Comparison of Three Methods to Quantify Repair Cartilage Collagen Orientation.

1Ross KA, 2Potter HG, 1Williams RM, 1Schnabel, LV; 1Bradica G, 1Castiglione EM, 3Saska RA, 3Fortier LA +Cornell University, Ithaca NY, 2Hospital for Special Surgery, New York NY, 3Kensey Nash Corp., Exton PA
Laf4@cornell.edu

Introduction: Histologic assessment of cartilage biopsies using polarized light (PL) microscopy has historically been considered as the gold standard for assessment of collagen orientation. More contemporary means to measure collagen alignment in vivo and non-destructively include quantitative 3Tesla T2 magnetic resonance imaging (T2 MRI), and multiphoton microscopy (MPM). The objective of this study was to compare the three methods (PL, T2 MRI, MPM) to determine which of them could quantitatively assess differences in collagen structure between repair and normal cartilage following a cartilage repair procedure. Our hypothesis was that all three imaging modalities would be quantitative.

Methods: In a previous study, mature goats underwent creation/repair of medial femoral osteochondral defects. Post-mortem gross evaluations and T2 mapping were performed. Samples from 5 goats were obtained for multiphoton microscopy for measurements of autocorrelation ellipticity, and for histologic staining with picrosirius red followed by polarized light microscopy and measurements of red, green and blue pixel intensity. The samples representing the worst gross tissue repair were selected in order for the imaging techniques to detect a difference. Regions of interest (ROI) for each type of imaging included central repair and remote host cartilage (>1cm from edge of defect) (Figure 1).

One sample t-tests were performed to determine if individual imaging techniques could detect a difference between central repair and remote normal cartilage. A value of p≤0.05 was considered significant. A McNemar’s chi-square test was then performed to assess agreement between imaging techniques that could detect a difference between central repair and remote cartilage measurements, as determined by the one-sample t-tests. A kappa coefficient was also calculated to account for chance agreement.

Results: There were visible and quantifiable differences in repair and normal cartilage imaged with MRI, MPM, and PL (Figures 2 and 3). Both MRI and MPM were able to detect a quantifiable difference between central repair and remote normal cartilage (p<0.01 and p=0.01 respectively), while PL was unable to do so (p=0.61). The mean ± T2 measurement for central repair cartilage was 38.12 ± 3.25 and for remote normal cartilage was 25.63 ± 0.56; mean MPM measurement for central repair cartilage was 3.75 ± 0.52 and for remote normal cartilage was 2.24 ± 0.23. The mean PL measurement for central repair cartilage was 16.43 ± 3.55 and for remote normal cartilage was 18.23 ± 4.28.

Discussion: Our results indicate that both T2 mapping and MPM provide quantitative, objective measures of collagen orientation, while the traditionally accepted method of polarized light microscopy might not be sensitive enough to detect a difference. This study suggests that either T2 mapping or MPM should be used as non-invasive measures of collagen orientation for assessment of cartilage repair procedures.

Significance: This study indicates that T2 mapping or MPM can be used to assess collagen orientation when evaluating cartilage repair in future in vivo studies. Further, the results suggest that histological analysis using polarized light does not provide additional or more sensitive data than T2 mapping or MPM regarding collagen orientation.