Following a Moderate Period of Immobilization, Tendon Properties and Joint Mechanics Are Not Altered With Exercise

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INTRODUCTION: Rotator cuff tears are a common clinical problem that can result in significant disability and often require surgical repair [1]. Previous animal studies have shown that immobilization results in superior tendon to bone insertion site properties compared to both cage activity and exercise [2,3]. Specifically, insertion site organization was improved after 4 weeks of immobilization, while mechanical properties were increased following 8 and 16 weeks [2,3]. However, the role of increasing activity level with exercise as compared to only cage activity following immobilization has not been fully elucidated. Recently, it was shown that after a short period of immobilization, increased activity level was detrimental to mechanical properties and shoulder mechanics [4]. Therefore, the objective of this study was to determine the effect of activity level after a moderate period of immobilization, previously shown to increase tendon organization, on insertion site mechanical properties and passive shoulder mechanics in a rat rotator cuff injury and 2) differing post-immobilization activity levels would not result in changes in passive shoulder mechanics 18 weeks post injury and repair.

METHODS: In twenty Sprague-Dawley rats (IACUC approved), the left supraspinatus tendon was detached (injured) and repaired as described [2] and the left shoulder was immediately immobilized for 6 weeks using Vetrap (Penn Vet Supply) as described [4]. After 6 weeks of continuous immobilization, the animals were divided into 2 remobilization groups: exercise (EX, n=12) and cage activity (CA, n=8). The EX group underwent controlled and gradual remobilization of moderate treadmill running (10m/min) from 7 minutes initially up to 1 hour per day by the end of 4 weeks and remained at 1 hour per day until the end of the study after 12 weeks of running (18 weeks post repair). The CA group received only cage activity for 12 weeks.

Range of motion (ROM) was measured for all animals prior to assignment to experimental group and 18 weeks post repair, similar to that described [5]. Briefly, at each time point, each animal was anesthetized and its arm placed in a rotating clamp at 0° of abduction and 90° of elbow flexion. This position was defined as neutral, consistent with that position in humans, and a torque was applied to the arm for three internal and external rotation loading and unloading cycles to a prescribed torque target. Internal, external and total ROM were determined using data from all three cycles.

At the end of the remobilization period, the injured and repaired tendons were dissected and cross-sectional area was measured using a laser-based system [6]. Tensile testing was performed as follows: preconditioning, stress-relaxation to 5% strain at a rate of 10%/sec for 600 sec, and ramp to failure at 0.3%/sec. Strain was measured optically. Results were compared between groups using t-tests (significance at p<0.05).

RESULTS: Surprisingly, at the end of the remobilization period, there were no differences between EX and CA in area (Figure 1A), percent relaxation (Table 1), stiffness (Figure 1B) or modulus (Table 1). As expected, there was no difference in total (Figure 1C), internal (Table 1) or external (Table 1) ROM between EX and CA groups.

DISCUSSION: We hypothesized that exercise following a moderate period of immobilization would result in superior insertion site properties and would have no effect on shoulder joint mechanics compared to cage activity. Our first hypothesis was contradicted as tendon cross-sectional area, percent relaxation, stiffness, and modulus were no different between groups that had cage activity or exercise following six weeks of immobilization. Our second hypothesis was supported in that total, internal and external ROM were no different after the EX and CA remobilization periods.

It is commonly accepted in orthopaedic tissues such as bone that increased loading is beneficial to healing while delayed loading was beneficial [7]. Similarly, a previous rotator cuff study in rats found that increasing post-operative activity immediately after the repair was detrimental to tendon healing [3]. These results led us to hypothesize that the potential benefit of increased activity could be realized after a period of immobilization to first protect the repair and enhance healing. We previously found that 2 weeks of immobilization was not sufficient, as tendon area, ROM and several mechanical parameters were all detrimentally affected by exercise following this short period of immobilization [4]. In the current study, we investigated the effect of increased activity following a more moderate 6 week period of immobilization. After 4 weeks of immobilization, the insertion site is more organized compared to groups that receive either cage activity or exercise for the same time period, but mechanical differences have not been demonstrated until at least 8 weeks [2,3]. Our current findings suggest that increased organization of the insertion site may not be enough to realize the potential benefits of increased loading and that it may be necessary to achieve superior mechanical properties before introducing exercise. After a longer period of immobilization, after which the tissue at the repair site is well-formed both structurally and mechanically, an increased loading protocol may produce and remodel more of the desired tendon tissue rather than scar, resulting in superior mechanical properties.

In conclusion, after a moderate period of immobilization, an increased level of activity has no effect on tendon mechanical properties and shoulder joint mechanics. Future studies will examine the effect of post-immobilization activity modification after longer immobilization which has been previously found to improve the mechanical properties of the repaired tendon to bone insertion site.

ACKNOWLEDGMENTS: This study was supported by the NIH/NIAMS and NSF.