Biceps Detachment Does Not Worsen Shoulder Function in a Multi-Tendon Rotator Cuff Tear Rat Model

Thomas, SJ
Reuther, KE
Sarver, JJ
Tucker, J
Satchell, L
Glaser, DL
Soslowsky, LJ

University of Pennsylvania, Philadelphia, PA, USA,

Introduction

Rotator cuff tendon tears are common, especially in populations performing repetitive overhead tasks and in individuals over the age of 50.[1,2] Clinically, the most common rotator cuff tears involve either the supraspinatus only (SO) or both the supraspinatus and infraspinatus (SI). Our lab has shown that shoulder function is diminished following SI tears compared to SO tears in an overuse model.[3] In addition, biceps (long head) pathology is often found secondary to SI tears and clinicians often tenotomize or tenodese the biceps to eliminate pain. However, the consequences on shoulder function following detachment of the biceps remains unknown and clinicians currently rely largely on anecdotal evidence to guide treatment. For patients with an intact rotator cuff, releasing the biceps is commonly thought not to have any deleterious effects on shoulder function. As rotator cuff tears become larger, the biceps role on shoulder function may become more important. Therefore, the objective of this study was to examine shoulder function following SO, SI, and supraspinatus, infraspinatus and biceps (SIB) tendon tears in a rat model. We hypothesized that shoulder function would progressively diminish as the size of the injury increased.

Methods

Experimental Design: Forty Sprague-Dawley rats (IACUC approved) were subjected to a two week training period followed by 4 weeks of overuse treadmill activity as described[4] to induce a chronic, tendinopathic condition prior to undergoing unilateral detachment of the SO (n=19), SI (n=16), and SIB (n=5) to model an acute on chronic injury. Following detachment surgery, animals were returned to normal cage activity for the remainder of the study.

Quantitative Ambulatory Assessment: In all animals, forelimb gait and ground reaction forces were quantified using an instrumented walkway.[5] Data was collected one day prior to detachment surgery to obtain baseline ambulatory values and then collected at day 3, 7, 14, 28, 42, and 56 days after detachment surgery prior to sacrifice. Ground reaction force data, including medial/lateral (ML), propulsion, braking, and vertical forces were collected for each walk. At each timepoint, at least two walks were recorded per animal, as well as animal body weight. Parameters were averaged across walks on a given day for each animal and normalized to the animal's body weight for that day.

Statistics: To evaluate the ground reaction force data, separate 3 (group; SO, SI, SIB) X 7 (time; -1, 3, 7, 14, 28, 42, 56) ANOVA's with repeated measures on time were performed. To compare the main effect for group and time, Tukey post hoc tests were used. To examine the interaction between group and time, post-hoc, paired t-tests were used (significance at $p<0.05$). Prior to statistical analysis, multiple imputations were used for a small number (~1%) of missing data points due to the inability to record a successful walk for a specific rat during a specific timepoint.

Results

For ML force, there was a significant main effect for time (Fig 1). The pre-injury ML force was greater than all other timepoints. In addition, there was a significant main effect for group. The ML force of the SO group was greater than both the SI and SIB groups.

For the propulsion force, there was a significant main effect for time (Fig 2). The pre-injury propulsion force was greater than later timepoints (3, 7, and 14 days). In addition, propulsion force was significantly greater for the SO group than for both the SI (3, 7, 14, and 28 days) and SIB groups (7 days). The braking force of the SO group (data not shown) was significantly less than the SI groups at 7 and 14 days.

Finally, the vertical force had a significant main effect for time (data not shown). The pre-injury vertical force was greater than later timepoints (3, 7, 14, and 28 days). In addition, the vertical force of the SO group was significantly greater than the SI group (3, 7, 14, and 28 days) as well as the SIB group (7 and 14 days).

Discussion

This is the first study to examine the functional role of the biceps at the shoulder joint in a multi-tendon rotator cuff tear rat model. Results demonstrate that shoulder function is significantly altered with a combined supraspinatus and infraspinatus tear while an additional detachment of the long head of the

