THE EFFECT OF DIFFERENTIAL FINGER MOTION ON THE SUBSYNOVIAL CONNECTIVE TISSUE BEFORE AND AFTER CARPAL TUNNEL RELEASE IN A CADAVER MODEL

*Yamaguchi, T; *Osamura, N; *Zhao, C; *An, K N; +*Amadio, P C
++Biomechanics Laboratory, Division of Orthopedic Research, Mayo Clinic College of Medicine, Rochester, MN
pamadio@mayo.edu

INTRODUCTION:
It is generally accepted that repetitive, forceful hand or wrist motion, often associated with awkward wrist posture, is a risk factor for carpal tunnel syndrome (CTS), but how these mechanical factors relate to the pathological changes of non-inflammatory synovial thickening seen typically in cases of carpal tunnel syndrome is unknown. Clinical studies have shown convincingly that CTS is a compression neuropathy of the median nerve, but have not identified how the compression is generated or maintained. This study investigated the functional structure and mechanical properties of the subsynovial connective tissue (SSCT) within the carpal tunnel, which, we believe, may play a very important role in the etiology of CTS. We hypothesize that activity-related damage occurs to the SSCT, with a resulting increase in gliding resistance between visceral and parietal synovium. To begin to test this hypothesis, we investigated the mechanical, histological and kinematic properties of carpal tunnel tenosynovium in normal human cadaver specimens, and measured the relative motion of the tendon, SSCT, and synovium in normal human cadaver specimens.

METHODS:
Seven human cadaver upper limb specimens were used. A skin incision was made longitudinally to expose the middle finger flexor digitorum superficialis (FDS) tendon from the muscle tendon junction to the proximal end of the finger flexor sheath, with the flexor retinaculum and ulnar bursa intact. A small window (5mm diameter) was made in the flexor retinaculum, visceral synovium, and subsynovial connective tissue to expose the middle finger FDS tendon. With the fingers fully flexed, a small metal marker was inserted into the tendon. Then, the fingers were fully extended, and another small metal marker was glued on the visceral synovium surface (401 Prism., Loctite Co. Rocky Hill, CT). A third metal marker was inserted into the flexor retinaculum to serve as a reference point. The carpal tunnel was otherwise left undisturbed. The hand was mounted in a custom fixture and the proximal ends of the finger FDS tendons were fixed with sutures and connected to an electric motor by one of two methods: the middle finger alone (simulated isolated middle finger motion), or all fingers together (simulated fist). 100g weights were attached to the fingertips to maintain extension. The motion of the three markers was recorded by anteroposterior view fluoroscopy (BV 25, Scopofix MDPM, Philips). (Figure 1) After testing, the carpal tunnel was opened and the relative motion of the three makers was measured directly, and captured on a digital video recording. The marker motion was analyzed for the two motion stylesd (single digit or fist) and conditions (open or closed carpal tunnel). All data were expressed as the mean ± standard error of the mean (SEM). The SSCT mechanical properties of the middle finger motion and fist motion were compared using Wilcoxon signed rank test. P values < 0.05 were considered to be statistically significant.

RESULTS:
The maximum SSCT motion for isolated middle finger motion with a closed carpal tunnel was 3.46 ± 2.82 mm. The maximum SSCT motion for fist motion with a closed carpal tunnel was 7.68 ± 2.58 mm. The maximum SSCT motion for isolated middle finger motion with an open carpal tunnel was 4.09 ± 2.58 mm. The maximum SSCT motion for fist motion with an open carpal tunnel was 9.49 ±2.90 mm. (Figure 2) Comparison between simultaneous and single digit motion showed a statistically significant difference in the maximum SSCT motion for both conditions (open and closed carpal tunnel). (p < 0.05) We found no significant difference in the maximum SSCT motion when comparing isolated middle finger motion or fist motion across conditions.

DISCUSSION:
In the normal human carpal tunnel, the tendons are surrounded by a multilayered SSCT (1, 2). Normally this SSCT allows differential gliding of the tendons, as when one finger flexes and an adjacent finger extends or remain still, as may occur in many tasks. Such activity imposes a shear strain on the SSCT. Here, for the first time, we have measured the normal amplitude of the normal SSCT, and have shown that fluoroscopic measurements are comparable to those measured directly. This information will serve as a useful study of SSCT mechanics in carpal tunnel syndrome, and suggests that SSCT motion could be analyzed non-invasively.

REFERENCES:

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