Supraspinatus and Infraspinatus Rotator Cuff Repair Prevents Mechanical Damage to the Intact Subscapularis Tendon in a Rat Model

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Introduction

Rotator cuff tendon tears are a common cause of pain and disability. An intact rotator cuff stabilizes the glenohumeral joint, allowing for concentric rotation of the humeral head on the glenoid. However, large tears involving the supraspinatus and infraspinatus tendons may disrupt the normal balance of forces, resulting in abnormal joint loading which can cause secondary damage to surrounding joint tissues such as cartilage and other tendons. As a result, surgical repair is often recommended to reduce pain and restore function. Our lab has previously shown that the properties of adjacent intact tendons (subscapularis and long head of the biceps) are significantly diminished following combined tears of both the supraspinatus and infraspinatus tendons.[1,2] However, it is unclear whether early rotator cuff repair can prevent the progression of these secondary degenerative changes. Therefore, the objective of this study was to determine if rotator cuff repair prevents mechanical damage to adjacent tissues (subscapularis and biceps). We hypothesized that rotator cuff repair will provide for superior adjacent tissue mechanical properties compared to no repair.

Methods

Experimental Design and Sample Preparation: Twenty adult Sprague-Dawley rats (400-450 g) underwent unilateral detachment of the supraspinatus and infraspinatus tendons (IACUC approved). Rats were then randomly assigned to two different treatment groups: no repair (n=10) or supraspinatus and infraspinatus (SI) repair (n=10). For both groups, the same approach to the rotator cuff musculature was used, followed by sharp transection of the supraspinatus and infraspinatus tendons from their insertions. Next, two parallel crossing 0.5 mm tunnels were drilled through the greater tuberosity of the humerus (with entrance and exit holes corresponding to the edges of the anatomic footprint of each tendon). For the repair group, the tendons were then reapposed to their insertion with a Modified Mason Allen technique. For the no repair group, the tendons were allowed to freely retract. All rats were sacrificed 4 weeks after surgery and frozen at -20C. At the time of testing, the animals were thawed and the scapula and humerus were dissected out with the biceps and rotator cuff tendons intact.

Tendon Mechanical Testing: Stain lines, for local optical strain measurement, were placed on the long head of the biceps and upper and lower bands of the subscapularis tendons (each tested separately).[2,3] Cross-sectional area was measured using a custom laser device. To determine biomechanical properties, tensile testing of each tendon was performed as follows: preconditioning, stress relaxation for 600 sec, and ramp to failure at 0.3%/sec.

Statistics: Significance between the two groups was assessed using a t-test (significance at $p<0.05$).

Results

For the lower band of the subscapularis tendon, the modulus was significantly greater in the SI repair group compared to no repair at both the insertion and mid-substance regions (Figure 1, TOP LEFT). Additionally, upper subscapularis modulus was significantly greater in the SI repair group compared to the no repair group in the mid-substance region (Figure 1,TOP RIGHT). No significant differences in area were determined in either tendon band (data not shown).

For the long head of the biceps tendon, modulus and area were not significantly different between groups (Figure 1, BOTTOM). No significant difference in tendon area was observed (data not shown).

Discussion

This is the first study to examine the role of rotator cuff tendon repair in the prevention of secondary degenerative changes in an animal model. Rotator cuff repair resulted in superior mechanical properties of the lower and upper bands of the subscapularis tendons relative to no repair (closer to pre-injury values[3]). Specifically, elastic modulus was significantly greater in the

