THE EFFECTS OF SINGLE- VS. DOUBLE-ROW SUPRASPINATUS SURGICAL REPAIR ON CYCLIC AND FAILURE LOADING

[1]Danny M. Pincivero, [2]Kelly R. Marbaugh, [3]Jason L. Levine, [3]Nicholas Iagulli, [3]Jason Rabenold, [3]Salvatore Frangiamore, [2,3]Vijay K. Goel
[1]Human Performance and Fatigue Laboratory, Department of Kinesiology, [2]E-CORE, Department of Bioengineering, [3]Department of Orthopedic Surgery, The University of Toledo
Email: danny.pincivero@utoledo.edu

INTRODUCTION

The objectives of this study were to examine tissue elongation and static failure differences between two different surgical repair techniques for a simulated supraspinatus muscle tendon injury.

METHODS

Twenty fresh-frozen human cadaveric shoulder specimens (right and left matched pairs) were initially obtained from a tissue bank. One matched pair and two other specimens were excluded from testing due to severe osteoarthritic degeneration of the humeral head, and technical issues related to specimen preparation. The resulting number of specimens was 7 right and 9 left shoulders (mean $\pm$ SD, age = 66.0 $\pm$ 15.1 years, range = 46 to 94 years, 7 men and 2 women). The humerus was first cut mid-shaft and the specimen was allowed to thaw. All skin and subcutaneous fat was removed, followed by the deltoid and trapezius muscles. Subperiosteol dissection was used to remove the subscapularis from the proximal humerus, which allowed better access to the supraspinatus footprint and articular margin. Using a 10-blade scalpel, the anterior 20 mm portion of the supraspinatus footprint was dissected from the articular margin of the humerus to simulate a full-thickness tear. The specimens were then randomly assigned to one of two different surgical repair techniques: modified single-, and double-row repair.

Surgical repair

For the modified single-row repair, the cortical bone at the anteromedial footprint was tapped, just lateral to the bone trough created at the anterior articular margin. A Smith and Nephew Twin-Fix double loaded suture anchor was placed at a 45 degree angle. The first suture was passed through the tendon in a horizontal mattress fashion in a posteromedial position. The second suture was passed through the cuff as a single suture configuration in the lateral portion of the rotator cuff. The horizontal mattress suture was tied first using a modified Roeder knot with three overlying and alternating half-hitches. The lateral suture was then tied in similar fashion using the same knot construct.

Specimens randomly assigned to the double-row repair group were first tapped at two sites of the supraspinatus footprint. The medial anchor was placed just lateral to the bone trough created at the anterior articular margin. The lateral anchor was placed 1 cm lateral to the medial anchor. Two Smith and Nephew Twin-fix single loaded suture anchors were placed at 45 degree angles, one medially and one laterally. The medial anchor suture was passed in a horizontal mattress fashion. The lateral anchor suture was passed in a single suture fashion through the lateral cuff. The medial anchor suture was tied first using a modified Roeder knot with three overlying alternating half-hitches. The lateral anchor suture was then tied in similar fashion using the same knot construct.

Experimental testing

Following the surgical repair, the coracoacromial arch, rotator cuff (excluding the supraspinatus muscle), and glenohumeral capsule were incised. The supraspinatus muscle-tendon complex was carefully removed from the bony attachment within the supraspinous fossa and elevated laterally until it was completely dissociated from the scapula, leaving the muscle and humerus intact. The humerus was anchored to an aluminum plate, via a U-bolt and two threaded screws placed through the bone (Figure 1A). The supraspinatus muscle belly was frozen to a custom designed cryogenic clamp, via the deposition of dry ice into the clamp pockets (Figure 1B).

