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Day-to-Day Variability of Median Nerve Location within the Carpal Tunnel

Jessica E. Goetz, Ph.D.^{*,†}, Daniel R. Thedens, Ph.D.[○], Nicole M. Kunze, B.S.E.⁺, Ericka A. Lawler, M.D.^{*}, and Thomas D. Brown, Ph.D.^{*,†}

^{*}Department of Orthopaedics & Rehabilitation, University of Iowa, Iowa City, IA, USA

[○]Department of Radiology, University of Iowa, Iowa City, IA, USA

[†]Department of Biomedical Engineering, University of Iowa, Iowa City, IA, USA

Abstract

Background—Carpal tunnel syndrome is a commonly encountered entrapment disorder resulting from mechanical insult to the median nerve. MRI-based investigations have documented typical locations of the median nerve within the carpal tunnel; however, it is unclear whether those locations are consistent within an individual on different days.

Methods—To determine the day-to-day variability of nerve location, 3.0T MRI scans were acquired from six normal volunteers over multiple sessions on three different days. Half of the scans were acquired with the wrist in neutral flexion and the fingers extended, and the other half were acquired with the wrist in 35 degrees of flexion and the fingers flexed. Prior to half of the scans (in both poses), subjects performed a preconditioning routine consisting of specified hand activities and several repetitions of wrist flexion/extension. The shape, orientation, location, and location radius of variability of the median nerve and three selected flexor tendons were determined for each subject and compared between days.

Findings—Two of the six subjects had substantial variability in nerve location when the wrist was in neutral, and four of the subjects had high variability in nerve position when the wrist was flexed. Nerve variability was typically larger than tendon variability. The preconditioning routine did not decrease nerve or tendon location variability in either the neutral or the flexed wrist positions.

Interpretation—The high mobility and potential for large variability in median nerve location within the carpal tunnel needs to be borne in mind when interpreting MR images of nerve location.

Keywords

Carpal Tunnel Syndrome; Magnetic Resonance Imaging; Day-to-day Repeatability; Median Nerve

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Corresponding Author: Jessica E. Goetz, Ph.D. Orthopaedic Biomechanics Lab 2180 Westlawn Building Iowa City, IA 52242-1100
Phone: (319) 384-4275 Fax: (319) 335-7530 jessica-goetz@uiowa.edu.

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INTRODUCTION

Carpal tunnel syndrome (CTS) is the most commonly encountered peripheral neuropathy, presenting with a collection of symptoms including paresthesia, numbness, muscle weakness, and pain in the portion of the hand that is innervated by the median nerve. CTS is caused by mechanical insult to the median nerve as it traverses the osseoligamentous carpal tunnel, which it shares with the nine digital flexor tendons. The high-quality images of the tendons and nerves provided by magnetic resonance imaging (MRI) hold appeal for advances in CTS diagnosis and research. On MR images the tendons, ligaments, and median nerve appear as discrete, identifiable structures. The tendons have low signal intensity and appear black in all imaging sequences (Buchberger 1997). The intermediate signal of the tendon sheaths allows for delineation of individual tendons. On MR images, the median nerve usually appears gray with a stippled texture (Middleton et al. 1987).

Typical conformations of the carpal tunnel soft tissues have been frequently described in the literature. When the wrist is in extension, and most frequently when in neutral flexion, the nerve is located on the volar side of the tunnel, between the transverse carpal ligament and the superficial flexor tendons of the index and long fingers (Figure 1A). A common positional variant when the wrist is in neutral is for the nerve to be located between the flexor pollicis longus (FPL) tendon and the superficial tendon of the index finger (Figure 1B) (Mesgarzadeh et al. 1989a; Middleton et al. 1987; Yu and Habib 2006; Zeiss et al. 1989). When the wrist is in flexion, the nerve has commonly been reported to be in either of the above common neutral-wrist locations, or to have shifted to a location between the superficial tendons of the long and ring fingers (Figure 1C) (Allmann et al. 1997; Howe et al. 1994; Yu and Habib 2006; Zeiss et al. 1989).

