Diffusion Tensor Imaging to distinguish white matter displaced or infiltrated by brain tumours

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Introduction:

Using the principle of anisotropic water diffusion measured by magnetic resonance methods, diffusion tensor imaging (DTI) may be useful to assess the effects of intracranial tumors on the cerebral white matter. DTI may provide information on the position of white matter fiber tracts (using fiber tracking algorithm) e.g. for pre-surgical planning [1] or may help distinguishing peri-tumoral edema from infiltration [2]. In the peri-tumoral white matter, tracts that are infiltrated or destroyed by tumor cells may have altered fractional anisotropy (FA) and mean diffusivity (MD) compared to edematous but non-infiltrated tracts, which may show increased MD [2]. We hypothesize that differences between white matter displaced and infiltrated/destroyed by intracranial neoplasms can be detected by three DTI methods: FA, MD and fiber tracking.

Materials and Methods:

Thirteen patients with large (5cm or larger) surgically proven intra-cranial brain neoplasms were divided into two groups: Group 1 comprised those with infiltrative tumors (3 glioblastoma, 2 oligodendroglioma, 1 lymphoma) and Group 2 those patients with non-infiltrative tumors (2 metastasis and 5 meningiomas). All patients underwent pre-surgical DTI on a 3 T clinical scanner (Philips Intera) using single shot echo planar imaging sequence of TR 7000ms, TE 90ms, 3 mm section thickness, FOV 21-24, matrix 128x128, b=800s/mm^2, and 6 non-collinear diffusion directions. FA and MD values of the tumor and adjacent white matter edema were compared between groups using Student t test. Fiber tracking of the corpus callosum and corticospinal tract was carried out using the fiber acquisition by continuous tracking (FACT) algorithm, as implemented in DTI Studio[1]) with seed points placed in the corpus callosum and internal capsule respectively [3]. Two experienced neuroradiologists reviewed the fiber tracts by consensus reading to assess if they were displaced (intact fibers surrounding the tumor) or infiltrated/destroyed (decreased number of fiber tracts).

Results:

Although FA and MD of the peri-tumoral edema were lower in infiltrative tumors in Group 1 (0.200 and 1.591 x 10^{-3} mm^2/s respectively) than the non-infiltrative tumors of Group 2 (0.263 and 1.60 x 10^{-3} mm^2/s), these differences did not reach statistical significance. The FA and MD values within the tumor were also not significantly different between Group 1 (0.208 and 1.01 x 10^{-3} mm^2/s respectively) and Group 2 (0.196 and 1.46 x 10^{-3} mm^2/s). Using fiber tracking, the normal corticospinal tracts and corpus callosum not affected by the tumor were consistently identified. In patients from Group 1, decreased and discontinuous fiber tracts were found in the peri-tumoral region compared to those from Group 2, in whom intact but displaced white matter fibers were clearly depicted around the tumor.

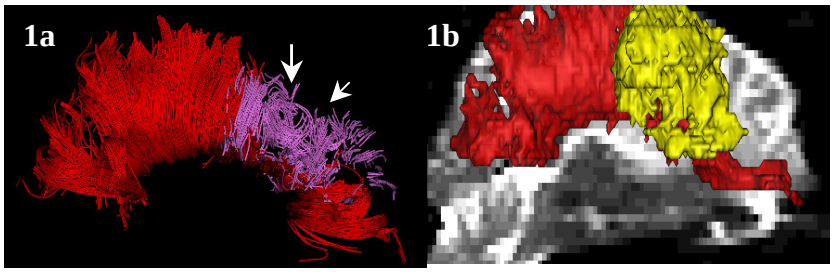

Fig 1: Fewer, discontinuous fragments of the corpus callosum (arrow, in purple) destroyed by an infiltrating glioma (in yellow).

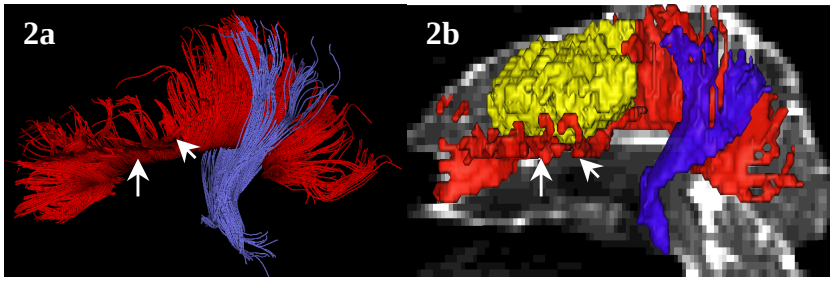

Fig 2: Intact fibers of the corpus callosum (arrow, in red) displaced around the large meningioma (in yellow).

Conclusion:

Our study verified that fiber tractography is more suitable for distinguishing between intracranial tumors than FA and MD measurements, as it can reliably demonstrate displaced and infiltrated/destroyed white matter fibers in individual patients. In addition to its usefulness for pre-surgical planning of brain tumors, fiber tracking may have another potential role in differential diagnosis between infiltrating and non-inflitrating neoplasms.

References:

[1] Mori et al, Ann Neurol 2002;51:377-380 [2] Lu et al, Am J Neuroradiol 2003;24:937-941 [3] Berman J et al, Neurosurg 2004;101:66-72

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