Detection of Patellofemoral Overload by $T_{1\rho}$ MRI

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Purpose: Patellofemoral pain syndrome (PPS) is a common ailment affecting the knee joint in young adults. There are a large number of causes of patellofemoral pain, including physical overload, patellar maltracking, and muscular dysfunction[1]. For clinicians, this large number of causes complicates the diagnosis and assessment of treatment options. Abnormal amounts of physical stress have been reported previously to cause changes to the macromolecular content of the cartilage matrix[2,3]. MRI can reliably detect a large number of disorders of the musculoskeletal system; however, conventional MRI is not accurate enough to detect biochemical changes to the cartilage matrix. Because of this, current diagnosis of patellofemoral overload in PPS patients relies on a combination of a physical examination and an assessment of patient history and symptoms, rather than imaging. Unlike conventional MRI techniques, however, emerging chemical exchange-sensitive MRI techniques, such as $T_{1\rho}$, allow for high resolution, quantitative detection of subtle biochemical changes in soft tissue. $T_{1\rho}$ imaging has been shown to reliably detect changes in the proteoglycan (PG) content in articular cartilage and to follow these changes in patients with osteoarthritis[4]. This study was undertaken to determine the capacity of $T_{1\rho}$ MRI to detect the presence of patellofemoral overload, a cause of patellofemoral pain, in patients presenting with PPS.

Materials and Methods: All human subject research was carried out in accordance with protocols approved previously by the Institutional Review Board of the University of Pennsylvania. Four subjects were recruited. Two male patients (ages 20 and 27) with PPS were examined by an orthopedic surgeon and were diagnosed on clinical grounds as having patellofemoral overload. One female patient (age 27) with PPS underwent the same examination, but was not diagnosed with patellofemoral overload. The remaining subject, a healthy volunteer (male, age 30), did not report patellofemoral pain or any other symptoms relating to the knee.

Conventional MRI and $T_{1\rho}$ imaging were performed on the symptomatic knee in each of the three subjects with pain and on a randomly chosen knee of the asymptomatic subject. All studies were performed on a 3T Tim Trio MRI scanner (Siemens, Erlangen, Germany) utilizing an 8-channel knee coil. 3D GRE-based $T_{1\rho}$ data was acquired with spin-lock times of 0, 10, 20, 30, and 40 ms, spin-lock amplitude (B_1 power) = 500 Hz, TR = 6 s, 0.5x0.5x3mm^3 resolution, and fat suppression. Shimming was performed on the region of interest including the patellofemoral compartment. The resulting data were then processed by calculating average $T_{1\rho}$ values over the patellar and femoral trochlear regions of interest. These regions of interest (ROIs) were then divided into medial and lateral sections for the purposes of analysis.

Results and Discussion: The two suspected overload patients exhibit approximately 15% increased average $T_{1\rho}$ values relative to both of the non-overloaded subjects (Fig. 1). However, analysis of each facet (Fig. 2) demonstrated a larger (>28%) difference in $T_{1\rho}$ values between the non-overload and overload subjects in both the lateral patellar and lateral femoral cartilage ROIs. As increased $T_{1\rho}$ is reflective of decreased levels of cartilage PG, this observation is consistent with previously reported changes in model cartilage PG during chronic overload[2]. However, this preliminary study represents, to the best of our knowledge, the first time that preoperative, specifically overload-generated $T_{1\rho}$ contrast has been seen in both the patellar and femoral trochlear cartilage ROIs in the human knee. In addition, our findings suggest that overload can be differentiated from other causes of patellofemoral pain. Additional work is in progress towards expansion of the study in order to recruit a larger cohort of patients, as well as utilizing more sophisticated statistical sub-regional analysis of the results, particularly relating to the relationship between the deep, middle, and superficial cartilage layers.

1

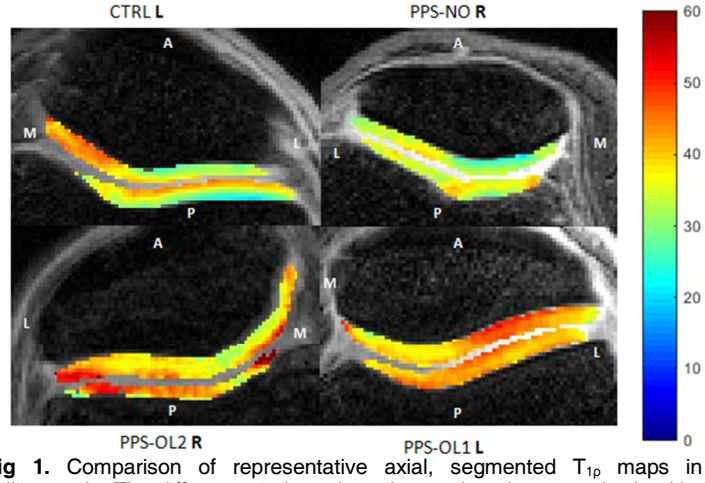

Fig 1. Comparison of representative axial, segmented $T_{1\rho}$ maps in milliseconds. The difference in lateral cartilage values between the healthy volunteer (CTRL) and non-overloaded patient (PPS-NO) and two overloaded patients (PPS-OL1 and PPS-OL2) is apparent.

2

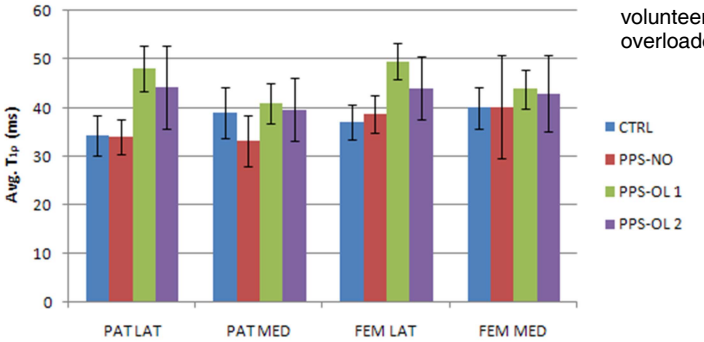

Fig 2. Comparison of average $T_{1\rho}$ values across patients, cartilage ROI, and mediolateral subsection. Average values for both overload patients (PPS-OL1 and –OL2) in the patellar lateral (PAT LAT) and femoral lateral (FEM LAT) ROIs are shown to be elevated compared to healthy volunteer (CTRL) and non-overloaded (PPS-NO) values.

References: 1. Juhn, MS, *Am Fam Physician,* 1999 Nov 1; 60(7) **2.** Wei, F et al. *J Orthoped. Res.* 2008 26:12 1636-1642 **3.** Roemhidt, ML et al. *J Biomech* 2010; 43:12:2301-2308 **4.** Borthakur A, et. al. *NMR Biomed* 2006;19(7):781-821

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