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Neurological picture

Diffusion tractography of axonal degeneration following shear injury

A 22-year-old construction worker presented after falling from a scaffold onto the vertex of his head. After suffering a brief loss of consciousness in the field, the patient was alert and oriented and without neurological deficits upon arrival to the Emergency Room. CT of the head demonstrated two small haemorrhages in the posterior aspect of the body of the corpus callosum, consistent with shear injury (fig 1). The patient was observed overnight and discharged the next day. Over the next several years, the patient had persistent cognitive difficulties, including memory loss and poor attentiveness, to the extent that he was unable to continue working. Diffusion tensor imaging (DTI) tractography performed 7 years after the original injury demonstrated severe disruption of white matter fibre tracts connecting the parietal lobes through the region of prior shear injury in the corpus callosum (fig 2).

Diffuse axonal injury (DAI) is one of the most important causes of cognitive disorders in patients with traumatic brain injury (TBI). DAI results from damage to the white matter caused by unequal rotation or deceleration/acceleration forces acting at the interface of tissues that differ in density or rigidity.[1] These forces stretch and injure axons, causing oedema, cytoskeletal derangement and axoplasmic leakage. Because DAI lesions are caused by shear strain deformation, they are known as shearing injuries. These lesions are typically located at the grey–white matter interface or within white matter fibre tracts.

Cognitive and behavioural disorders are often severe problems following DAI.[2] These disorders may interfere with the ability to function independently and with resumption of employment. An accurate evaluation of the extent of neural injury in DAI patients is essential for treatment planning, for developing a rehabilitation programme, and for providing appropriate counselling to patients concerning their cognitive disorders.

Figure 1 Axial unenhanced CT image of the brain demonstrates two small linear haemorrhages in the posterior aspect of the body of the corpus callosum (arrows), consistent with shear injury.

Conventional neuroimaging underestimates the true extent of DAI and inadequately localises axonal shearing within specific white matter tracts for correlation with functional deficits.[3] DTI is a type of MRI that can characterise the directionality of water diffusion in three-dimensional space. Within coherently organised white matter tracts with parallel fibre bundles, water diffuses more freely along the direction of the white matter fibres than across the fibres. This phenomenon, known as anisotropic diffusion, can be quantified at each

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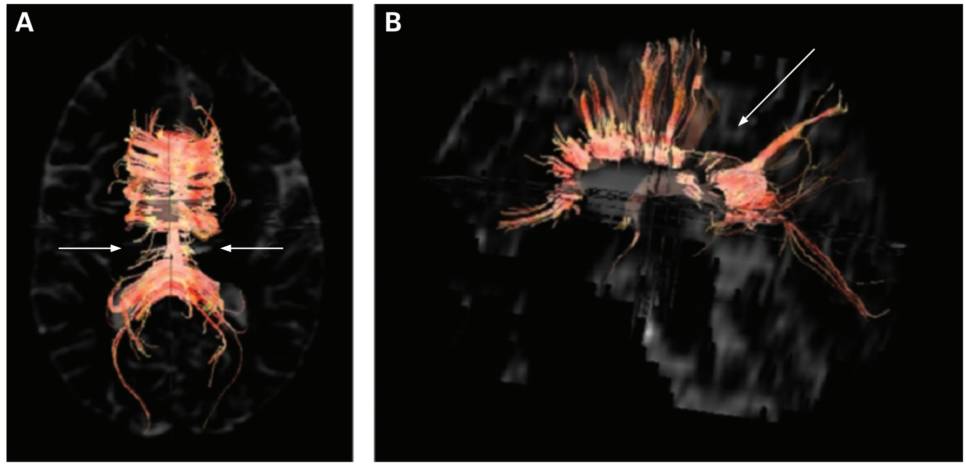

Figure 2 Diffusion tensor tractography in (A) superior and (B) lateral projections demonstrates severe disruption of the white matter fibre tracts extending from the parietal lobes through the region of prior shear injury in the corpus callosum.

voxel using DTI. The direction of diffusion determined using DTI is used to delineate the three-dimensional white matter connectivity among regions of the brain, a form of non-invasive *in vivo* tract tracing known as DTI fibre tractography.[4] DTI is reported to be useful in detecting white matter damage, which is not evident on conventional T1- and T2-weighted MR images.[5] In this case, the dramatic loss of anisotropy in the parietal white matter demonstrated by tractography is evidence of axonal degeneration due to the initial corpus callosum shear injury.

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