An Analysis of Rotator Cuff Repair Loading in Musculoskeletal Shoulder Modeling

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Introduction

Rotator cuff (RC) tears, which can severely impair daily activities, are treated with RC repair (RCR), but up to 70% re-tear occure, depending on severity [1]. Factors such as tear size, shape, retraction, muscle atrophy, fatty infiltration, and tendon quality affect repair outcomes, but their influence is not well understood. Arm positioning during surgery and rehabilitation can affect outcomes, with tendon force exceeding pull-out forces leading to increased risk of re-tears . Further patients show no visible re-tear but loss in muscle strength and therefore compromised shoulder functionality. Musculoskeletal simulation programs can aid in predicting forces, but a comprehensive approach is needed to optimize RCR outcomes.

Materials and Methods

The thesis aims to improve the Hill muscle model for accurate muscle behaviour prediction. A parameter study using AnyBody integrated Hill muscle model of the supraspinatus was conducted to assess its sensitivity. The effect of tendon retraction, tendon stiffening and fatty infiltration on rotator cuff repair with and without medialization was assessed in 18 subjects with full thickness supraspinatus tears. Muscle strength, supraspinatus passive force and overall tendon force were assessed over an abduction motion from 0 to 120°.

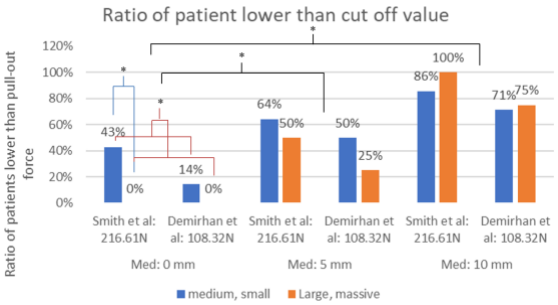

Fig. 1 Shows the percentage of simulations with medialization distances of 0mm, 5mm, and 10mm that fall below the respective pull-out limits for patients classified into small, medium (0cm - 3cm), large, and massive (larger than 3cm) tear sizes [2],[3].

Results

The findings of the parameter study revealed that physiological cross section area, tendon length, and muscle length had the most significant influence on the muscle strength and the tendon force. In patient data with a rotator cuff tear, 43% of small to moderate tears were repairable without medialization, while none of large to massive tears were (p-value = 0.0002). The repairability of large-massive tears increased from 0% to 64% for 5 mm medialisation and to 86% for 10 mm medialisation of the insertion point of the supraspinatus. By applying decision criteria's, a significant improvement in repairability prediction from 33% to 89% was achieved (p-value = 0.0002).

Discussion

The parameter study allowed for identification of sensitive Hill parameters for subsequent rotator cuff repair simulations. Simulation results showed that small-medium tears are more likely repairable than large tears, and greater medialization improves repairability. Through applying of decision criteria's an improvement of the repairability prediction was achieved, but limitations include difficulty in isolating individual muscle properties and lack of post-operative patient data for validation.

References

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