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sjthomasatc@gmail.com

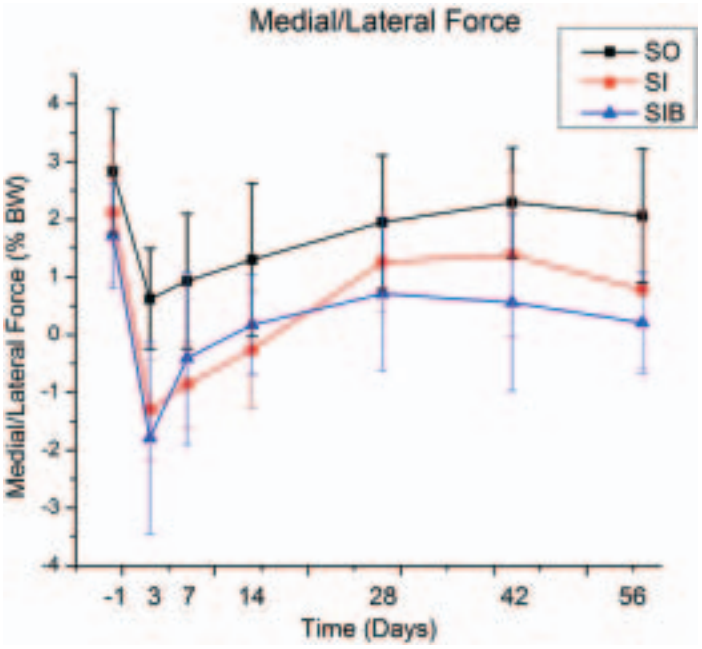

Figure 1. ML force (mean±stdev) at pre-injury through 56 days post-injury. Results demonstrate a significant difference between pre-injury and all post-injury timepoints. The SO group was significantly greater compared to both the SI and SIB groups.

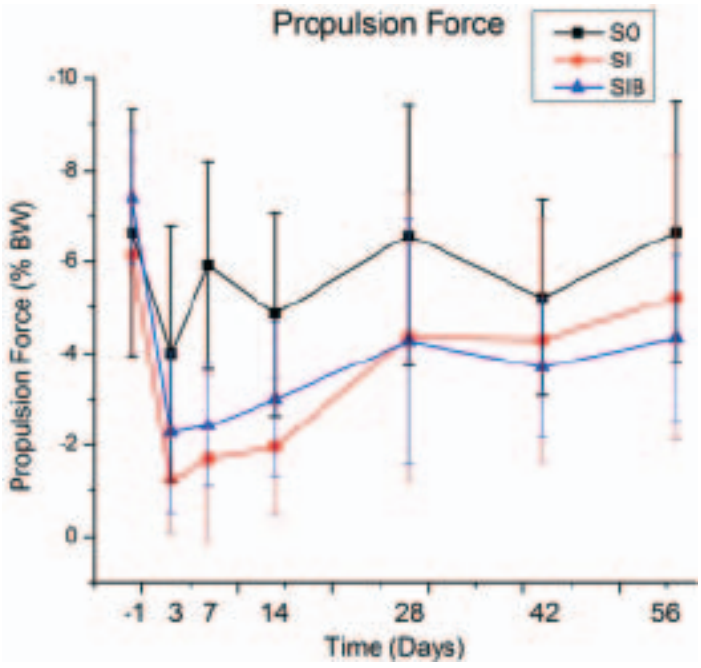

Figure 2. Propulsion force (mean±stdev) at pre-injury through 56 days post-injury. The SO group was significantly greater than the SI group at 3, 7, 14, and 28 days and also greater than the SIB groups at 7 days.

biceps tendon did not further diminish shoulder function. Specifically, injury caused a reduction in ground reaction forces and these decreases were larger for the SI and SIB groups compared to SO, but not different between SI and SIB. Furthermore, the directionality of the losses in ground reaction forces is consistent with the diminished dynamic function of the supraspinatus and infraspinatus at the glenohumeral joint. Consistent with our hypothesis, tears involving both the supraspinatus and infraspinatus decreased shoulder function compared to an isolated supraspinatus tear. Results suggest that the infraspinatus plays a significant role in shoulder function which is consistent with the anterior/posterior glenohumeral joint force balance concept.[6] However, contrary to our hypothesis, results demonstrate that a detachment of the biceps tendon does not further diminish shoulder function. Surgical management of biceps pain is controversial because it has been suggested that the biceps tendon plays an important role in shoulder function, particularly in the presence of a multi-tendon rotator cuff tear. However, in the case of a massive irreparable rotator cuff tear, our results suggest that tenotomy or tenodesis of the biceps may be recommended to manage pain because shoulder function was not further compromised in this model. Further investigation is required to determine the mechanical integrity of the remaining joint structures following a SIB injury.

Significance

Clinically, results suggest that the severity of diminished shoulder function following rotator cuff tears is dictated by disruption of the anterior/posterior force balance. Specifically, tears involving both the supraspinatus and infraspinatus decreases shoulder function while the additional detachment of the long head of the biceps tendon does not. This provides clinicians with valuable information to help guide treatment options for patients with massive rotator cuff tears that also have significant long head of the biceps pain.

Acknowledgements

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