Complete removal of load from the rotator cuff repair site is detrimental to healing

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Introduction: Rotator cuff healing is characterized by reparative scar tissue rather than regeneration of new tendon. Quantity and quality of scar tissue generated after cuff repair are affected by activity level. Specifically, in rats, immobilized shoulders formed biomechanically superior tissue compared to shoulders subjected to exercise1. This effect is likely due to excessive motion at the repair site and gap formation in the exercised shoulder. On the other hand, early mobilization improves anterior cruciate ligament healing compared to immobilization2, and static stress is beneficial to medial collateral ligament healing3. This evidence suggests that some controlled force may be beneficial to soft tissue healing. The purpose of this study was to evaluate the effect of the mechanical environment on healing rotator cuff by paralyzing the supraspinatus muscle of the operative shoulder after cuff injury and repair. We hypothesized that paralysis would be detrimental to healing.

Materials and Methods: The supraspinatus tendons in unilateral shoulders of 20 rats were transected from the bone and repaired with suture through a transosseous bone tunnel, reattaching the tendon in its anatomic position. The supraspinatus muscles of 10 shoulders were injected with 0.5 units/gram body weight of botulinum toxin A with a 30 g needle. The supraspinatus muscles of 10 control rats were injected with an equal volume of saline as a control. Shoulders were immobilized in a cast postoperatively to optimize healing environment1. Rats were sacrificed 56 days after surgical repair. All animal studies were approved by the Institutional Animal Care and Use Committee. Specimens were biomechanically tested as described previously4. All biomechanical testing was performed in a 39°C saline bath. Tendon-humerus specimens were rigidly fixed at 90 degrees of abduction in a material testing machine (Instron 8500). Specimens were subjected to a preload of 0.2N and pre-conditioned for five cycles. A static stress relaxation test was performed for 300 seconds at 0.38mm displacement (approximately 20% of ultimate displacement) followed by 300 seconds of recovery. Specimens were then tested to failure in tension. Stress relaxation data was fit to the quasilinear viscoelastic model to determine elastic parameters (A and B) and viscoelastic parameters (C, tau1, and tau2)1. Ultimate stress, tangent modulus, ultimate force, and stiffness were determined from the tensile tests to failure.

Results: Gross observations of the Botox injected specimens 8 weeks after surgical repair demonstrated obvious atrophy of the rotator cuff musculature. The cross-sectional area of the tendons in the Botox group was significantly smaller than that in the saline group (2.7+/−0.5 vs. 5.0+/−0.8 mm², p<0.0001) (Fig. 1). All tendons were healed in both groups. There was no visible gap formation at the repair sites in either group. Biomechanical testing demonstrated that the structural properties of the healed tendons were significantly greater in the saline injected specimens compared to the Botox injected specimens. Stiffness was 18.6+/−6.2 N/mm in the saline group compared to 12.3+/−5.8 N/mm in the Botox group (p=0.04) (Fig. 2). Ultimate strength was 26.4+/−8.6 N in the saline group compared to 13.3+/−4.9 N in the Botox group (p=0.001). Material properties, specifically ultimate stress and tangent modulus, showed no statistically significant difference (Fig. 2). Viscoelastic parameters A and tau1 were significantly higher in the Botox group compared to the saline group. Viscoelastic parameters B, C, and tau2 were not different between groups.

Discussion: Removing all load from a healing rotator cuff insertion site is detrimental to tendon healing. In this study we demonstrated that when load is removed from the healing tendon by paralyzing the supraspinatus muscle, the cross-sectional area and the structural properties are lower than in control specimens. There were few differences in viscoelastic properties between groups. Given that the material properties were not affected regardless of the load conditions, the decreased strength resulted from a decrease in the quantity of repair tissue generated. While protective cast immobilization is beneficial to healing, complete removal of load can be detrimental. Clinical significance: Optimizing the repair environment both biologically and mechanically is important to improve tendon healing. Providing the proper load environment has clinical implications in terms of immobilization and rehabilitation protocol after surgery. Paralyzing the supraspinatus to minimize the risk of tendon pull-off may actually be detrimental in rotator cuff repair if coupled with cast immobilization.


Acknowledgements: This study was funded by an American Shoulder and Elbow Surgeons Research Award and an OREF Career Development Award.