

**Optimization of diffusion-weighted MR imaging for body applications**  
**Dr. Dow-Mu Koh.**  
**Royal Marsden NHS Foundation Trust, Sutton, UK**

**Target audience:** Radiologists, radiology fellows & residents, MR technologists

**Objectives:**

1. To highlight growth of diffusion-weighted MR imaging in body applications.
2. To discuss technique of body diffusion-weighted MR imaging at 1.5T and 3.0T.
3. To learn optimization of diffusion-weighted MR imaging at image acquisition, as well as at imaging display and analysis.

**Defining the problems:**

Diffusion-weighted MR imaging (DW-MRI) produces unique imaging contrast based on differences in the mobility of water protons between tissues. Cellular tissues (e.g. tumours) have reduced water diffusivity, appearing high signal intensity on the b-value DW-MR images and return low apparent diffusion coefficients (ADC).

The technique can be performed at both 1.5T and 3.0T in the body. However, imaging at 3.0T is more challenging because magnetic field inhomogeneity at the higher field strength can lead to more image artefacts from chemical shift and suboptimal fat suppression.

Fat suppressed echo-planar spin-echo diffusion-weighted MR imaging is the technique that is most widely used for image acquisition at both 1.5T and 3.0T. However, the imaging sequence should be optimized to ensure the highest quality images are obtained. Furthermore, optimization of image display and analysis will aid workflow and help to avoid mistakes.

**Addressing the problems:**

In order to harness the full potential of DW-MRI, the imaging sequences should be tailored to specific indications, anatomical region, local machine hardware and technical expertise.

It is important to be consider whether the DW-MRI images are to be used primarily for visual assessment or for the quantification of ADC values. For visual qualitative assessment, an optimal b-value could be chosen, which would maximize the conspicuity of the disease relative to the background. For the calculation of ADC values, using three or more b-value should be considered to improve quantitative fitting of ADC.

Extracranial DW-MRI has been applied to nearly all anatomical regions in the body. The choice of technique and b-values are influenced by the area of evaluation. Generally, DW-MRI in the body is performed using b-values between 0 and 1000 s/mm<sup>2</sup>. However, in the breast and the pelvis, it may be advantageous to use higher b-values (> 1000

s/mm<sup>2</sup>). In the liver, because of the shorter T2-relaxation time of liver parenchyma, smaller b-values (< 800 s/mm<sup>2</sup>) are typical.

The choice of imaging technique depends in part on local machine hardware and available expertise. The fat-suppressed spin-echo echo-planar DW-MRI technique is most widely used. At 3.0T combinatorial fat suppression schemes (e.g. Short-tau inversion recovery with slice selective gradient reversal) may be needed to ensure optimal fat suppression. Imaging may be performed in free-breathing or in breath-hold. The free-breathing technique may be used in combination with respiratory and/ or cardiac triggering.

Imaging acquisition parameters are tweaked to maximize image signal-to-noise and to minimize artefacts that degrade image quality. Methods to increase signal-to-noise include using the shortest echo-time, increasing the number of signal averages, using coarser matrix size and larger partition thickness. The influence of a variety of imaging artefacts, such as motion, chemical shift, eddy currents, Nyquist ghosting, susceptibility effects and G-noise will be discussed and along with possible imaging strategies to reduce these, so that high quality DW-MR images may be consistently attained (1, 2).

A systematic approach to image processing and image display will help to improve workflow. Stacked b-values images, multiplanar reformats and maximum intensity projections can help to visualize disease. The b-value images should be interpreted with the ADC map and other anatomical T1/ T2-weighted images for best interpretation.

### **Conclusions**

DW-MRI is widely used to evaluate disease in the body. Imaging optimization will help to ensure consistency of results, reduce image artefacts and maximize benefits of applying the technique.

### **References**

1. Koh DM, Blackledge M, Padhani AR, et al. Whole-body diffusion-weighted MRI: tips, tricks, and pitfalls. *AJR Am J Roentgenol.* 2012;199(2):252-62.
2. Koh DM, Takahara T, Imai Y, Collins DJ. Practical Aspects of Assessing Tumors Using Clinical Diffusion-weighted Imaging in the Body. *Magn Reson Med Sci.* 2008;6(4):211-24.