INTRODUCTION: Osteoarthritis (OA) is a degenerative disease of articular cartilage in synovial joints. The mechanical function of cartilage declines during OA progression, including the softening of the tissue coupled with increased friction and wear [1,2]. Structurally, cartilage wear is regionally nonuniform over the entire articular surface, and load-bearing regions often show more OA severity compared to non-load-bearing regions in the same joint [2].

Magnetic resonance imaging (MRI) is currently a gold standard for diagnosing late-stage OA. However, there still remains a need to advance imaging methods to better detect early- to mid-stage OA in vivo. Some success has been achieved with quantitative MRI, including T1ρ or T2 mapping [3,4]. Because OA severity influences cartilage mechanics, techniques that noninvasively measure internal deformation may further enable detection of OA in the earliest stages. Displacement-encoded MRI (deMRI) allows for the measurement of deformation, i.e., displacements and strains, in articular cartilage [5]. In this preliminary study, our objectives were to determine internal and regional strains in human OA cartilage by deMRI, and to evaluate the potential of deMRI to assay and detect OA in the earliest stages.

METHODS:

**Specimen Acquisition:** Human osteochondral explants were acquired from three male subjects (62.0 ± 1.4 years) who underwent elective total knee replacement surgery, with institutional approval. Cylindrical osteochondral samples (15 total; diameter = 6.0 mm, height = 3.5 mm) were harvested from standardized locations using a coring reamer and custom cutting jig (Figure 1). Two samples were harvested from each location; one was used for deMRI (described subsequently), and the other was used for histological analysis and comparison to deMRI (ongoing). The mediolateral orientation of samples was not clearly identified at the time of surgery. Consequently, for the current analysis, anterior femoral condyle harvest locations near respective wear tracks of exposed subchondral bone, most likely the medial femoral condyle [2], were herein referred to as the AF high wear condyle. Tibial explants were taken from low wear and non-load-bearing regions for comparison.

**deMRI:** Osteochondral samples bathed in PBS were cyclically and intermittently loaded with a flat indenter at 235 kPa and 0.33 Hz until they reached a quasi-steady state load-deformation behavior [5]. A 14.1 Tesla MRI system (Bruker Medical GMBH) noninvasively acquired displacement-encoded data through the center of the samples. A DENSE-FISP imaging sequence was used with a displacement encoding gradient area of 2.13 mm; FISP parameters were: TR/TE = 3.7/1.85 ms; in-plane spatial resolution = 100 x 100 × 256 pixels; number of averages = 4; slice thickness = 1.0 mm; flip angle = 25°. Displacement fields were obtained from imaging data using MATLAB (R2010b, Mathworks) software. Finite strains were computed as described previously [5]. The highest 20% of the data for each strain field were averaged to provide a single measure for comparison. This measure was used as a compromise between average strains (which did not adequately characterize concentrated high values) and maximum strains (that were susceptible to extreme local strains). A single-factor ANOVA test (α = 0.05) was used to determine significance.

RESULTS: Nonuniform displacement and strain fields were observed in the cartilage samples (Figure 2). Strains in transverse and loading directions, and shear strains, were all elevated in the AF high wear condyle (Figure 3). The ratio of transverse to loading strain was also found to be elevated in tibial samples. Strain variability at each location was large compared to means, and statistical results showed no significant difference between locations for any of the strains (p > 0.05).