR=4000 ms and TE=107 ms within a mean time 4min 26 sec. In conjunction with post processing of axial T_1 MPRAGE images in Neuro 3D application, intra-operative fiber tracking was accomplished using seed points placed either along known white matter tracts or adjacent to the surgical pathology. 3D reconstruction was performed (Siemens software) to illustrate the relationship of fiber tracts to the lesion. Changes to the planned surgical procedure were recorded and presented as *craniotomy placement*, *change in trajectory to the lesion* or *nature of surgical resection* (Fig 1).

Results Among the 177 patients, 140 had neoplasm out of which 56 were intra- and 83 were extra-axial, 21 had epilepsy, 12 vascular lesions, 2 radiation necrosis and 2 cerebral abscesses (Fig. 2). DTI sequences and demonstration of fiber tracts were acquired in 5-7 minutes. Of the 177 patients *craniotomy placement was modified in* **one**, *surgical trajectory was altered by 20-90° in* **eight** (Fig. 3-representative image) and in **twenty** *patients*, *fiber tracking modified the extent of resection or emphasized the importance of maintaining the pia/arachnoid plane* (Fig. 4-representative image).

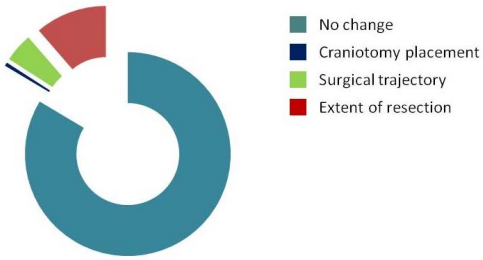

Fig. 1 Surgical planning based on iMRI and DTI

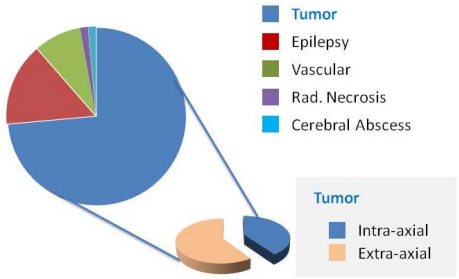

Fig. 2. Patient population (iMRI and DTI).

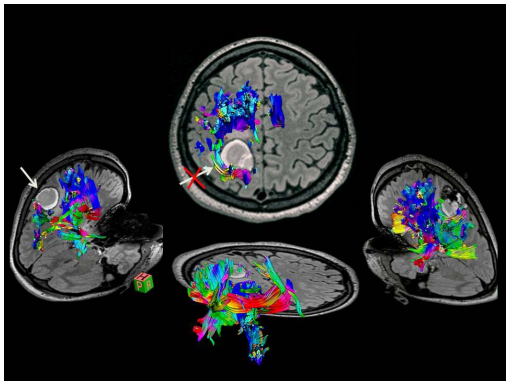

Fig. 3 Intra-operative T_1 weighted MR image with 3D reconstruction diffusion tensor fiber tracking from a patient with cavernous angioma: Surgical trajectory was modified based on the relationship of motor and sensory fibers to the lesion.

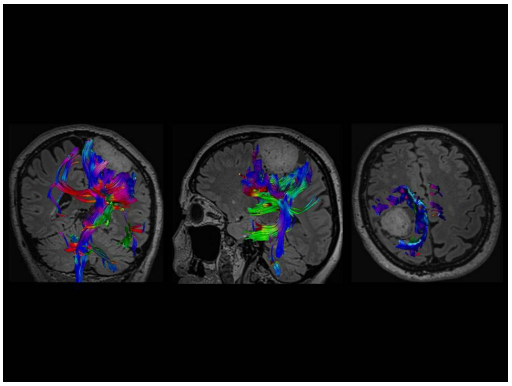

Fig. 4 Intra-operative fiber-tracking showing relationship of motor and sensory fibers to paracentral meningioma and therefrom, the importance of maintaining the pia/arachnoid during dissection.

In addition, in nearly every case, fiber tracking provided an educational platform for discussing white matter anatomy and the importance of its preservation during surgery.

Conclusions Intra-operative fiber tracking proved to be a valuable adjunct to neurosurgery affecting surgery in up to 16% of cases. Furthermore fiber tracking performed at the time of the surgical planning provided an excellent forum for the discussion of white matter anatomy amongst resident and staff neurosurgeons.

Reference: 1. Lang MJ, Kelly JJ, Sutherland GR. A Moveable 3-Tesla Intraoperative Magnetic Resonance Imaging System. *Neurosurgery* 68[ONS Suppl 1]168-179, 2011.