Purpose:

The purpose of this study was to build diffusion phantoms and employ post-processing techniques for validating the diffusion spectrum imaging (DSI)-derived fiber orientation distribution function (ODF) in the crossing regions.

Methods:

To establish a ground truth, we constructed a phantom with a fixed crossing fiber configuration of 45° and another with 3 crossing fibers at 60°. Phantom construction involved hollow plastic capillaries which were filled with water and wrapped around a plastic plate to form a number of interleaved parallel layers resulting in fibers crossing at the desired angle. We also implemented a technique to de-convolve the response function of an individual peak from the overall ODF. The technique involves representing a DSI derived ODF with its spherical harmonic coefficients and performing the de-convolution using the Funk-Hecke theorem. Unlike the methodology in which deconvolution is applied to the spherical q-ball signal by Descoteaux et. al, (2009), our method applies it directly on the ODF derived from DSI. DSI data was acquired on the phantom on a Philips 3.0 T Intera scanner (with SENSE Flex M coil) using spin-echo echo-planar imaging (EPI) sequence with b-value of 6000 and 515 sampling points.

Results:

Our deconvolution methodology greatly improves the angular resolution of the otherwise un-resolvable peaks in the ODF. Quantification of a crossing region with 10x10 pixels in the 45° and 60° phantoms resulted in a successful detection with mean Â± sd of 44.6°Â±1.6° and 59.4°Â±6.8° respectively, while simultaneously sharpening the ODFs in regions containing single fibers.

Conclusions:

We developed a diffusion phantom with 3 crossing fibers for the first time. Our proposed methodologies significantly improved the angular accuracy of the crossing fibers and are applicable to ODFs obtained from other high angular resolution diffusion imaging such as Q ball imaging.