INTRODUCTION: Long head of the biceps tendon pathology is common, is often considered a source of shoulder pain, and is frequently present with rotator cuff tears [1,2]. However, the relationship between biceps pathology and rotator cuff disease is not well defined and as a result, controversy exists regarding its optimal treatment [3,4]. While degeneration, inflammation, and altered loading are thought to play a role, the mechanisms which lead to biceps damage remain unknown. Therefore, the objective of this study was to determine the histological, organizational, compositional and mechanical changes along the length of the biceps tendon following a rotator cuff tear to begin to assess the mechanisms of biceps pathology initiation. Our hypotheses were that: 1) histological, organizational and compositional changes will appear before mechanical changes and 2) changes in all properties will begin at the insertion site and then proceed along the length of the tendon.

METHODS: Sixty-five Sprague-Dawley rats (IACUC approved) underwent either sham surgery or detachment of the supraspinatus and infraspinatus tendons. Animals were sacrificed at 1, 4 and 8 weeks post-surgery for histological analysis (n=4-5 per group and time point) and at 4 and 8 weeks post-surgery for mechanical testing (n=8-10 per group and time point). For mechanical testing, biceps tendons were dissected out of the skin, fat and bone and pinned along the proximal biceps tendon insertion site, the portion of the tendon in the intra-articular space, and the portion of the tendon in the bicipital groove. Cross-sectional area at each of these locations was measured using a laser system [5]. To determine biomechanical properties, tensile testing along the long axis of the tendon was performed: preconditioning, stress-relaxation to 4% strain at a rate of 0.575 mm/sec (5%/sec) for 600 sec, and ramp to failure at 0.33/sec. Local strain was measured optically.

Additionally, sagittal sections (7µm) were prepared and stained with H&E to evaluate collagen organization using polarized light microscopy to measure angular deviation (an increase in which indicates more disorganized collagen) as well as changes in cell shape and cellularity. Finally, extracellular matrix proteins were localized in the biceps tendon using immunohistochemistry. One section from each specimen was stained for collagens type I, II, III and XII as well as proteoglycans aggrecan, biglycan and decorin [6].

Mechanical data and angular deviation were compared between groups at each time point using t-tests, and data is presented as mean ± standard deviation. For histological and immunohistochemical analyses, median grades were compared for each tendon location between groups at each time point using a non-parametric Mann-Whitney test.

RESULTS: After 1 week, area was unchanged at the insertion site, intra-articular space, and bicipital groove compared to sham (Table 1). However, at 4 and 8 weeks, area increased at all locations (Table 1). Modulus was not different at any location at 4 weeks, though by 8 weeks, modulus was decreased in the intra-articular space compared to sham (Fig 1). Angular deviation was increased in the intra-articular space at both 1 and 4 weeks (Table 2). After 8 weeks, angular deviation was increased at all locations compared to sham (Table 2).

After 1 week, a more rounded cell shape was seen in the intra-articular space with rotator cuff detachments (note that histologic and immunohistologic data is not shown in figures/tables). At 4 and 8 weeks, cellularity was increased and a more rounded cell phenotype was found in the intra-articular space and proximal and distal bicipital groove. Also at 1 week, aggrecan was increased along the entire tendon length and biglycan and collagens I and XII were increased at the insertion site. At 4 weeks, biglycan was increased in the intra-articular space and decorin was increased in the intra-articular space and proximal and distal grooves. Finally, at 8 weeks, there were trends for increased biglycan along the entire tendon length.

DISCUSSION: Results support the hypothesis that histological and organizational changes precede mechanics changes as more disorganized tissue and rounded cell shape were seen in the intra-articular space at 1 and 4 weeks followed by a decrease in modulus in the intra-articular space at 8 weeks. Immunohistochemical results support our hypothesis that changes begin at the insertion site as, other than aggrecan, all changes at 1 week were only at the insertion site. However, histological and organizational results indicate changes may begin in the intra-articular space. Importantly, while not all changes occur first at the insertion site, it was consistently shown that changes occur first in the intra-articular portion of the tendon before the extra-articular portion. These results illustrate that changes in the biceps tendon occur gradually over time, with histological changes preceding area and mechanical changes, and represent true degenerative changes rather than inflammation alone. Additionally, changes occurring first in the intra-articular space indicate that the biceps tendon likely plays an increased role as a load bearing structure against the humeral head in the presence of rotator cuff tears and these changes proceed along the tendon length with time. These results indicate that increased compressive loading on the biceps tendon in the presence of a rotator cuff tear may play a role in the development of pathology and therefore, rotator cuff repair may help to resolve these changes. Future work will focus on the effect of increased and decreased loading on the biceps tendon following rotator cuff tears as well as the effect of rotator cuff repair on the biceps tendon.

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