Diffusion tensor imaging shows that supraspinatus muscle architecture changes after rotator cuff tear and surgical repair

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Summary

Instances of rotator cuff tears (RCT) have steadily increased over time, affecting older adults at a greater rate [1]. Previous research has shown an increase in fatty infiltration (FI) occurs after RCT, but how FI affects muscle composition and architecture is not fully understood [2]. The objective of this study is to quantify changes in muscle architecture over time after RCT and surgical repair. This study used diffusion tensor imaging (DTI) to calculate the fractional anisotropy (FA) of the supraspinatus muscle to quantify change in architecture.

Introduction

Rotator cuff tears are one of the most prevalent musculoskeletal disorders in the U.S. and are thought to cause irreversible damage to nearby muscles and tissues [3]. Prior work shows an increase in FI post-RCT [2]. Yet, there remains a knowledge gap about how muscle morphology and architecture change over time after RCT. The goal of this study is to assess changes in supraspinatus muscle architecture over time after RCT and surgical repair using DTI.

Methods

Ten New Zealand White Rabbits were studied, as part of a larger, ongoing study (IACUC #201800257). Animals were randomly assigned to 1 of 5 groups by time point, ranging from 2- to 16-weeks. Eight animals underwent surgery to introduce unilateral RCT to the supraspinatus tendon on a randomly selected side via sharp dissection. Two of the RCT injury animals also underwent rotator cuff repair (RCR) surgery at 8-weeks post-RCT. Two animals underwent sham injury surgery and one underwent sham repair surgery. Animals were euthanized at the assigned time point, and the forelimb including the injured shoulder was harvested. DTI was conducted on a 7T MRI scanner (Bruker BioSpec 70/30 Avance III HD, Bruker, Ettlingen, Germany) to determine supraspinatus muscle architecture: TE: 17.70 ms, TR: 5s, diffusion gradient duration time: 3.2ms, diffusion time: 8.5ms, b-value: 1000mm/s^2, FOV: 80mm x 80mm, slice thickness: 0.6mm, 44 slices, number of averages: 8. After scanning, images were motion corrected using automatic image registration, followed by manual segmentation of the supraspinatus muscle [4]. The diffusion tensor was then calculated using a weighted least squares method in MRtrix3 software [5] and used to create a fractional anisotropy map that provides a measure of the directionality of water along muscle tissue. FA is reported as an index from 0-representing anisotropic diffusion to 1-fully isotropic diffusion, meaning muscle fibers are strongly aligned for water to smoothly diffuse across the muscle. Formal statistical analysis was unable to be run due to small sample sizes.

Results and Discussion

As time post-RCT increases, FA decreases from 0.29 (2-week group) to 0.21 (8-week group) and does not improve post-RCR, indicating an increase in diffusion direction, suggesting less organized fascicle orientation over time (Figure 1). Decreased FA indicates the temporal alteration of muscle composition, where FI increased post-RCT, but does not improve post-RCR. Unpublished work by our group used a Dixon imaging sequence on these same samples and found the amount of fat increased in the muscle post-RCT that does not improve after RCR, supporting these findings.

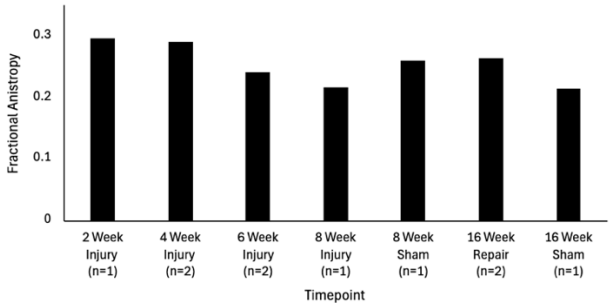

Figure 1: Mean fractional anisotropy of supraspinatus muscle.

Conclusions

As study timepoint increased, this preliminary work shows that FA values decrease, suggesting a change in muscle architecture after RCT and RCR. These results, along with additional unpublished imaging results from our group, correspond to an increase in FI after RCT and RCR. This work is part of a larger ongoing study that continues to examine muscle morphology and architecture changes over time after RCT and RCR, to better quantify how muscle changes following a common musculoskeletal disorder.

Acknowledgments

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