An Osage Orange As A Diffusion Imaging Phantom For The Evaluation Of Slice-Accelerated Diffusion Imaging Sequence

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TARGET AUDIENCE: MR physicist to evaluate and set the diffusion imaging sequence and parameters

PURPOSE: The evaluation of MR sequence and its parameters for the diffusion tensor imaging is a difficult topic because of the physiology noise in the in vivo study and the lack of a proper diffusion phantom. Available phantoms are structured to provide the proton signal outside the tube, which is opposite to the structure of the neuronal fiber. The magnetic susceptibility of the tubes in the phantom resulted in a directional dependence of the MR signal. Osage orange is a fruit with columns running from the center core to the surface. Each column was found to provide anisotropic diffusion. Therefore, it was used as a diffusion phantom to evaluate the effect of slice acceleration factor (SAX) in the slice-accelerated diffusion sequence [1] on the diffusion tensor tracts.

METHODS: An Osage orange that was picked up in a local park was placed in the 20-channel head and neck coil at 3T. The diffusion images with SAX from 1 to 4 were collected from the Osage orange using the slice-accelerated diffusion sequence with 64 diffusion weighting vector directions of b=1000 s/mm^2, voxel size = 2x2x2mm^3, and TE=98ms. TR was minimized for each SAX as 7.9, 4.0, 2.8 and 2.3 sec for SAX=1 to 4. The tensor and tracking were processed using the DSI Studio program [2]. A sphere to cover the center core of the fruit was used as a seed for the tracking. The tracking parameters were constant for all SAX images: FA threshold = 0.12 and angular threshold=30°. The statistics of tracts were compared for different SAX's.

RESULTS: Unlike the diffusion phantom, no angular dependency of the signal was observed. Indeed, there were tracts that radiated from the center core to the surface with a similar tracking parameters as the human brain (Fig. 1). The mean FA of the tracts was maximum at SAX = 2 while it was minimum at SAX =1 (Table 1). The mean tract length and tract count were also maximum at SAX=2 and they degraded fast as SAX increased. As SAX increased, the intensity of b=0 images decreased due to the shorter TR and consequent T1 saturation.

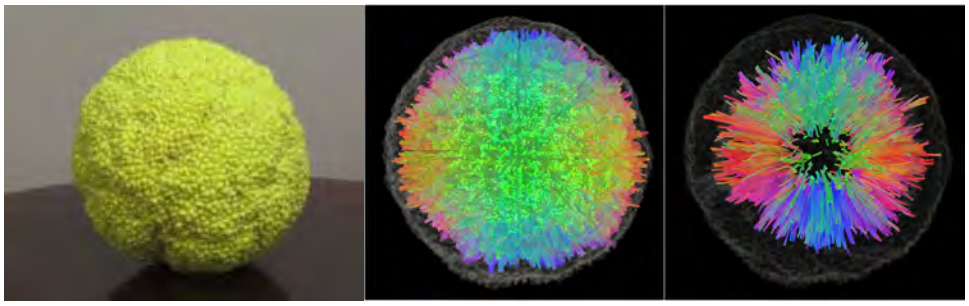

Fig. 1. A picture of Osage orange (left most) and diffusion tracts of SAX=1and 4.

SAX	1	2	3	4
mean FA	0.26	0.30	0.29	0.28
mean tract length (mm)	32.0	33.3	24.9	17.9
tract count	43239	47276	27296	6508

Table 1. Statistics of tracts of the Osage orange.

DISCUSSION: The shorter TR and increased T1 saturation at a higher SAX resulted in a reduced b0 image signal and accordingly an increased FA of the tracts [3]. However, the T1 saturation also degraded the signal-to-noise ratio of both b0 and diffusion weighted image. Therefore, as SAX increased beyond 2, both tract length and tract counts decreased.

CONCLUSION: The Osage orange was acceptable as a diffusion phantom and the tract distribution was circularly uniform without a directional attenuation of the signal. The Osage orange was useful in evaluating the effect of the slice acceleration factor on the diffusion tracts.

REFERENCES: 1. Setsompop K, et al. Blipped-controlled aliasing in parallel imaging for simultaneous multislice echo planar imaging with reduced g-factor penalty. Magnetic resonance in medicine : official journal of the Society of Magnetic Resonance in Medicine / Society of Magnetic Resonance in Medicine 2012;67(5):1210-1224. 2. Yeh FC, et al. Estimation of fiber orientation and spin density distribution by diffusion deconvolution. Neuroimage;55(3):1054-1062. 3. Jung KJ. Removal of partial volume averaging with free water in MR diffusion tensor imaging using inversion recovery for b0 image. Magn Reson Imaging 2014;32(6):619-624.