These previous studies have focused on either cataloging anatomy for descriptive purposes, or for comparison with CTS patient patho-anatomy. Several of these studies have noted that in CTS patients, there is an altered incidence of certain tendon/nerve conformations when compared to normal individuals (Allmann et al. 1997; Howe et al. 1994; Middleton et al. 1987). The well-documented frequent shifts in nerve position associated with hand movement from neutral to flexion, and the modification of those shifts that may be associated with pathologic conditions, are suggestive of significant movement of these structures in an axial plane through the carpal tunnel in healthy subjects.

While the inter-subject variability of nerve location and movement has been well-documented, to date all such assessments have been made based on a single MRI session. It remains unknown whether location of the median nerve in specific hand poses is consistent for a given individual over time. The purpose of this work was to determine if the location of the median nerve within the carpal tunnel was consistent over the course of several days. A second purpose was to test whether a preconditioning regimen would improve the day-to-day consistency of median nerve location by “seating” the nerve in a preferential location within the tunnel.

METHODS

Six subjects (4 female, 2 male, ages 22-29) with no history of CTS, hand, or wrist pathology volunteered for this study. The hand sizes of the volunteers, measured from the tip of the long finger to the distal wrist crease, were very similar between females (average 17.8 cm; range 16.8-19.1 cm) and males (average 18.9 cm; range 18.16-19.56 cm). Under an IRB-approved protocol, the carpal tunnel of each subject was imaged on three different days using a Siemens TIM Trio 3T scanner (Siemens Medical Solutions, Erlangen, Germany) with a 3D Dual Echo Steady State (DESS) pulse sequence (TR/TE = 13/4.3ms, 25° flip angle). Subjects were positioned head-first prone in the scanner with the dominant hand extended overhead. Plastic

splints formed at angles of 0° (neutral position) and 35° of flexion held the wrist in the desired position. A transmit-receive extremity coil was used to accommodate variations in wrist pose during imaging. Resolution was 0.2mm × 0.2mm × 1.0mm (384 × 288 × 72 matrix) with a scan duration of 90 seconds per volume.

During the first session of Day 1, an initial volume scan was acquired with the wrist in neutral flexion and the fingers extended (“neutral pose”), followed immediately by the acquisition of a second volume with the wrist flexed 35° and the fingers gently curled around a 4 cm diameter grip (“flexed pose”). Data in the literature document tendon arrangement in a given individual being generally similar in neutral and extended wrist positions, but different with the wrist flexed (Keir and Wells 1999). Also, it has been reported that when the wrist is neutrally positioned, the effects of finger flexion on tendon and nerve movement are negligible, whereas when the wrist is flexed, finger flexion causes additional tendon movement and nerve deformation (Zeiss et al. 1989). The two specific hand poses were selected in order to obtain appreciably different conformations/arrangements of the tendons and the nerve within the tunnel.

Following the neutral and flexed-pose scans, subjects then completed five minutes of specified activities of daily living: typing for two minutes at a self-selected speed, sending a text message (fine motor task), lifting a can (feeding activity), and performing a dressing task (tying shoes – male subjects, or putting on and taking off a coat – female subjects). Subjects then performed ten cycles of wrist and finger flexion to precondition the tendon/nerve conformation within the tunnel into a potentially more reproducible state. To complete the imaging session, two more volume scans were acquired for the wrist, again in neutral and then again in the flexed pose. Each session thus generated four volumetric data sets. On Day 2, the order of scans was reversed, with the flexed position being imaged before the neutral position. On Day 3, the order was again neutral prior to flexed.

Four of the six subjects underwent two scanning sessions on each of the three days (total of 24 scans), and the other two subjects underwent two scanning sessions on one or two of the three days (total of 16 and 20 scans for subjects 1 and 3, respectively). For all subjects, on days with two imaging sessions, the splinting order in the second session was reversed from that of the initial, and there were 60 minutes of recovery time between sessions (with the exception of a 30-minute recovery time for two subjects on days 1 and 3). During the recovery period, subjects were allowed to leave the MRI suite and perform self-selected hand activities/rest. The purpose of the extended recovery time was to eliminate the effects of preconditioning, and simulate a fully independent trial within the same day.

