Tagged MRI of Ocular Tissues at 3T and 7T

Thomas Stewart Denney Jr[1,2], Nouha Salibi[3], Ronald Beyers[1], and Paul Gamlin[4]

[1]*AU MRI Research Center, Auburn University, Auburn, AL, United States,* [2]*Electrical and Computer Engineering, Auburn University, Auburn, AL, United States,* [3]*Research Collaborations, Siemens Medical Solutions USA, Inc, Auburn, AL, United States,* [4]*Department of Vision Sciences, University of Alabama Birmingham, Birmingham, AL, United States*

TARGET AUDIENCE: Vision scientists, ophthalmologists, and optometrists.

PURPOSE: To optimize cardiac sequences and use existing head coils in order to acquire tagged MRI of ocular tissues at 3T and 7T with high-resolution and minimal susceptibility artifacts with the goal of performing quantitative static and dynamic strain mapping (Fig 1).

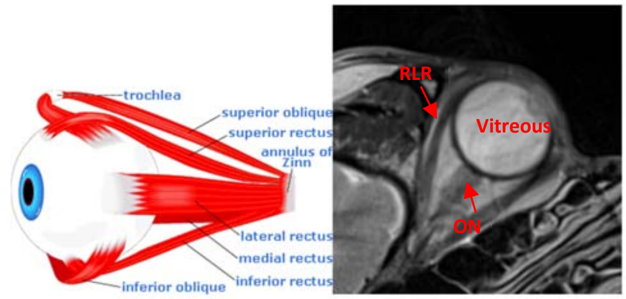

Fig. 1: (Left) Extraocular muscles. (Right) T2-weighted axial image of the right eye showing the right lateral rectus muscle (RLR), optic nerve (ON), and vitreous.

METHODS: Normal volunteers were imaged at both 3T and 7T while undergoing a smooth pursuit eye motion generated by tracking a white target that moved back and forth in a sinusoidal fashion on a black background (Fig. 2) [1]. An MPRAGE anatomical scan was acquired first with no eye motion for subsequent motion slice planning. The moving target (4° white square) oscillated with an amplitude of ±20° and a period of 2 sec. When the target was at the left-most position, the presentation program provided a trigger signal to the MRI scanner to apply tags and begin acquisition. Tagged image planes were approximately transverse, but were oblique on both coronal and sagittal orientations to align the planes parallel to the right lateral rectus muscle and in the rotation plane of the eye globe.

3T MRI: Tagged images were acquired in a double-oblique transverse plane with a standard cardiac, prospectively gated, fast low angle single shot (FLASH) gradient-echo sequence on a Siemens Verio 3T scanner (Siemens Healthcare, Erlangen, Germany) using a clinical 32-channel head coil. Scanning parameters were FOV: 125x180mm^2, 0.7x0.7mm^2 in-plane resolution, 3mm slice thickness, TR/TE of 9.0ms/4.2ms, flip angle: 10°, 300Hz/pixel. 27 phases were acquired during 1 sec for a temporal resolution of 37ms. Total acquisition time was 2 min.

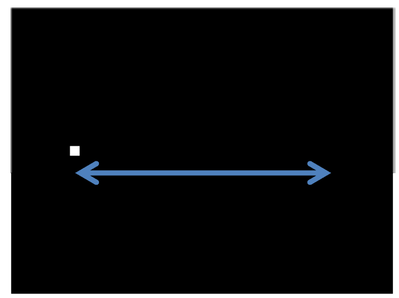

Fig. 2: Smooth pursuit stimulus.

7T MRI: Tagged images were acquired in a double-oblique transverse plane with a standard cardiac, prospectively gated, gradient-echo sequence on a Siemens Magnetom 7T scanner (Siemens Healthcare, Erlangen, Germany) using a 32-channel head coil (Nova Medical, Boston, Mass.). Scanning parameters were 0.44x0.44mm^2 in-plane resolution, 1.5mm slice thickness, TR/TE: 8.5ms/4.0ms, flip angle: 10°, 302 Hz/pixel. 16 phases were acquired during 1 second for a temporal resolution of 62.5ms. Total acquisition time was 3.5 minutes.

