Imaging White Matter Damage in Multiple Sclerosis Using Advanced Diffusion MRI

Motivation

- Multiple sclerosis (MS) affects 400,000 people in the US, with 200 new cases diagnosed every week.
- It is the **leading cause of non-traumatic disability** in young adults and **affects patients during their most productive years**.
- It is common for patients with MS to experience worsening physical disability and cognitive decline without clear changes on imaging examinations such as magnetic resonance imaging (MRI).

Research Methods

- Our research leverages recent technological advancements for the Human Connectome Project through a custom-built MRI scanner equipped with ultra-high gradient fields up to 300 mT/m.

The Connectome MRI scanner provides **unprecedented sensitivity to white matter microstructure in the brain**

- We used the Connectome scanner to study axonal damage and myelin loss in 12 patients with multiple sclerosis.

Imaging Axonal Damage

Lesions in MS showed (A) increased axon diameter and (B) decreased axon density (white arrows), indicative of axonal loss and damage within (C) T2 hyperintense lesions (red arrow) in the corpus callosum, a major white matter bundle in the brain.

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Imaging Remyelination

- We also imaged the myelin g-ratio, defined as the thickness of the myelin sheath, which may be **more specific for lesions in varying stages of repair**.

Above: (A) FLAIR, (B) myelin, (C) axon density, and (D) g-ratio maps in an MS patient. Red arrow shows a lesion with elevated g-ratio > 0.8 suggesting more profound myelin loss, while white arrow shows a lesion with g-ratio=0.6, similar to surrounding white matter.

Conclusion

- Advanced diffusion MRI using the Connectome scanner provides specific evaluation of white matter damage and may improve monitoring of disease progression and treatment response in MS.

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