From each MRI scan, a 2D axial section (transverse to the carpal tunnel) was selected at the level of the hook of the hamate. Similar sections were selected from the scans acquired over multiple days by identifying sections with similar carpal bone appearance. In the selected 2D sections, the boundaries of the median nerve, the carpal tunnel, and the FPL, superficial index, and superficial long tendons were manually segmented using tools developed in MATLAB (The Mathworks, Natick, MA, USA) (Kunze et al. 2009). All segmentation data were transformed into a tunnel-based coordinate system defined with the origin located at the centroid of the tunnel and the positive x-axis directed radially (Figure 2). An ellipse was fit to the median nerve that had an equivalent normalized second moment of inertia as the nerve's cross-sectional area. The median nerve was characterized in terms of that ellipse by its aspect ratio (major axis/minor axis) and orientation (angle of its major axis relative to that of the tunnel), plus a normalized polar coordinate location (angle of the centroid from x-axis of the tunnel, and distance between the nerve and tunnel centroids divided by the tunnel dimension at that particular angle).

Plots of segmented tunnel and nerve boundaries from a given subject on subsequent days were overlaid onto each other in order to visualize location and conformation differences. To quantify the variation in anatomic location of the nerve for an individual on different days, and before and after preconditioning, a radius of variability measure was utilized. This metric, also implemented with custom-written code in MATLAB, was defined as the radius of the minimum enclosing circle which encompassed the nerve centroids for the poses of interest. For the purposes of comparison, a radius of variability was also calculated for centroids of the three selected flexor tendons. Statistical significance of the differences in average nerve location and conformation under various scanning conditions was evaluated using two-tailed paired and two-sample t-tests at a significance level of $P \leq 0.05$.

RESULTS

In five of the six subjects, the aspect ratio of the median nerve was larger when the wrist was in the neutral pose than when in the flexed pose (Table 1). This indicates that the nerve adopted a rounder shape when the wrist was flexed ($P = 0.011$). In the only subject where this trend was not manifest, the nerve was nearly round (aspect ratio close to unity) in both poses. The orientation of the major axis of the nerve relative to the major axis of the carpal tunnel was much more varied in the flexed pose than in the neutral pose. Each subject had a characteristic nerve orientation within the tunnel, but the standard deviations around each subject-specific average were larger ($P < 0.05$) for the flexed versus the neutral pose, regardless of whether or not there had been preconditioning (Tables 1 & 2). The average carpal tunnel cross sectional areas for each of the four postures (neutral -PC, neutral +PC, flexed -PC, flexed +PC) were 179 mm² for both neutral postures, 183 mm² for the flexed pose without conditioning, and 185 mm² for the flexed pose with conditioning. Standard deviations around these averages were less than 17mm², which corresponded to less than 8% of the average tunnel area.

There were substantial differences in the day-to-day variability of nerve position between certain individuals (Figure 3). In the neutral pose, the nerve typically resided toward the radial side of the tunnel, adjacent to the transverse carpal ligament and between the FPL and the superficial flexor tendons of the index and long fingers (Figure 1A). In three of the six subjects, the radius of variability of the nerve location for the neutral pose was less than 1 mm, indicating that on every given day the nerve was very similarly located. A radius of less than 1 mm corresponded to the nerve centroid being located within the same <1.5% of total tunnel cross sectional area. In contrast, Subjects 1 and 3 had radii of variability of 2.4 mm and 2.6 mm for the neutral pose (respectively). These larger radii of variability (2-3 mm) indicate the nerve was only localized within 10%-15% of the carpal tunnel cross sectional area. The dimensions of the most commonly adjacent flexor tendons were approximately 2-3 mm by 4-5 mm, so the larger radii of variability were indicative of nerve movement sufficient to cause the nerve to move from one side of a flexor tendon to the opposite side.

