High-resolution ultrasonography measurement of dimensions of median nerve at wrist in asymptomatic adults

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Abstract

Background: Ultrasonography (USG) is a cheap, easily available and painless modality for the diagnosis of carpal tunnel syndrome. However, the main sonographic criteria of cross sectional area (CSA) and flattening ratio (FR) of median nerve show a wide normal variation which warrants establishment of normal range of variability in the dimensions of median nerve in different populations.

Objective: The main aim of this study was to calculate the mean cross sectional area (CSA) and flattening ratio (FR) of median nerve at wrist in asymptomatic adults.

Materials and methods: This prospective observational study included asymptomatic adults visiting our tertiary care hospital for unrelated health conditions with no symptoms to suggest carpal tunnel syndrome. Ultrasound examination of both wrists was carried out by high frequency linear array transducer with frequency of 10MHz with the arm in supine neutral position on LOGIQ P5 (GE Healthcare, Chicago, Illinois, USA) ultrasound machine. The cross-sectional area (CSA) and flattening ratio (FR) of the median nerve was measured at the level of carpal tunnel inlet and mean values with standard deviation were calculated.

Results: Three hundred seventy six (376) wrists of 188 subjects were examined. 36 wrists were excluded owing to presence of anatomic variations of the median nerve in them. 340 wrists of 170 patients were included in the study. Mean cross sectional area of median nerve was 9.2 mm² (±1.2).
Mean value of flattening ratio was 2.4 (±0.6). Mean CSA (9.26 ±1.2 mm$^2$) and FR (2.41 ±0.6) of males was not significantly different from mean CSA (9.16 ±1.2 mm$^2$) and FR (2.4±0.55) of females. However, mean CSA of right wrist (9.4 ±1.2 mm$^2$) was significantly different from mean CSA of left wrist (9.10 ±1.1 mm$^2$).

**Conclusion:** We found a higher mean cross sectional area (CSA) of 9.2 mm$^2$ of median nerve in our population. There was a significant difference in the cross sectional area of median nerve between right and left wrists. However, we did not find statistically significant difference in the CSA and FR between the males and females. Establishment of normative data for the dimensions of median nerve is essential for different populations given the wide range of variations in the dimensions of median nerve.

**Key words**
High resolution ultrasonography, Median nerve, Wrist, Asymptomatic.

**Introduction**

Nerve entrapment syndromes are a constellation of compressive neuropathies in which a nerve gets compressed by adjacent structures leading to clinical syndrome of pain and other symptoms of nerve compression [1, 2]. Median nerve in its journey from its origin from brachial plexus to its destination in hand is prone to get entrapped at three sites named after the structures where the nerve gets compressed as pronator teres syndrome, anterior interosseous nerve syndrome and carpal tunnel syndrome with the latter being the most common among the three [1, 2, 3]. Though classically diagnosed by the unique combination of clinical profile and the nerve conduction velocity tests, ultrasonography (USG) is an easily available and painless alternative diagnostic modality for the diagnosis of carpal tunnel syndrome (CTS). The ability to directly visualize and measure median nerve by USG has been exploited to diagnose CTS [4]. However, given the wide variation in the dimensions of median nerve at wrist with ethnicity, researchers have since long tried to establish the cut-off value for dimensions of median nerve at wrist [5]. We undertook this study with the aim to find the mean size of median nerve using high resolution ultrasonography in asymptomatic adults.

**Materials and methods**

This was a prospective observational study. The study included asymptomatic adults visiting our tertiary care hospital for unrelated heath conditions with no symptoms to suggest carpal tunnel syndrome. The study excluded individuals with previous history of trauma or surgery to wrist, history of conditions predisposing to carpal tunnel syndrome including pregnancy, hypothyroidism, acromegaly, oral contraceptive pill usage, collagen vascular disease, multiple myeloma, amyloidosis, diabetes mellitus and sarcoidosis. Patients with positive provocative tests for median nerve compression like Tinel’s and Phalen’s tests were also excluded from the study. Individuals with variant median nerve anatomy like bifid median nerve or high dividing median nerve were also excluded from the study. In all cases informed verbal consent was obtained after explaining the procedure to the volunteers. Institutional ethical clearance was also obtained for the study. The study was carried out on LOGIQ P5 (GE Healthcare, Chicago, Illinois, USA) ultrasound machine. Ultrasound examination of both wrists was carried out by high frequency linear array transducer with frequency of 10MHz. The arm was placed in a supine neutral position and the fingers were semi-extended. The cross-sectional area (CSA) of the median nerve was measured by the electronic caliper for area measurement given in the ultrasound machine by drawing a trace around the margins of median nerve. The trace was drawn around the hypoechoic nerve fascicles and within the hyperechoic nerve sheath (Figure - 1). The cross-sectional area (CSA) of
the median nerve was measured at the inlet of the carpal tunnel defined by the landmarks of proximal scaphoid (laterally) and pisiform bone (medially). Flattening ratio (FR) of the median nerve was also obtained at the level of inlet of carpal tunnel. Flattening ratio (FR) is defined as the ratio of the maximum transverse to maximum antero-posterior (AP) diameter of the nerve (Figure - 1). The data was analyzed using statistical softwares SPSS v 20 and STATA v 11.