Poster No: 1106
2013 Annual Meeting
Orthopaedic Research Society
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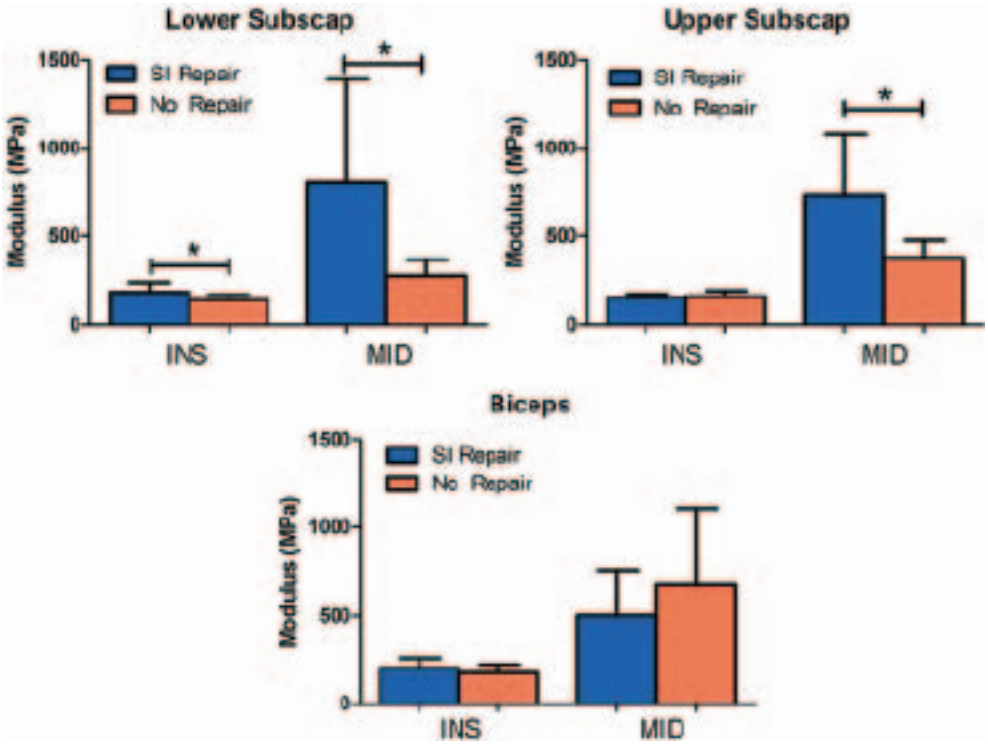

Figure 1. Following SI (supraspinatus-infraspinatus) repair, the lower band of the subscapularis tendon modulus is increased at the insertion and mid-substance (TOP, LEFT) and the upper band of the subscapularis tendon modulus is increased at the mid-substance (TOP, RIGHT). No differences were observed in the biceps tendon (BOTTOM). (Insertion=INS, Mid-substance= MID) (Mean±SD,* $p<0.05$).

lower band of the subscapularis tendon at both the insertion and mid-substance regions and in the upper band at the tendon mid-substance compared to no repair. These results suggest that early rotator cuff repair may help maintain subscapularis tendon loading by re-establishing the balance of glenohumeral joint forces and may therefore decrease the risk of anterior cuff tear progression. Interestingly, there was no improvement in biceps tendon mechanical properties observed with cuff repair. Clinically, the long head of the biceps tendon is often damaged in conjunction with rotator cuff tears. Management of biceps pathology is controversial, and surgeons often perform biceps tenotomy or tenodesis when repairing torn rotator cuff tendons to reduce pain and improve clinical outcomes. Results from this study suggest that rotator cuff tendon repair will not recover biceps tendon properties, lending support for augmentation of cuff repairs with biceps tenotomy or tenodesis.

Given the contrasting tendon results, it should be noted that the subscapularis and biceps tendons are functionally and organizationally distinct and therefore may respond in different manners to alterations in mechanical loading secondary to cuff tears. Specifically, the anatomy of the biceps in the rat (and human) is complex, comprising intra- and extra-articular portions, each with distinct nutrient and loading environments.[4] This study suggests that the biceps tendon may have less healing potential than the subscapularis tendon.

Future studies will examine alterations in cartilage properties and glenohumeral joint mechanics in order to elucidate the mechanism by which joint damage may be prevented following cuff repair.

Significance

This study suggests that rotator cuff tendon repair can prevent subscapularis tendon damage but is insufficient for restoring biceps tendon properties. Clinically, this supports early rotator cuff tendon repair augmented with biceps tenotomy or tenodesis in order to achieve optimal clinical outcomes.

Acknowledgements

This study was funded by NIH/NIAMS.

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