The differences in variability of nerve location on different days were even more pronounced for the flexed hand pose (Table 3). Nerve location radii of variability for some subjects were 3.1-4.8 mm, which corresponded to localization only within 22%-36% of the total carpal tunnel area. The literature-described movement of the median nerve from a volar to a more dorsal location within the tunnel during wrist flexion was observed at least once in all six subjects. However, only two of the six subjects demonstrated that dorsal shift in all imaging sessions. The other four subjects had shifts in some of the scanning sessions, while in other sessions the nerve remained on the volar side of the tunnel, albeit shifted slightly ulnarly. This variable occurrence of dorsal nerve shift with flexion caused the radii of variability for the flexed pose to be 2-5 times larger than those for the neutral poses in several of the subjects.

Typically, the nerve location radius of variability was larger than the radii of variability for the individual flexor tendons (Table 3). The average radius of variability for the FPL was less than 0.8 mm in all hand poses, indicating that this tendon is not very mobile within an axial plane through the carpal tunnel. This FPL radius of variability was significantly smaller ($P < 0.05$) than nerve radius of variability in all six subjects in both the neutral and flexed poses. In the neutral pose, the average radii of variability for the superficial index and superficial long tendons were less than 1 mm, again significantly smaller ($P < 0.03$) than the nerve radius of variability in neutral. However, when the wrist was in a flexed pose, the variability in location of the superficial index and superficial long tendons increased slightly. While there was still a pronounced tendency for the location variability of these two tendons to be smaller than that of the nerve, this trend did not reach statistical significance ($0.08 < P < 0.22$).

The pre- to post-conditioning changes in tunnel cross sectional area were less than 5% of the neutral tunnel area, and the changes in nerve cross sectional area were less than 13% of the non-conditioned nerve area. Preconditioning did not cause the nerve to find a more consistent position within the tunnel in either the neutral or the flexed poses. In four of the six subjects, the preconditioning regimen actually caused *increased* radii of variability in *both* the neutral and the flexed poses (Table 3). Even in instances where the variability of nerve location was decreased by preconditioning, such decreases never exceeded 0.5 mm. In general, the change in variability due to preconditioning was not statistically significant ($P = 0.30$ for the neutral pose and $P = 0.10$ for the flexed pose).

DISCUSSION

Most subjects exhibited some minor day-to-day variations in median nerve location within the tunnel when the wrist was in a straight neutral position with the fingers extended. There was typically much more variability in the location of the median nerve when the wrist and fingers were in the flexed pose. The increased variability of nerve position for the flexed pose was attributable primarily to variable or incomplete occurrence of a median nerve dorsal shift.

It was somewhat unexpected that the preconditioning regimen often served to increase, rather than to decrease, the variability of the nerve location. In biomechanical and functional studies, it is fairly common to precondition soft tissues in order to establish a baseline from which to measure changes of interest. It is well known that biological soft tissues demonstrate time dependent behavior as specific architectural components of the tissues (e.g. collagen) are recruited, relax, and reorient (Schatzmann et al. 1998; Teramoto and Luo 2008). Mechanical behavior of tendon and ligament has been shown to be more consistent following preconditioning. Therefore, it was hypothesized that performing flexion/extension cycles after the specified activities of daily living would cause the tissue constituents to arrange in their preferred configuration, thereby decreasing the tendency for variability in position.

In the present study, the first two scans of any given imaging session were designed to be completely non-preconditioned. The working assumption was that under such circumstances, the location of the nerve would have the greatest chance of being variable, since the subjects were being scanned after unknown/variable activities. By contrast, the second two scans of each imaging session were intended to be a maximally controlled situation, in which any effects of previous (varied) hand activities or nerve location would be obviated by having performed standardized preconditioning activities. A potential explanation for preconditioning failing to decrease the variability in nerve position is that the addition of the repetitive flexion/extension cycles may have undone the standardization of positioning that resulted from completion of the specified hand activities. Of course it is also possible that the specific hand activities chosen, and/or the duration of those activities, were simply insufficient to overcome whatever residual variation was present from the uncontrolled hand situation.

