Transosseous and Suture Anchor Fixation Techniques Restore Mechanical Interactions between the Supraspinatus and Infraspinatus Tendons

INTRODUCTION: The supraspinatus tendon is commonly torn and supraspinatus tendon repair techniques have been developed to restore shoulder function and reduce pain. Previously, we have shown that the supraspinatus and infraspinatus tendons interact mechanically such that conditions that cause increased strain in the supraspinatus tendon also cause increased strain in the infraspinatus tendon. However, the ability of a supraspinatus tendon repair to restore interactions between the supraspinatus and infraspinatus tendons has not been evaluated. Therefore, the objective of this study was to investigate whether “open” and/or “arthroscopic” supraspinatus tendon repair techniques restore strain levels in the infraspinatus tendon through a range of rotation angles. We hypothesize that: H1) infraspinatus tendon strain will be higher for each supraspinatus tendon repair technique when compared to the intact tendon case; H2) the effect of tendon repair on strain in the infraspinatus tendon will differ with changes in supraspinatus tendon loadings; H3) infraspinatus tendon strain will not differ between the two supraspinatus tendon repairs; and, H4) increasing supraspinatus tendon load will cause an increase in infraspinatus tendon strain.

METHODS: Ten cadaveric human shoulders (age 48.7±15.1 yrs) were dissected retaining only the humerus, supraspinatus and infraspinatus tendons. Tendons were air-brushed with fine black paint to create a speckled texture for subsequent texture correlation strain analysis using Vic-2D. The humerus was mounted in PMMA in custom grips and a controlled loading protocol was applied to the supraspinatus tendon. Throughout the experiment, a nominal, constant load of 9.8N was applied to the infraspinatus tendon. The supraspinatus tendon loading protocol consisted of preconditioning followed by a constant ramp to 90N. The loading protocol was applied to the intact supraspinatus tendon at neutral, 30° internal and 30° external rotations. A full-thickness tear was surgically created in the anterior 66% width of the supraspinatus tendon and then repaired with two techniques whose order was randomized. The loading protocol was repeated at all joint positions. Supraspinatus tendons were repaired first with either a modified Mason-Allen grasping suture with transosseous bone fixation (Trans) or with a “transosseous-equivalent” 4-suture-bridge arthroscopic (Arth) technique. Between repairs, the first repair was undone and the tendon was placed in PBS bath to recover prior to the second repair. Digital images were taken of the infraspinatus tendon insertion site throughout testing. At each testing condition, images at 5N, 30N, 60N and 90N were chosen for evaluation. Texture correlation, (a pattern matching algorithm) was used to calculate pixel displacements between the 5N loaded image and all other images. Maximum and minimum principal strains (MaxPS and MinPS, respectively) were calculated. To evaluate H1, data was normalized by the intact tendon case, and paired t-tests were used to compare the normalized repair data to control. To evaluate H2, data was normalized as the difference between strain for the repaired and the intact tendon case at each load, and one way ANOVA with repeated measures was conducted with a post-hoc Bonferroni test. To evaluate H4, data was normalized by strain at 30N, and paired t-tests were used to compare the normalized data. Significance was set at p<0.05 and a trend at p<0.1 (denoted by * and #, respectively).

RESULTS: In contrast to H1, at neutral and 30° internal rotation, strain in the infraspinatus was generally higher in the intact supraspinatus tendon than in either of the supraspinatus tendon repair cases (shown for 30° internal rotation in Fig 1 as bars below 1.0). At 30° external rotation, strain in the infraspinatus tendon was higher in the intact supraspinatus tendon when compared to the repair cases (data not shown).

In general, supporting H2, the difference between infraspinatus tendon strain associated with the repaired and intact supraspinatus tendon was greater with increased loads at neutral joint position (Fig 2A) and at 30° internal rotation (Fig 2B). At 30° external rotation, no increase was observed for average MaxPS or MinPS (data not shown).

DISCUSSION: Both supraspinatus tendon repair techniques restored infraspinatus tendon strain levels similar to intact values. Previous studies compared transosseous and arthroscopic supraspinatus tendon repairs by examining insertion site stress concentrations and pressure distribution.6,9 While transosseous repair was previously thought to more optimally restore intact tendon conditions, the evolution of arthroscopic repair has minimized the difference between the two techniques. Since both supraspinatus tendon repairs restore the tendon footprint contact, both were expected to restore interaction between the supraspinatus and infraspinatus tendon. Further, for both repair cases, the infraspinatus tendon experienced changes in strain that paralleled those experienced under loading of the intact supraspinatus tendon, further supporting the existence of mechanical interaction between the two tendons. Interestingly, the difference between strains in the infraspinatus tendon for an intact or repaired supraspinatus tendon increased with greater loads, implying that at larger loads, both repair techniques may fail to restore mechanical interactions between the two tendons. However, at the load levels evaluated, both repairs yielded similar results.

The mechanical interaction measured between the two tendons implies a shielding effect on the supraspinatus tendon from re-rupture. Since both repairs restore interactions between the two tendons, neither repair is preferred based on the current data and further study is needed.


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