Diffusion MRI: A non-invasive window to histology of white matter

Diffusion-weighted magnetic resonance imaging (dMRI) has been used extensively to evaluate microstructural characteristics of white matter, and to infer long-range anatomical connectivity in the human brain. Several neurological disorders have shown extensive white matter diffusion abnormalities that are compatible with specific histological features. In particular, many patients with epilepsies of focal origin have white matter abnormalities located near and remote to the epileptogenic zone. Through histological evaluation of resected tissue of patients undergoing surgery, it has been confirmed that these dMRI abnormalities are related to axonal loss and myelin abnormalities. Similar dMRI changes are seen in other neurological disorders, yet caution is needed not to over-interpret findings, as similar diffusion patterns can result from other histological features. Tractography, the natural extension of dMRI that enables the visualization of macroscopic white matter fascicles, has allowed the investigation of anatomical connectivity and is being increasingly used in pre-surgical planning and prognosis of post-surgical deficits, such as visual field defects following temporal lobe resection. As with all non-invasive tools, these must be validated and their results interpreted in light of possible artifacts, such as spurious connections or lack thereof, particularly if using simple models, such as the tensor.