Because of the excellent image quality that can be obtained using MRI, substantial effort has been extended towards developing MRI as a tool for diagnosing CTS. This has included identifying particular MRI-apparent characteristics that are frequently seen in CTS patients (nerve enlargement, nerve flattening, volar TCL bowing, and increased nerve signal intensity), and qualitative documentation and comparisons of median nerve location within the carpal tunnel (Allmann et al. 1997; Girgis and Epstein 2000; Howe et al. 1994; Mesgarzadeh et al. 1989b; Middleton et al. 1987; Shafer-Crane et al. 2005). However, such MRI-apparent characteristics have proven to be rather insensitive and non-specific for diagnosing CTS (Radack et al. 1997; Steinbach and Smith 2000). The results from the present study provide a novel quantitative comparison of nerve location and add a further caveat to attempts to identify CTS based on comparisons of median nerve location. For location comparisons between single-day scans to potentially be useful for such purpose, it would be necessary to identify a preconditioning regimen that would ensure consistent median nerve positions within the carpal tunnel. The present results suggest this would be a difficult challenge.

The variability of the median nerve location within the tunnel was quite high in comparison to the variability of location of the tendons. The FPL, superficial index, and superficial long tendons were chosen for comparison based on their close proximity to the median nerve. The tendons each have a specific origin from a muscle belly in the forearm and a particular insertion location on the bones of the fingers. The median nerve, by contrast, descends the entire length of the forearm, and it branches prior to innervation of the digits. Tendons, therefore, are much more functionally constrained, and would not be expected to be as free to move transversely within the tunnel as is the median nerve. While statistical significance was not reached in all cases, the trend of the tendon locations within the tunnel having less variability than the nerve location was quite evident. The FPL, with its insertion on the thumb and its more pronounced wrapping around the carpal bones, may be considered to be the tendon with the shortest unconstrained length. It had the smallest variability in location within the tunnel, which lends support to the notion that the amount of constraint proximal and distal to the tunnel influences the ability of the structure to move transversely within the tunnel. The nerve's lesser constraint is consistent with the wide variety of transverse movement observed in this study.

Furthermore, the flexor tendons are maintained under slight tension owing to physiologic muscle tone, while the nerve is typically loaded only by interactions with adjacent structures. The slight tensile load on the tendons may constrain transverse motion by dominating the translational effects of transverse forces on the tendons. Lack of normal longitudinal tensile load may leave the nerve with less constraint to normalize its position within the tunnel. A decrease in flexor tendon tension associated with a passively flexed wrist (Tanaka et al. 2005), as was the case for our relaxed and splinted subjects, may be responsible for the increase in tendon and nerve variability that was found between the neutral and the flexed wrist poses. While not explicitly investigated in this work, the increased location constraint potentially provided by increased tendon tension during passive wrist extension may explain why other investigators have only seen one tendon/nerve arrangement (Variant 0 in Figure 1) within the tunnel when the wrist is positioned in extension. Similarly, it can also be speculated that pathological changes associated with carpal tunnel syndrome that would serve to constrain the nerve (e.g. adhesions, thickened tenosynovium, etc.) may decrease the day to day variability of the nerve location in CTS patients.

Using a single section from the level of the hook of the hamate facilitated consistently matching the bony anatomy in scans collected during different sessions. The level of the hook of the hamate, being the narrowest part of the carpal tunnel, was selected because it would be expected to exert the most constraint on tissue location. The complex interactions and deformations between the carpal tunnel structures at that level may potentially lead to carpal tunnel syndrome pathology. While there may have been some minor imprecision in identifying perfectly

equivalent sections, all sections utilized were within a 3 mm range (within 3 sections taken at 1 mm intervals) of the most prominent part of the hook. The nerve appeared in a very similar anatomic location within this longitudinal span, and the variability of the nerve centroid within this 3 mm span was associated with a radius of 0.7 mm for the most variable subject, and within 0.3 mm for the least variable subject.

