Diffusion Weighted and Diffusion Tensor Imaging: A Clinical Guide

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Diffusion-weighted imaging (DWI) and its counterpart, diffusion-tensor imaging (DTI), are two powerful magnetic resonance imaging (MRI) techniques that have found multiple clinical applications. While extracting meaningful metrics from a DWI and DTI dataset has been an intense area of research for the past 20 years, quantitative diffusion-weighted MRI has not been fully integrated into routine clinical practice. The book, *Diffusion Weighted and Diffusion Tensor Imaging: A Clinical Guide*, by Dr. Leite and Dr. Castillo, presents a concise review of the role of diffusion-weighted MRI in the evaluations of the central nervous system and the head and neck in 15 chapters and 215 figures. In all, 32 experts in the field contributed to describe the clinical use of DWI and DTI in a wide range of medical conditions. The book is homogeneous in its presentation, which makes it very easy to read. Each chapter starts with a number of key points summarizing its contents and contains tables comparing the main DWI characteristics for various pathological conditions.

The initial chapter is a short and concise presentation of DWI and DTI basic concepts. Along with the presentation of standard water diffusion models and their derived parameters, the chapter discusses some unique technical aspects of DW MRI, such as the perfusion contribution to the signal decay measured by DWI/DTI methods, "T_2 shine-through" effects, and how the choice of **b**-values influence the estimated parameters. A number of artifacts are also discussed and illustrated using excellent-quality images. The following two chapters present the pathophysiological aspects of brain edema and the physiology and organization of white matter tracts. These chapters introduce important concepts for understanding the nature of DWI characteristics described in the following chapters. Chapter 4 is a review of the temporal/spatial maturation of white matter (WM) during the first 2 years of life, where changes in diffusion-derived metrics are clearly observed, while Chapter 5 deals with changes observed with aging. These chapters provide an overview of what are the expected natural variations in various DWI-derived parameters such as FA and axial/radial diffusivity, during maturation, and aging. Chapter 4 also explores the genetic and environmental effects on the spatiotemporal growth of different major WM fiber tracts as described by DW MRI. The numerous reports on the correlations of DTI measures between different WM fiber tracts and cognitive performance in confirm that DTI has great potential for clinical applications.

Chapter 6 deals with the most successful clinical application of DWI: the diagnosis of brain vascular pathology. The chapter includes a schematic description of the pathophysiology of stroke that illustrates the biochemical mechanisms driving cellular swelling and contrast changes in DTI-derived metrics. The various stages of stroke (acute, subacute, chronic) are explained and illustrated. The next chapter describes the use of DWI and DTI to diagnose, characterize, and monitor brain tumor lesions. Due to the complexity and variability of the various tumor types, the authors emphasize the need to combine these measurements with other approaches (spectroscopy, dynamic imaging) to improve specificity and sensitivity of tumor characterization. Chapter 8, focused on infectious diseases, is very complete and shows numerous examples of how to differentiate some of the common bacterial, fungal, and viral infections as well as parasitic diseases. Meningitis, ventriculis, herpes encephalitis, HIV, brain abscesses, toxoplasmosis, and many other infection types imaging features are described in 32 figures. A table summarizes the main DWI findings on bacterial infections, but not for the other types of infections, which would have been helpful to summarize the vast array of results presented here.

There are two chapters (9 and 10) regarding demyelinating diseases, with one focusing exclusively on pediatric diseases. The first chapter presents cases illustrating the difficulties encountered when conventional MRI findings overlap between syndromes and can mimic high-grade gliomas or other neoplastic lesions. As often, DTI offers additional parameters which can facilitate the tissue characterization and classification to a specific category. A large portion of the chapter is dedicated to the DWI of chemotherapeutic response to drugs (such as methotrexate or fluorouracyl), recreational drugs (such as cocaine and heroin), and environmental toxicity.

We should note that most of the DWI/DTI routine clinical data analysis remains largely semiquantitative. To generate quantitative results one must address the needs of measurement standardization and spatial coregistration of image data. In my opinion this should have justified a chapter on its own, but the reader can get an excellent overview of these issues in Chapter 11, which discuss the use of DWI for traumatic brain injury (TBI).

Chapter 12 illustrates many aspects of brains hematomas and its authors note that DWI of hemorrhage should be interpreted cautiously and always in conjunction with T_2- and T_2*-weighted MRI. In addition to the overview of the main applications of DWI and DTI in the brain, the book also reviews their applications in the spine and spinal cord and in the head and neck. Some of the DWI images and associated apparent diffusion coefficient (ADC) maps presented in necks are of relatively lower

quality due to susceptibility artifacts. It is noteworthy that recent technical developments such as small field of view and parallel imaging techniques have dramatically improved the prospective of DWI/DTI in these challenging areas.

The final chapter focuses almost exclusively on diffusion kurtosis imaging (DKI) as a potential future direction for clinical DWI. DKI relies on a different data analysis to extract parameters with higher sensitivity and specificity compared with DTI in identifying white and gray matter microstructure abnormalities. The authors also mention briefly diffusion spectrum imaging (DSI) and Q-ball imaging, which are high **b**-value diffusion techniques that are being developed as well. This is far from a comprehensive review of what is being currently developed in terms of new data collection schemes or new data reconstruction approaches. Nevertheless, it underlines the ongoing effort to provide robust quantitative DW MR methods in clinical settings.

In summary, *Diffusion Weighted and Diffusion Tensor Imaging: A Clinical Guide*, covers a broad range of DWI/DTI applications in the central nervous system. The book is well-written, nicely illustrated, and constitutes a great introduction for those clinicians and researchers who want to become familiar with the current clinical applications of the DWI and DTI techniques. It should also be a valuable reference tool for both practicing radiologists and residents within a clinical service.

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Level of Evidence: 5
Technical Efficacy: Stage 3

These clinical studies demonstrated the potential of diffusion to detect cartilage damage after injury, to early diagnose OA, and to measure cartilage remodeling after cartilage repair surgery. In this review, we provide a comprehensive overview of the literature on diffusion measurements on cartilage from ex vivo validation to its most recent clinical applications.