# Morphometric Changes Of The Carpal Tunnel Contents During Pinching: An MRI Assessment

U. C. Ugbolue[1], T. D. Nguyen[2], X. Guo[1], Y. Wang[2], Z. M. Li[1]

[1]Department of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh, PA, United States, [2]Department of Radiology, University of Pittsburgh, Pittsburgh, PA, United States

## INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common peripheral neuropathy that results from intrinsic (anatomic, physiologic) or extrinsic (forceful grip, awkward wrist positions, repetitive activities) factors[1,2]. This disease predominantly occurs over a prolonged period of performing work-related tasks involving the hands and wrists such as office and industrial activities. Various methods of assessment have been investigated to understand the underlying mechanisms responsible for compression of the median nerve. These evaluations have focused on pressure changes within the carpal tunnel[3] and how intrinsic and extrinsic factors can lead to compression of the median nerve, a widely agreed reason leading to CTS. However, some controversies still remain on certain etiological factors such as carpal tunnel size and movement of its contents. Therefore, more research is essential for a complete understanding of the fundamental mechanisms associated with CTS. Provocative exercises such as wrist flexion/extension, repetitive grasp-release, squeezing and pinching have been studied[4,5], in which parameters such as cross-sectional areas, bowing of the transverse carpal ligament, changes in shape to the carpal tunnel and median nerve were measured to evaluate both normal and symptomatic hands. The purpose of this study was to quantify the migration of tendons towards the median nerve during maximum pinching.

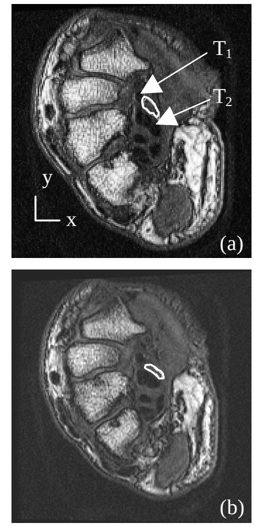


Figure 1: (a) Axial image of the carpal tunnel showing the shape of the nerve and tendon levels ($T_1$ and $T_2$) during "contact pinching" and (b) during "maximum pinching".

## METHODS

Experiments were performed on three healthy human volunteers (2 males/1 female, aged 28/32/25) using a 1.5 T Signa CV/i system (General Electric, Milwaukee, WI) with maximum gradient strength of 40 mT/m and maximum slew-rate of 150 T/m/s. A dedicated 4-element phased-array wrist coil (Medical Advances, Milwaukee, WI) was used for signal reception. Subjects were examined supine and feet-first with their wrists positioned on their sides. A custom-made splint was designed for each subject in order to minimize wrist movement during the pinching task. Each exam started with a 2D axial scout scan to determine the off-center position of the wrist (body coil, gradient echo, TR/TE/FA/rBW = 6.9 ms/1.8 ms/20°/±31.25 kHz , fractional echo, FOV = 40 cm, 256x160 matrix, slice thickness = 10 mm), followed by a 2D sagittal localizer scan to identify the area of interest, typically from the radial-ulna heads to the metacarpal bases (wrist coil, gradient echo, TR/TE/FA/rBW = 6.1 ms/1.7 ms/20°/±31.25 kHz, fractional echo, FOV = 15 cm, 256x160 matrix, slice thickness = 5 mm). Axial images of the carpal tunnel were then obtained using a 3D fast gradient echo pulse sequence (TR/TE/FA/rBW= 6.9 ms/1.8 ms/30°/±31.25 kHz, fractional echo, FOV = 10 cm, in-plane resolution = 0.4x0.4 $mm^2$, slice thickness = 3 mm, 16 slices. The scan time was 19 seconds, during which subjects were instructed to perform either "contact pinching" (thumb and index finger made a touching contact without any force application) or " maximum pinching" (thumb and index fingers made a pinching contact with maximum force application). Images were analyzed using MRview software (Mayo Clinic, Rochester, MN) by comparing "contact pinching" and "maximum pinching" images at the levels of the hook of hamate and pisiform (Figure 1). Our result analyses focused on four main parameters (a) migration of tendons towards the median nerve, (b) migration of the median nerve, (c) the median nerve flattening ratio (defined by nerve width divided by its thickness) and (d) the distance between the center of the cross-sectional area of tendons $T_1$ and $T_2$. The migration was determined in the x and y directions by calculating the displacements of the center of the cross-sectional area of the tendons or median nerve as a result of "maximum pinching".

**Table 1: Results of tendon migration towards the median nerve in x and y directions due to maximum pinching.**

| Subject | Migration at the level of the hook of hamate | | Migration at the level of the pisiform | |
|---|---|---|---|---|
| | x (mm) | y (mm) | x (mm) | y (mm) |
| A | 0.78 | 1.77 | 0.13 | 1.61 |
| B | 1.24 | 0.74 | 0.86 | 0.25 |
| C | 1.23 | 0.78 | 1.13 | 0.79 |

## RESULTS AND DISCUSSION

Our preliminary results have revealed that the tendons migrated towards the median nerve at the levels of the hook of hamate and pisiform (Table 1).This level of migration was subjective and very much dependent on the degree of pinching forces applied. The "maximum pinching" forces ranged from 7N to 15N. As a result of the tendon migration the median nerve was displaced at the level of the hook of hamate in the x (and y) directions by 0.4mm (1.26mm), 1.33mm (0.13mm) and 1.2mm (0.71mm) for subjects A, B and C respectively. At the level of the hook of hamate, the median nerve flattening ratio (mean (SD)) revealed the "maximum pinching" task as having a higher flattening ratio (3.19 (0.86)) in comparison to "contact pinching" (2.09 (0.11)) and furthermore the distance between the tendon levels $T_1$ and $T_2$ during "maximum pinching" reduced considerably. In summary, these results demonstrate the converging of tendons during "maximum pinching" and the influence the migration of tendon has on the change in shape of the median nerve as confirmed by the flattening ratio. These preliminary results suggest that force exertions generated by manual tasks may contribute towards changes in the morphology of the carpal tunnel and its contents in relation to median nerve compression.

## REFERENCES

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