$T_{1\rho}$ MRI of the glenohumeral joint cartilage

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Introduction: Glenohumeral arthritis is a disabling condition and may severely affect quality of life and activities of recreation and daily living (1). Primary glenohumeral osteoarthritis predominantly occurs in older individuals; however, a younger cohort of patients has been recently described with end stage glenohumeral arthritis after shoulder arthroscopy (2). With shoulder injuries, either acute traumatic event or repetitive stress, the integrity of the cartilage may become compromised due to several factors such as abnormal loading conditions and repeated stresses. Injuries to the glenohumeral articular cartilage can be visualized with MRI, which is the only modality for detailed non-invasive assessment of this joint space. Osteoarthritic changes to articular cartilage such as loss and breakdown of proteoglycan molecules has been quantified with high sensitivity with $T_{1\rho}$ MRI (3,4). Therefore, the aim of this study was to develop a $T_{1\rho}$ MRI protocol to accurately quantify biochemical properties of the glenohumeral articular cartilage to monitor the development of cartilage degeneration in vivo.

Methods: All experiments were performed with approval from the Institutional Review Board and informed consent. Four individuals were imaged on a Siemens clinical 3 T scanner (Siemens Medical Systems, Erlangen, Germany) with a vendor-supplied shoulder coil. Two individuals were healthy men (mean 24 y/o), one female (22 y/o) who had a history of shoulder pain and discomfort, and one was a healthy older man (44 y/o). Volumetric $T_{1\rho}$ MRI (5) was performed with the following parameters: TSL = 5, 20, 40 ms, B_{1amp} = 500 Hz, TE = 3.41, TR: 484 ms, resolution: 0.54 mm^2 x 3 mm. 16 slices were acquired to cover entire volume of glenohumeral joint. ROI Analysis of cartilage $T_{1\rho}$ values was divided into three cartilage compartments: humeral head between the lesser tuberosity and scapula (top), humeral head within the glenoid cavity (bottom), and scapula within the glenoid cavity (scapula). The last two compartments are classified as the glenohumeral joint. Patients were supine with arm extended at their sides.

Results:
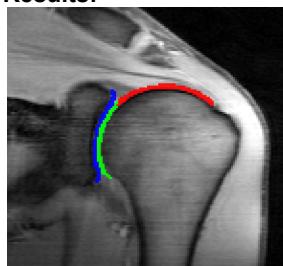
Figure 1: ROIs of the glenohumeral joint. Top of the humeral head (red), humeral head in the glenoid cavity (green) and scapula in the glenoid cavity (blue).
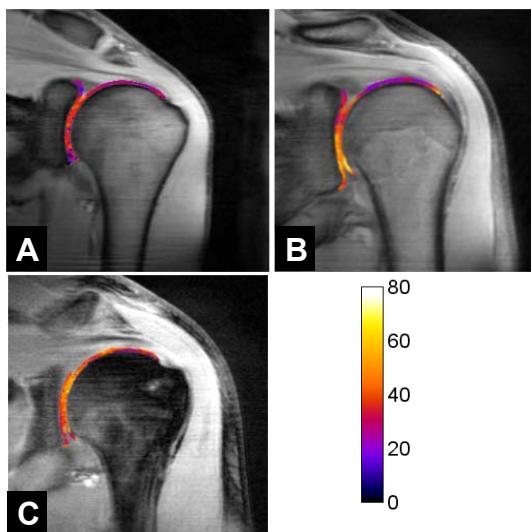
Figure 2: $T_{1\rho}$ map of a young healthy (A), young volunteer with painful shoulder (B), and old normal (C) shoulder overlaid on a $T_{1\rho}$-weighted image. Colorbar is in ms.
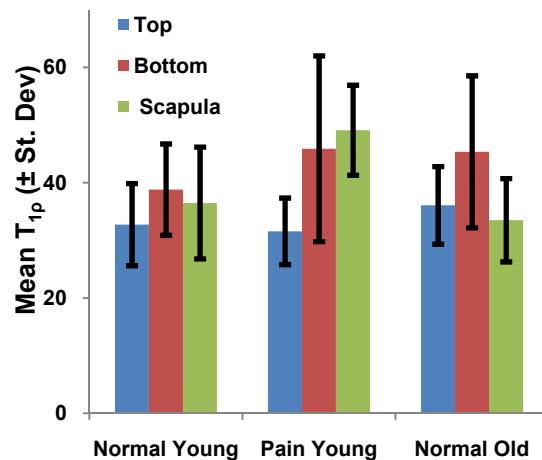

Figure 3: Mean $T_{1\rho}$ values for the three cohorts imaged. $T_{1\rho}$ values in the glenoid compartment cartilage are higher for the subject with pain but are not significantly high (mean z = 1.55). Mean values are noticeably higher in the humeral compartment within the glenoid in all cohorts suggesting increased articular damage.

Conclusions: The data presented demonstrate the feasibility of performing $T_{1\rho}$ MRI on the glenohumeral joint. Early findings show potential age dependent changes to cartilage in the shoulder similar to that of the knee which has been studied extensively. $T_{1\rho}$ quantification in the shoulder has seen to be significantly more challenging than on knee imaging as (i) cartilage is significantly thinner, (ii) visualization due to curved surface of the humerus and glenoid, (iii) patient movement of the humerus and scapula due to uncontrollable motion. Further imaging is currently ongoing to determine (i) age dependent cartilage degeneration as quantified by $T_{1\rho}$ MRI and (ii) quantify differences in dominant and non-dominant joints, (iii) volumetric changes in various cohorts. Future work utilizing this protocol will be applied to individuals who have had traumatic injury to the shoulder joint to quantify early onset degeneration of the cartilage tissue.

References: 1. de Beer J. et. al., Knee Surg Sports Traumatol Arthrosc 2010. **2.** McNickle A., et. al., Am J Sports Med 2009;37(9):1784-1791. **3.**Akella S., et. al. Magn Reson Med 2001;46(3):419-423. **4.** Borthakur A., et. al., NMR Biomed 2006;19(7):781-821. **5.** Witschey WRT, et. al., J Magn Reson Imaging 2008;28(3):744-754.