It is unlikely that differences in the radial/ulnar angulation of the wrist contributed appreciably to variability in median nerve location. While not explicitly controlled by the splinting, radial/ulnar orientation of the wrist was standardized by having the same two individuals apply the splints and position the subject in the receiver coil. Visual inspection of the localizer images obtained in a coronal plane confirmed only minor differences in radial/ulnar wrist angles, and comparable differences were present in subjects with both high and low variability of median nerve location. There was no evidence of lumbrical muscles inside the tunnel in any of the neutral wrist scans. In some subjects, there appeared to be a slight incursion of the lumbricals into the tunnel associated with wrist flexion. However, in the subjects where this occurred, it occurred in every replicate of that position, and therefore lumbrical muscles were likely not a principal reason for variation in nerve position.

In conclusion, the locations of the median nerve within the carpal tunnel commonly reported in literature in fact may vary substantially day-to-day within a given individual. Preconditioning by a several-minute regimen of prescribed hand activities followed by repetitive flexion/extension cycles failed to reduce the variability in nerve location. Usage of MRI for clinical diagnosis of CTS, or for research purposes, is predicated on consistent baseline conformations of the tendons and the nerve. The present work has documented that the conformations of the structures within the carpal tunnel are in fact appreciably variable, implying that attributions of changes of position within the tunnel as being due to pathology need to be tempered accordingly.

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Figure 1.

Common location variants of the median nerve location that have been reported in literature. The nerve (N) is highlighted in yellow, 1 is the flexor pollicis longus tendon, and 2, 3, 4 are the superficial tendons of the index, middle, and ring fingers, respectively. In this work, we observed all three location variants. While variant 2 has only been reported in the literature for wrists imaged in flexion, this position was encountered in several of the present subjects imaged with a neutral wrist position.

Figure 2. Tunnel-based coordinate system illustrated on an MRI section. Angle α (blue) is the nerve location angle, and angle β (green) is the nerve angle relative to the tunnel x-axis.

Figure 3.

Illustrative plots of nerve and tunnel boundaries, grouped by pose. The multiple lines in each plot are the segmented boundaries from the different scanning sessions, and the symbols denote the centroids of the nerve. The four plots on the left are from Subject 5, who demonstrated the least amount of nerve location variability. The plots on the right are from Subject 1, who demonstrated the most variability.

Average median nerve aspect ratios (standard deviation) and average orientation (standard deviation) of the median nerve major axis with respect to the tunnel major axis for each subject in each hand pose. Gender is shown in parentheses next to the subject number. All angles are expressed in degrees, and positive angles indicate that the radial-most portion of the nerve is more dorsally located (the nerve orientation shown in Figure 2). -PC indicates scans without preconditioning, +PC indicates scans preceded by the preconditioning routine. There were no statistically significant differences between the average nerve shapes or orientations before versus after preconditioning for either the neutral or the flexed poses. However, the nerve was significantly ($P = 0.01$) rounder in the flexed pose compared to the neutral, and its major axis was in a significantly ($P = 0.01$) different orientation.

Table 1

Subject	Nerve Aspect Ratio				Nerve Orientation			
	Neutral -PC	Neutral +PC	Flexed -PC	Flexed +PC	Neutral -PC	Neutral +PC	Flexed -PC	Flexed +PC
1 ^(f)	2.9 (0.2)	2.7 (0.7)	1.7 (0.7)	1.5 (0.2)	18.7 (13.4)	28.5 (7.0)	-23.3 (48.7)	-16.0 (49.3)
2 ^(f)	3.1 (0.3)	3.0 (0.3)	2.6 (0.3)	2.4 (0.7)	5.8 (8.3)	6.4 (9.8)	-16.6 (32.6)	-11.8 (12.3)
3 ^(m)	3.3 (0.7)	3.1 (0.6)	2.1 (0.3)	2.2 (0.2)	26.9 (11.6)	26.3 (12.9)	-49.3 (11.2)	-19.7 (48.3)
4 ^(m)	3.0 (0.1)	3.2 (0.4)	2.2 (0.7)	2.3 (0.6)	21.2 (5.8)	20.9 (1.6)	-9.8 (54.2)	-41.2 (41.8)
5 ^(f)	1.7 (0.2)	1.7 (0.2)	1.5 (0.3)	1.7 (0.3)	58.3 (13.5)	65.1 (13.3)	-27.5 (57.6)	-51.9 (12.9)
6 ^(f)	2.3 (0.4)	2.4 (0.5)	1.7 (0.6)	1.7 (0.3)	34.2 (3.5)	42.0 (19.2)	-36.3 (16.6)	-13.3 (50.2)
Average	2.73 (0.3)	2.69 (0.5)	1.97 (0.5)	1.96 (0.4)	27.5 (9.4)	31.5 (10.6)	-27.1 (36.8)	-25.7 (35.8)

