



Biomechanical analysis of bursal-sided partial thickness rotator cuff tears

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Background: Treatment of partial thickness supraspinatus tendon tears is controversial with no clearly defined treatment algorithms based on severity of tears. This study aims to evaluate the relationship between depth of partial thickness tears and strain.

Methods: Bursal-sided partial thickness tears were created at 1 mm increments in depth at the anterior portion of the supraspinatus tendon to 3/4 tendon width on ten fresh-frozen shoulder specimens. The supraspinatus muscle was dynamically loaded from 0-50N, and strain recorded at both the anterior and posterior portions of the tendon.

Results: Strain in the intact posterior portion increased monotonically with tear depth and supraspinatus force. Strain in the torn anterior portion decreased with increasing tear thickness and loading force. At 60% thickness tear, strain was significantly higher ($P = 0.023$) in the intact posterior portion compared to intact tendon. As the tear thickness exceeded 50% tendon thickness, the strain in the intact tendon rapidly increased nonlinearly.

Conclusions: Biomechanical results herein suggest increasing potential for tear propagation in the transverse plane with increasing depth of tears, and biomechanically supports repairs of grade III (>50% thickness).

Level of evidence: Basic science study.

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Keywords: Rotator cuff; rotator cuff tear; supraspinatus tendon; partial thickness tear; dynamic loading; tendon strain

The supraspinatus muscle is a primary abductor of the arm, and is most commonly torn in partial thickness rotator cuff tears.⁸ Partial thickness rotator cuff tears (PTRCT) are a common sports and age related phenomena.^{17,29} PTCRTs

of the supraspinatus tendon can be classified based on location as bursal-sided, articular-sided, or intratendinous. Factors contributing to formation of PTCRTs include sub-acromial impingement as a main proponent of bursal sided tears and intrinsic age related phenomena as an important contributor to articular sided tears.^{5,23,12} Articular or bursal sided partial thickness supraspinatus tears have been historically difficult to treat due to the lack of agreement on

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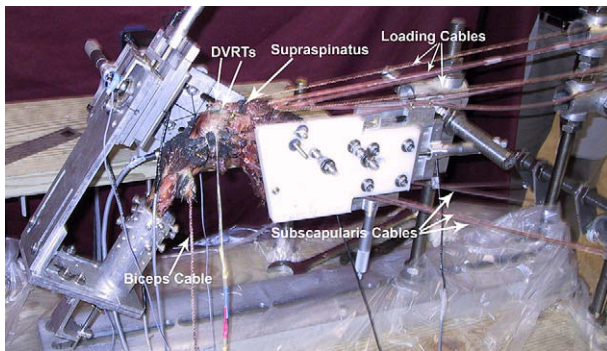


Figure 1 Experimental setup with affixed fiberglass mesh for each muscle loaded along the lines of action, proportional to the physiological cross-sectional area.

accepted treatment algorithms. Nonoperative and various operative options have been tried with inconsistent results.^{3,6,7,11,21} Conservative treatment is effective in reducing inflammation in all stages of rotator cuff tendon pathology,¹⁹ but a satisfactory result from conservative care alone is successful in less than half of degenerative partial thickness tears.²

A recent study with long follow-up described poor results when acromioplasty & debridement were used to manage partial thickness tears, including up to 35% of patients progressing to full thickness tears within 5 years.¹¹ With failure of nonoperative treatment and in the absence of other clinical pathology, surgeons have been limited to the existing literature regarding the decision for repair versus debridement and acromioplasty.

Several studies have recommended or described favorable clinical results when using 50% thickness tendon tear as a threshold for repair of bursal-sided tears.^{14,20,24,30,31} For tears less than 50%, conservative treatment consisting of subacromial decompression without arthroscopic repair yielded satisfactory results at a minimum 1-year follow-up.²⁰ Despite consensus among many orthopaedic surgeons that a tear thickness of 50% warrants repair,³¹ a biomechanical analysis on the supraspinatus tendon to support this practice has not been previously performed. A biomechanical analysis of the bursal-sided partially torn tendon may elucidate the underlying mechanisms behind the outcomes observed in clinical practice when using 50% thickness tears as a threshold for repair. Furthermore, such a study can provide quantitative insight regarding the behavior of a bursal-sided partially torn supraspinatus tendon among the whole range of thickness tears, from an intact tendon to a fully torn tendon.

The purposes of this study were to 1) examine the strain in both the torn portion and the remaining intact portion of the partially torn supraspinatus tendon when subject to dynamic loading along increasing levels of partial thickness tears, and 2) subsequently evaluate if a cutoff for repair of a partial thickness supraspinatus tendon of 50% is biomechanically justified.

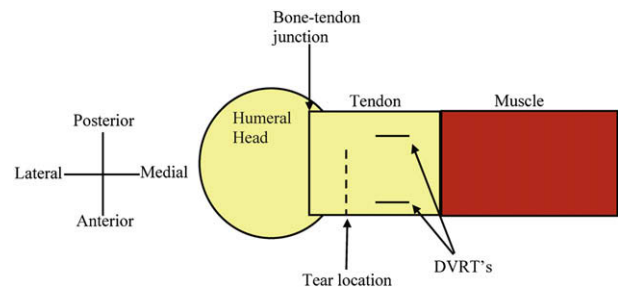


Figure 2 Schematic diagram of tear location with relation to DVRTs.

Materials and methods

Specimen characteristics

Ten fresh-frozen upper extremities were used for testing. Seven male and three female specimens with an average age of 63.3 (range, 52-77 years) comprised the testing group.

Set-up

After the removal of all overlying soft tissue, the specimens were prepared for testing. All muscles, with the exception of the deltoid, supraspinatus, infraspinatus, teres minor, subscapularis, and long head of the biceps, were removed. The biceps was sectioned distally to allow for loading of the muscle belly. The deltoid was elevated from its origins and the acromion was partially excised to allow better visualization and access to the supraspinatus tendon. Careful macroscopic examination was undertaken to ensure absence of cuff tendon pathology.

Each muscle was elevated partially from its origin (with the exception of the biceps which was detached distally). The deltoid was divided into 3 distinct sections (anterior, middle, and posterior) as were the subscapularis (upper, middle, and lower) and infraspinatus (upper, middle, and lower) muscles. Individual muscle bellies were then wrapped proximally and secured with fiberglass mesh to allow for loading along its line of action with an amplitude proportional to its physiological cross-sectional area (Figure 1). Compliant cable was secured to the fiberglass mesh to allow for attachment of the pre-determined calculated weight to simulate resting tension for neutral positioning of the rotator cuff. This method of muscle loading has been published in a previous study.¹⁶

The scapula was mounted rigidly onto an aluminum plate and secured with 3 bolts, taking care to minimally disrupt any overlying muscle. The humerus was centered into an aluminum tube and secured using screws with sharpened tips. Muscle bellies were then loaded along their line of action through the cable affixed to the mesh. Cables were run through pulleys and eyebolts as needed to ensure the proper line of action was maintained. Muscles were loaded to 2% of their maximal force proportional to their cross-sectional area^{15,10} to maintain the glenohumeral joint and the supraspinatus tendon in a physiological position.

With the arm fixed at 30° of glenohumeral abduction in the scapular plane, 2 differential variable reluctance transducers (DVRT; Microstrain, Burlington, VT) were affixed with barbs and 4-0 prolene suture to the anterior and posterior portions of the

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