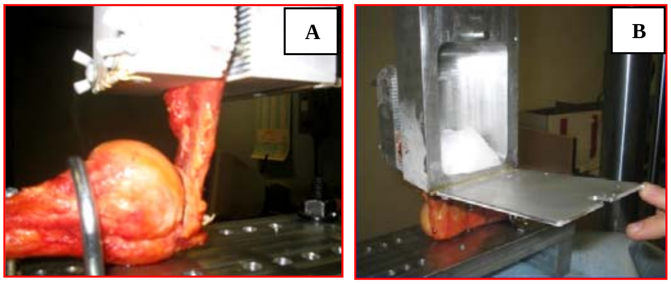

FIGURE 1: Supraspinatus muscle-humerus specimen preparation for cyclic and static loading. (A) Humerus and muscle fixation to the aluminum plate and clamp, respectively. (B) Deposition of dry ice into the muscle clamp.

Axial loading was applied to the supraspinatus muscle on a servo-controlled hydraulic materials testing machine equipped with a 2.5 kN load cell (MTS Corp., Eden Prairie, MN). When the specimen was semi-thawed, the muscle was transected proximal to the myotendinous junction. A digital image of the muscle cross-sectional area was manually traced using an imaging software program (ImageJ, NIH), and was multiplied by 30 N/mm^2 to estimate the force generating capacity of the muscle. The first experimental procedure involved cyclic loading (1000 cycles, 1 Hz) between a pre-load of 10 N and 50% of the estimated force generating capacity of each specimen (mean ± SD, 61.8 ± 23.9 N). The resulting viscoelastic induced deformation (mm) of the specimen was determined as the difference between the first and last peak lengthening cycles (Figure 2). Following the cyclic protocol, each specimen was loaded to failure at 1 mm/s. The stiffness of was calculated along the linear region of the load-deformation curve, while the failure load occurred at the terminal point of the linear region.

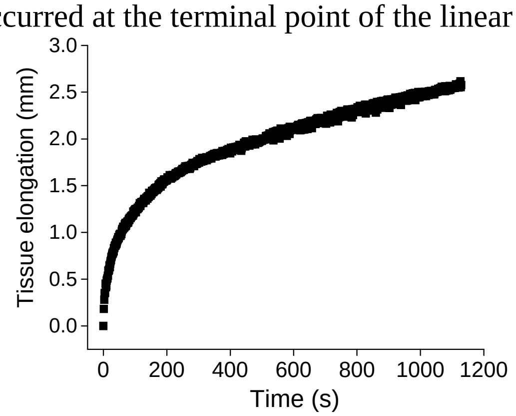

FIGURE 2: Tracing of cyclic loading of a sample specimen illustrating time-dependent lengthening.

RESULTS AND DISCUSSION

The results demonstrated no significant differences ($t_{14} = -0.57$, $p = 0.58$) in viscoelastic deformation across the 1000 cycles (single-row group = 2.05 ± 0.25 mm, double-row group = 1.79 ± 0.29 mm). No significant differences between the single and double-row repairs for specimen stiffness (mean ± SD, 40.3 ± 6.6 and 37.0 ± 4.2 N/mm, respectively) and failure loads (mean ± SD, 248.1 ± 64.3 and 193.8 ± 28.9 N, respectively) were observed.

Comparing the biomechanical properties of the single-row repair with the modified suture configurations and double-row repair may be of great value, especially if double-row repair requires longer surgical time, leads to higher implant cost, and is technically more demanding (1). The findings of the present study found no significant differences between the two constructs in terms of static failure loads or cyclic displacement, thereby suggesting a viable alternative approach for supraspinatus tendon repair. As the present investigation, however, is the first such study involving the modified single-row procedure, caution is warranted in extrapolating the results to a direct clinical application.

CONCLUSIONS

The major findings of the current investigation present evidence that a modification to the standard single-row technique of repairing full-thickness supraspinatus tendon tears appears comparable to the double-row procedure. It is recommended that future studies addressing clinical outcome measures following the modified single-row technique be incorporated to validate treatment efficacy.

REFERENCES

1. Ma CB, et al. *J Bone Joint Surg* 88, 403-410, 2006.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance of David Dick, M.S., Aaron Matyas, M.S., and Nathan Patrick, B.S. for their assistance with specimen preparation and mechanical testing.