Table 2

Average (standard deviation) distance of the median nerve centroid from the centroid of the tunnel, expressed as a percentage of the distance from the tunnel centroid to the tunnel boundary. There was a trend toward the nerve being more centrally located within the tunnel for the flexed pose, but this did not achieve statistical significance ($P = 0.15$).

Nerve Relative Radial Position				
<i>Subject</i>	<i>Neutral -PC</i>	<i>Neutral +PC</i>	<i>Flexed -PC</i>	<i>Flexed +PC</i>
1 ^(f)	82% (3%)	78% (2%)	61% (15%)	58% (18%)
2 ^(f)	71% (1%)	71% (3%)	68% (5%)	68% (4%)
3 ^(m)	75% (2%)	77% (2%)	63% (15%)	72% (2%)
4 ^(m)	64% (3%)	64% (3%)	65% (3%)	67% (2%)
5 ^(f)	68% (3%)	67% (2%)	67% (2%)	70% (2%)
6 ^(f)	71% (5%)	69% (7%)	67% (4%)	67% (4%)
Average	72% (3%)	71% (3%)	65% (7%)	67% (5%)

Table 3

Radius of variability (mm) for each subject in each pose. Nerve values are shown for each individual for comparison to individual tendon data. Nerve values in parentheses have been normalized by individual tunnel cross-sectional area to facilitate comparisons of variability independent of hand size. Data for the radii of variability of three tendons (FPL, superficial index – SI, superficial long – SL) are shown in italics for reference. Statistical significance with a two-tailed test was not achieved for differences in nerve variability between the flexed and neutral poses ($P = 0.32$).

Subject	Neutral -PC			Neutral +PC			Flexed -PC			Flexed +PC						
	Nerve	FPL	SI	SL	Nerve	FPL	SI	SL	Nerve	FPL	SI	SL				
1 ^(b)	2.4 (2.4)	0.5	0.8	0.8	2.0 (1.8)	0.3	1.0	0.7	4.1 (3.9)	1.0	1.0	1.7	4.8 (4.3)	0.8	1.3	0.5
2 ^(b)	1.3 (7.7)	0.5	0.7	0.8	1.9 (2.3)	0.8	0.7	0.9	3.1 (4.0)	1.3	1.3	3.4	3.8 (4.8)	1.0	3.4	1.6
3 ^(m)	2.6 (2.5)	0.5	0.7	0.9	2.8 (2.7)	1.0	1.9	2.0	2.0 (1.7)	1.2	1.2	1.5	2.8 (2.5)	0.5	1.4	2.2
4 ^(m)	0.6 (0.6)	0.6	0.3	0.4	0.9 (0.9)	0.2	0.6	0.6	3.9 (3.8)	0.3	1.1	1.5	3.5 (3.3)	0.4	1.2	1.2
5 ^(b)	1.0 (0.9)	0.5	0.4	0.4	0.6 (0.5)	0.5	0.6	0.4	0.7 (0.6)	0.4	0.7	0.7	0.5 (0.4)	0.6	0.8	0.9
6 ^(b)	0.8 (0.9)	0.4	0.6	0.5	1.3 (1.4)	0.4	0.7	0.6	0.5 (0.5)	0.7	2.3	0.9	1.0 (7.0)	0.5	1.0	0.8
Average	Nerve	FPL	SI	SL	Nerve	FPL	SI	SL	Nerve	FPL	SI	SL	Nerve	FPL	SI	SL
	1.5	0.5	0.6	0.6	1.6	0.5	0.9	0.9	2.4	0.8	1.3	1.6	2.7	0.6	1.5	1.2