THE EFFECT OF DIFFERENTIAL FINGER MOTION ON THE SUBSYNOVIAL CONNECTIVE TISSUE AND MEDIAN NERVE BEFORE AND AFTER CARPAL TUNNEL RELEASE IN A CADAVER MODEL
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Introduction: Although fibrosis of the subsynovial connective tissue (SSCT) is a common finding in cases of carpal tunnel syndrome, little is known about the physical properties of this tissue. 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.

Materials and Methods: Eight human cadaver upper limb specimens were used. A small window (5mm diameter) was made in the flexor retinaculum. A small metal marker was inserted into the tendon and median nerve and glued on the visceral synovium surface and the flexor retinaculum to serve as a reference point. 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 or all fingers together. The motion of the four markers was recorded by anteroposterior view fluoroscopy before and after the carpal tunnel release (Figure 1). The marker motion was analyzed for the two motion styles (single digit or fist) and conditions (open versus closed carpal tunnel).

Results: Comparison between simultaneous and single digit motion showed a statistically significant difference in the maximum SSCT and median nerve motion for both conditions (open and closed carpal tunnel). (p < 0.05) We found no significant difference in the maximum SSCT and median nerve motion when comparing isolated middle finger motion or fist motion across conditions (Figure 2).

Discussion: In the normal human carpal tunnel, the tendons are surrounded by a multilayered SSCT. 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. Recent studies suggest that there is evidence of damage to the SSCT in patients with CTS. If that is so, the damage may be reflected in abnormal SSCT motion. We have here measured the amplitude of motion in the normal SSCT, and have shown that fluoroscopic measurements are comparable to those measured directly. This information suggests that SSCT motion could be analyzed non-invasively, and thus may serve as a useful baseline for the study of SSCT mechanics in patients with carpal tunnel syndrome. Indeed, there is some human cadaver data suggesting that ultrasound may be useful in measuring SSCT motion. Other studies have looked at the effect of tendon motion after carpal tunnel release. While the findings of Brown and Peimer differ from ours, the conditions were different, in that we only monitored middle finger FDS motion after release of the flexor retinaculum, with the fingers moving and the wrist fixed, while Brown and Peimer looked at the effect of wrist motion with the fingers fixed. Our findings of tendon motion are comparable to those of Ugbolue et al. The motion of the median nerve in carpal tunnel syndrome has been studied by others. These data suggest that the nerve motion is restricted in patients with carpal tunnel syndrome. Our findings in our cadavers are similar to those reported by others for normal median nerve motion. The strengths of this study are that it validated an indirect measure of tendon, SSCT and median nerve motion in a human cadaver model. It has also demonstrated the relative motion of these structures in situ, and has shown that opening the carpal tunnel to directly observe their motion does not alter that motion, provided that the wrist is fixed in the neutral position. The weaknesses of this study relate to the fact that it is a cadaver study. The results need to be verified in vivo. However, there is already some data on the relative motion of the FDS and SSCT in patients with carpal tunnel syndrome, which has been correlated with cadaver motion. Thus, we believe it is likely that the measurements observed here will be comparable to in vivo motion. In conclusion, we have demonstrated that fluoroscopic imaging of FDS, SSCT and median nerve motion in the intact carpal tunnel is comparable to direct imaging with the carpal tunnel open, provided that the wrist is fixed in the neutral position. This data suggests the possibility of in vivo imaging of such motions, which may in turn shed light on the kinematics of tendon and nerve interactions in patients with CTS.

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