RESULTS: Fig. 3 shows minimum intensity projections of tagged images with orthogonal tag line directions at 3T from a 22y (left) and 45y (right) volunteer with apparent decreased viscosity of the vitreous indicated in the older subject (right). Fig. 4 shows images acquired at 3T at the rightmost and leftmost positions of the smooth pursuit stimulus. Fig. 5 shows images acquired at 7T at the leftmost (when tags were applied) and rightmost positions (maximum contraction of the RLR) of the smooth pursuit movement.

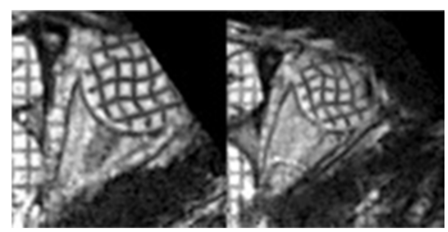

Fig. 3: Minimum intensity projection of two images with orthogonal tag lines acquired at 3T in a 22y (left) and 45y (right) volunteer show decreased viscosity of the vitreous.

DISCUSSION: Minor susceptibility artifacts were observed at 3T and 7T outside the region of interest. Previous work [1,2] used special sequences (CSPAMM) and a custom eye coil, whereas the methods in this study can be performed with standard sequences and coils. The viscosity of the vitreous is reported to decrease with age [2] and this is observed in the older volunteer in Fig. 3. Tagged images at 3T have sufficient resolution to quantify gross deformation of the RLR muscle (Fig. 4). At 7T, the increased spatial resolution is able to resolve differential motion in the medial side of the RLR muscle (Fig. 5).

CONCLUSION: Tagged MRI can be performed with standard coils and pulse sequences at 3T and 7T with minimal susceptibility artifacts. Post-processing techniques for quantitative strain mapping in the extraocular muscles, optic nerve and globe are under development.

REFERENCES

[1] Piccirelli et al *Inv Ophth Vis Sci* 2009. [2] Piccirelli et al, *NMR Biomed*, 2012

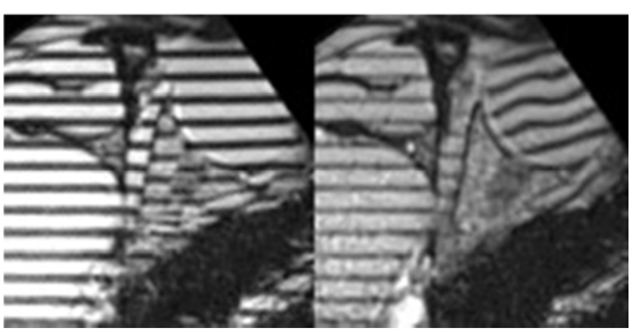

Fig. 4: Tagged images of the right lateral rectus muscle acquired at 3T at 0deg (left) and 40deg (right).

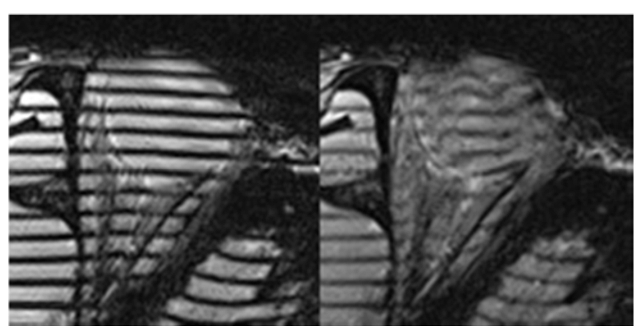

Fig. 5: Tagged images of the right lateral rectus muscle acquired at 7T at 0deg (left) and 40deg (right).