Diffusion Tensor Imaging of Cerebral White Matter

Technique, Anatomy, and Pathologic Patterns

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KEYWORDS

• Diffusion tensor imaging • White matter • Physiologic imaging • Magnetic resonance imaging • Anatomy • Brain

KEY POINTS

- Diffusion tensor imaging is a magnetic resonance (MR) imaging technique that allows visualization of location, orientation, and integrity of white matter pathways.
- Mathematical constructs underlying diffusion tensor imaging are complex, but a basic understanding can guide interpretation.
- Interpretation of diffusion tensor parameter maps in conjunction with conventional MR imaging techniques can aid in diagnosis of white matter development and disorders.
- Processing diffusion tensor imaging data via diffusion tensor fiber tracking tractography allows mapping of individual tracts, which can be useful in surgical planning.

INTRODUCTION

The use of diffusion-weighted imaging (DWI) is well established in the rapid diagnosis and evaluation of cerebral infarction,[1] as well as for identifying lesions such as epidermoids and, more recently, characterizing the cellularity of tumors.[2] Diffusion tensor imaging (DTI), an advanced form of DWI, is an important tool in evaluating white matter anatomy and in pathology.[3,4] Although originally a research tool and only used in academic centers, DTI has become a valuable part of the clinical evaluation of brain development, and in surgical planning for brain tumors.[5–8] The use of DTI has recently been investigated in the spinal cord.[9–11]

This article reviews the techniques of DTI and provides a practical approach for clinical implementation and interpretation. The anatomy of the white matter tracts, previously largely unseen by the radiologist, is increasing in importance (**Table 1**). This article reviews the fundamental

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Table 1
Major white matter tracts

Tract	Origin	Destination	Course	Function
Corticospinal tract	Precentral gyrus	Anterior horn cells of spinal cord	Traverses PLIC, cerebral peduncle, pyramidal decussation, lateral columns of spinal cord	Motor control for body
Corticobulbar tract	Precentral gyrus (inferiorly)	Pons	Traverses PLIC, cerebral peduncle, pyramidal decussation	Motor control for cranial nerves
Spinothalamic tract	Posterior horn cells of spinal cord	Rostral ventromedial thalamus	Lateral and anterior tracts in cord, anterior white commissure decussation, posterolateral pons, and midbrain	Sensory information from body to the thalamus
Geniculocalcarine tract	Lateral geniculate nucleus	Juxtacalcarine occipital cortex	Lateral margin of atrium and occipital horn of lateral ventricles	Visual fibers
Forceps major	Occipital cortex	Contralateral occipital cortex (homotopic)	Splenium of corpus callosum	Visual association
Forceps minor	Frontal pole cortex	Contralateral occipital cortex (homotopic)	Genu of corpus callosum	Frontal association
Central Tegmental Tract				
Ascending fibers	Solitary tract nucleus	Ventral posteromedial nucleus of thalamus	Midbrain and pons	Ascending taste fibers