INTRODUCTION:

Carpal tunnel syndrome (CTS) in one of the most common diagnoses of a compression neuropathy of the median nerve at the wrist. 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. The purpose of the current study was to investigate the gliding resistance of a representative tendon, the middle flexor digitorum superficialis (FDS) within the carpal tunnel during simultaneous (making a fist) and single finger movement of the middle finger, which may help us to understand the relationship between carpal tunnel syndrome and repetitive hand motion.

METHODS:

Eight fresh frozen human cadaver upper extremities without previously diagnosed CTS were used. The FDS tendons of the second, third and fourth digits were exposed proximal and distal to the flexor retinaculum, maintaining the carpal tunnel region intact. The excursions of the FDS tendons from index, middle, and ring finger were measured during all figures motion and middle finger motion alone with the wrist in neutral position (0°), 60° and 30° of extension, and 30° and 60° flexion. Then, the tendons were dissected from their distal attachments, and the index, middle, ring, and small fingers were amputated at the MCP joint level, leaving the flexor retinaculum intact. A custom-made external fixator was used to position the wrist in the desired position.

The specimen was then mounted on the testing apparatus (Fig 1).

Fig 1. Testing apparatus. 1. Actuator; 2. Load transducer (F2); 3. Specimen; 4. Three FDS tendons; 5. Retinaculum; 6. Three FDP tendons; 7. Load transducer (F1); 8. Three 2-Newton weights attached to the FDS tendons; 9. Three 1-Newton weights attached to the FDP tendons; 10. External fixator.

Load transducers were connected to the distal (F1) and proximal (F2) ends of the middle finger FDS tendon using a nylon cord. The proximal end of all three FDS tendons (index, middle and ring fingers) were connected to a mechanical actuator. Three 2-Newton loads were attached to each of the distal ends of the index, middle and ring finger FDS tendons. Three 1 N loads were attached to each of the distal ends of the index, middle and ring finger FDS tendons, to maintain a minimal level of tension.

The FDS tendons were pulled proximally by the actuator against the weight at a rate of 2.0 mm/sec. This movement of the tendon toward the load was regarded as flexion. The actuator movement was then reversed, causing the tendons to be pulled distally by the distal 2N load. This movement of the tendon toward the load was regarded as extension. In simulating making a fist motion, the excursion of the FDS tendon with the least excursion was used as the excursion for all three tendons. Therefore, during testing, all FDS tendons moved within a physiological range. For the testing of the middle finger FDS tendon motion alone, the proximal tendon ends of the second and fourth FDS tendons were disconnected from the actuator and fixed in one position, simulating 0° flexion of these digits, while tendon tension was maintained by the 2N load at their distal ends. Then the middle finger FDS tendon was moved by the actuator to simulate a flexion/extension motion cycle of this digit alone, based on the tendon’s previously measured excursion with fixation of the index and ring finger in the neutral position.

The data was analyzed in two sets of data, mean gliding resistance (MGR) and peak gliding resistance (PGR). Mean gliding resistance was calculated based on the force values measured throughout the range of excursion by the following formula: (F2f-F1f) + (F1e-F2e) / 2. As F1f = F1e = 2 Newton (the applied load), the MGR formula simplifies to (F2f-F2e). The PGR was the measured peak force during flexion (F2f-F1f). Data obtained from the gliding tests were analyzed using one factor repeated ANOVA measurement analysis of variance test to assess whether there were measured differences among the different groups, followed by a Tukey-Kramer post-hoc test for individual comparisons. A p<0.05 significance level was used in all cases.

RESULTS:

While moving all three fingers together, the MGR of the middle FDS tendon with the wrist in the neutral position was significantly lower than the MGR with the wrist in 60° of flexion (p<0.05) (Fig 2). While moving the middle finger FDS tendon alone, the MGR in 60° of flexion was significantly higher than the MGR at 0° and 30° of extension (p<0.05) (Fig 3). Moving all three fingers together, the PGR at 60° of flexion was significantly higher than that at 0°, 30° extension, or 60° extension (p<0.05) (Fig 4). While moving the middle finger alone, the PGR in 60° extension was significantly lower than the PGR at 60° flexion and 30° flexion (p<0.05) (Fig 5).

DISCUSSION:

This study assessed for the first time the flexion tendon gliding resistance within the carpal tunnel. We demonstrated that the middle finger FDS gliding resistance was elevated when the wrist was in 60 degrees of flexion. Differential finger motion increased the peak gliding resistance, especially with the wrist in flexion. Based on this data, future studies can be designed to study in more detail the viscoelastic properties of the SSCT, and the role that SSCT mechanics and injury may play in the etiology of carpal tunnel syndrome.

REFERENCES:


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