The Gliding Characteristics of the Flexor Pollicis Longus Tendon in the Carpal Tunnel: Potential Implications for Pipetters

+Morizaki, Y; Zhao, C F; Zhao, K D; van Doesburg, M H; An, K-A; Amadio, P C
+Biomechanics Laboratory, Division of Orthopedic Research, Mayo Clinic, Rochester, MN
pamadio@mayo.edu

INTRODUCTION

Hand and wrist complaints, principally affecting the thumb, are common in individuals who use pipettes regularly in their work, occurring in up to 90% in individuals who continuously use pipettes for more than 60 min. One of the characteristics of the pipetting motion is repetitive thumb flexion in various positions of wrist deviation, especially wrist extension with radial deviation. We hypothesized that the gliding characteristics of the flexor pollicis longus (FPL) differed according to wrist position, and that certain positions might minimize FPL friction during pipetting motions. In order to test this hypothesis we investigated FPL gliding resistance within the carpal tunnel in a human cadaver model.

MATERIALS AND METHODS

After IRB approval, nine fresh frozen human cadaver upper extremities, amputated approximately 15 cm proximal to the proximal extremities, were thawed at room temperature immediately prior to testing. Review of the medical records was performed on each cadaver donor, to obtain demographic data and to be sure the individual did not have a recorded antemortem history of any wrist pathology.

Two partially threaded small pins were inserted to each radius and second metacarpal bone to fit an external fixator. The first metacarpal was fixed to the trapezium using a K-wire at 40 degrees of volar abduction and 20 degrees of radial abduction. The flexor digitorum superficialis (FDS), profundus (FDP) and FPL tendons were exposed proximal to the flexor retinaculum. Marks were placed on the FPL tendon and the flexor retinaculum, a fixed reference point. The excursion of the FPL tendon was measured from full extension to full flexion in the following wrist positions of interest:

- Neutral (N),
- 30 degrees extension (30E),
- 60 degrees extension (60E),
- 30 degrees flexion (30F),
- 60 degrees flexion (60F),
- 30 degrees ulnar deviation (30UD),
- 15 degrees radial deviation (15RD),
- 20 degrees RD and 40 degrees extension (20RD+40E), and
- 30 degrees UD and 40 degrees flexion (30U+40F).

After measurement of excursion, the FPL tendon was dissected from its distal attachment and the thumb was amputated at the metacarpophalangeal joint level. The specimen was then mounted on the testing device by clamping the proximal end of both the radius and ulna in a custom made clamping device. Load transducers were connected to the distal (F1) and proximal (F2) ends of the FPL tendon using a nylon cord. A 5 N load was attached to the distal end of the FPL tendon. The proximal end of the FPL tendon was connected to a mechanical actuator. A 2 N load was attached to the proximal end of each FDS tendon to maintain the light fist position. A 5 N load was attached to the proximal end of FDP tendons for the same purpose (Fig. 1).

The FPL tendon was pulled proximally by the actuator against the weight at a rate of 2.0 mm/s. After moving the excursion distance in one direction, the actuator was reversed, causing the tendon to be pulled back to the starting position by the distal 5 N load. These movements were regarded as one cycle of flexion/extension. Three cycles of testing in each position were recorded and the data from the second cycle was used for analysis to avoid any static friction effects. Both F1 and F2 forces were collected and the difference of the two, the gliding resistance, was calculated. Peak gliding resistance (PGR) and mean gliding resistance (MGR) were used for the analysis. Order of experiment was randomly assigned to avoid any effect of the order.

RESULTS

Mean Gliding Resistance (MGR)

MGR in ulnar deviation was significantly lower than MGR in 60 degrees flexion, 60 degrees extension, or 20 degrees radial deviation with 50 degrees extension (Fig. 2).

Peak Gliding Resistance (PGR)

PGR in ulnar deviation was significantly lower than PGR in wrist 60 degrees flexion (Fig. 3).

DISCUSSION

In this study, the MGR of the FPL tendon in wrist extension with radial deviation was higher than the other groups, and the difference was significant when compared to the ulnar deviation position. Considering that wrist extension with radial deviation is the most common pipetting position, our results might provide one explanation for the prevalence of hand complaints among pipette users. Based on our data, a pipette designed to be used in a more ulnar deviated wrist could have some ergonomic advantages, and we plan to devise such a device and test it in the future.

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