THE EFFECT OF TFCC INJURY ON ECU FUNCTION AND FRICTION

1Zac Domire, 1Furkan Karabekmez, 1Ahmet Duymaz, 2Timothy Rutar, 1Peter Amadio, 1Steven Moran
1Mayo Clinic, Rochester, MN, 2Washington State University, Pullman, WA
email: Domire.Zachary@mayo.edu

INTRODUCTION
Injury to the triangular fibrocartilage complex (TFCC) is a frequently occurring wrist injury. Treatment options following injury vary widely, but, it has been proposed that extensor carpi ulnaris (ECU) function is an important consideration when making surgical decisions about TFCC repair. Tang et al. [1] showed that the TFCC acts as a retinacular component for the ECU tendon, and that injury to the TFCC increases the moment arm of the ECU by nearly 30 percent.

Increasing the moment arm of the ECU will adversely effect force production by increasing muscle excursion and velocity for any given movement. However, muscle function is determined not by muscle force, but by muscle moment, which increased moment arm may enhance. It is unclear how the decrease in muscle force will balance with the increased mechanical advantage. The following study will examine the effects of increasing the moment arm of the ECU on moment producing capacity using a simple musculoskeletal model. It is also possible that TFCC injury may increase friction acting on the ECU tendon. This increased friction may cause additional wear on the surface of the tendon, which would further increase friction. The resulting vicious cycle of tendon damage could lead to tendonitis, tendon injury and pain. The following study will also examine the effects of TFCC injury on ECU tendon friction by using a cadaveric model.

METHODS
Isometric and isokinetic joint strength curves were simulated for the ECU in both injured and non-injured states. The ECU was modeled as a hill type, muscle like actuator. The muscle had force-length and force-velocity properties and was connected in series with an elastic element representing the tendon. The moment arm and muscle length of the ECU was changed in the injured simulation based on data from Tang et al. [1]. Muscle model parameters were taken from the literature [2,3].

Six human cadaveric wrists were studied. Frictional testing was performed by applying a constant load to the proximal tendon and measuring the load at the distal tendon while moving through a range of motion. A custom made motorized apparatus was used to move the specimens. Three cycles of motion were completed for both radio-ulnar deviation and flexion/extension. The range of motion was from 35° extension to 40° flexion and 15° radial to 35° ulnar deviation. The speed was 5°/s for each test. Force at the distal tendon was measured throughout the motion at 45 Hz.

To create a TFCC injury, a 2 cm longitudinal incision was made over the volar side of the ulnocarpal joint. The attachment to the TFCC to the fovea and peripheral margin of ulna was separated with a scalpel. The ulnolunate ligament and the ulnotriquetral ligament, the palmar and dorsal radio-ulnar ligaments were also incised. The horizontal portion of the TFC was divided to the ulnar styloid but ulnar styloid was left intact. To complete the injury the TFCC’s dorsal edge which mingles with the fibrous sheet of the ECU was separated carefully to avoid any damage to the ECU tendon. Following the creation of the injury, friction was tested repeating the same procedure as above.

Before calculation of friction the force data were smoothed using a fourth order bi-directional Butterworth filter with a cutoff of 4Hz. From the filtered force data, friction was calculated at each position. This was done by calculating the difference between the recorded force and the dead weight force for each direction of movement and then averaging the absolute value of this difference for each direction. The mean friction was calculated across all three cycles of motion. Friction was compared between the intact and the
injured condition using a paired t-test. The level of significance was set at 0.05.

RESULTS AND DISCUSSION
The ECU force was reduced following injury (Figure 1). The difference increased with the amount of wrist extension and with increasing velocity. The largest decrease in force was seen at 60° of extension at 300°/s. The difference in force here was less than 4 N. The ECU moment producing capacity was increased following injury (Figure 2). The difference decreased with the amount of wrist extension and with increasing velocity. The smallest increase in moment was seen at 60° of extension at 300°/s. The difference in moment here was nearly 30 Nmm.

Friction during flexion/extension was slightly decreased following TFCC injury. The difference was small in absolute terms, but was statistically significant and was seen in all six specimens. Friction was unchanged following TFCC injury for radio/ulnar deviation (Table 1).

Table 1: Mean friction

<table>
<thead>
<tr>
<th></th>
<th>Intact</th>
<th>Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flex./Ext.*</td>
<td>0.18 ± 0.11 N</td>
<td>0.13 ± 0.09 N</td>
</tr>
<tr>
<td>R/U Dev.</td>
<td>0.21 N ± 0.10 N</td>
<td>0.21 ± 0.13 N</td>
</tr>
</tbody>
</table>

Note - * indicates significant difference.

The reason behind the small force decrease following TFCC injury is related to the ratio of the optimum fiber length to the moment arm of the muscle. This ratio has been previously identified as an important factor in muscle function [4]. This ratio is very large (12.77) for the ECU. Consequences of a high optimum fiber length to the moment arm ratio are very flat relationships between muscle force and joint angle or angular velocity. While injury to the TFCC does decrease this ratio, it is still large (9.75) following injury.

CONCLUSIONS
While injury to the TFCC does result in decreased ECU force producing capacity, moment producing capacity is increased. Additionally, as a result of TFCC injury, the friction acting on the ECU tendon was decreased during flexion/extension movements and unchanged during radio/ulnar deviation. There are many valid reasons for deciding to perform a TFCC repair, including pain and instability; however, neither ECU function nor friction should be a consideration when deciding on TFCC repair.

REFERENCES

ACKNOWLEDGEMENTS
This study was supported by a grant from the Mayo Foundation.
We would like to thank Lawrence Berglund and Chunfeng Zhao for their technical assistance.