![Image](image.png)

**Figure 1.** Transverse high resolution USG image at the inlet of carpal tunnel showing flattening ratio (FR) and cross sectional area measurement of median nerve.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSA (mm²)</td>
<td>6.6</td>
<td>11.4</td>
<td>9.2</td>
<td>1.2</td>
</tr>
<tr>
<td>FR</td>
<td>1.9</td>
<td>3.2</td>
<td>2.4</td>
<td>0.6</td>
</tr>
</tbody>
</table>

**Table – 1:** Cross sectional area (CSA) and flattening ratio (FR) of median nerve.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Right (n=85)</th>
<th></th>
<th>Left (n=85)</th>
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<th>p-value</th>
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<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>CSA</td>
<td>9.40</td>
<td>1.2</td>
<td>9.10</td>
<td>1.1</td>
<td>0.04</td>
</tr>
<tr>
<td>FR</td>
<td>2.40</td>
<td>0.6</td>
<td>2.41</td>
<td>0.54</td>
<td>0.518</td>
</tr>
</tbody>
</table>

**Table – 2:** Comparison of measurements between right and left wrists.

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>Female (n=70)</th>
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<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>CSA</td>
<td>9.26</td>
<td>1.2</td>
<td>9.16</td>
<td>1.2</td>
<td>0.630</td>
</tr>
<tr>
<td>FR</td>
<td>2.41</td>
<td>0.60</td>
<td>2.40</td>
<td>0.55</td>
<td>0.650</td>
</tr>
</tbody>
</table>

**Table – 3:** Comparison of measurements between males and females.

**Results**

Three hundred seventy six (376) wrists of 188 subjects were examined. 36 wrists were excluded owing to presence of unilateral or bilateral anatomic variations of the median nerve in them. 340 wrists of 170 patients were included in the study. The study included 100 male and 70 female subjects. The age range was from 15 to
52 years (mean age 33 years). The cross sectional area (CSA) and flattening ratio (FR) of the median nerve obtained at the carpal tunnel inlet is given in Table - 1. CSA and FR of right and left wrists were noted separately. Paired t-test was used for comparison of values from the right and left wrists. The CSA of the median nerve at carpal tunnel inlet was significantly different between the two sides. However, FR was not significantly different between the right and left wrists (Table - 2). Independent t-test was used to compare measurements of median nerve between males and females (Table - 3). No significant difference (p-value >0.05) was found in cross sectional area and flattening ratio of median nerve at carpal tunnel inlet between men and women.

Discussion

The median nerve takes origin from the medial and lateral cords of the brachial plexus (C6–C8, T1) and lies in close association with the brachial artery both in the anterior compartment of the arm and at the elbow. Within the forearm, the nerve lies between the flexor digitorum superficialis and flexor digitorum profundus muscles [6, 7]. Median nerve enters the carpal tunnel to supply hand. The carpal tunnel is a fibro-osseous tunnel formed by volar aspects of the carpal bones dorsally and the flexor retinaculum volarly. The flexor retinaculum is a fibrous band that stretches between the tip of the hook of the hamate and the pisiform medially and the trapezium and scaphoid laterally. The carpal tunnel contains nine tendons (the four flexor digitorum superficialis tendons, four flexor digitorum profundus tendons, and flexor pollicis longus tendon) and the median nerve, which lies along the volar aspect of the tunnel. The proximal aspect of the tunnel is at the scaphoid–pisiform level, and the distal aspect is at the trapezium–hamate bone [2, 6, 7, 8]. On USG median nerve appears speckled, lies superficial at wrist and exhibits relative lack of movement with finger flexion. Out of 376 wrists that were examined 36 were excluded due to presence of unilateral or bilateral anatomic variations of the median nerve in them. The anatomical variations of median nerve seen included either a bifid nerve defined as separate radial and ulnar fascicular bundles enveloped by a common sheath or a high dividing nerve defined as bifurcation proximal to carpal tunnel. Lanz has classified variations in the median nerve at the wrist into four groups [9]. All the variations of median nerve encountered by us fall into group 3 of Lanz classification. Mani B, et al. reported a high number of variant median nerves. Among a total of 234 wrists examined by them 84 had a variant median nerve [10]. In a study of 294 cases of CTS, Iannicelli, et al. reported six cases of bifid median nerve [11]. Mean cross sectional area (CSA) of median nerve at the carpal tunnel inlet in our study was 9.2 mm² (±1.2). The mean CSA of the median nerve for the right and left wrists was 9.4 mm² and 9.1 mm² respectively. This difference was statistically significant. The CSA of median nerve in men (9.26 mm²) was not significantly different from women (9.16 mm²). Mean flattening ratio (FR) of median nerve in our study was 2.4±SD. FR of median nerve in men (2.41) was not significantly different from women (2.40). FR of median nerve between right (2.40) and left (2.41) wrists was not significantly different. Mani B, et al. [10] reported a mean median nerve CSA of 7.6 mm² in a study population of 75 patients. They also did not find statistically significant difference between the median nerve CSA of men and women. However, they reported significant difference in the CSA of right and left wrists. With regards to FR they did not find statistically significant difference between males and females or between right and left wrists. Burg EW, et al. [5] in a comparative study of Dutch and Indian population found that the CSA of median nerve is significantly different between healthy Dutch (8.3 ± 1.9 mm²) and Indian subjects (7.0 ± 1.1 mm²). Using the criteria of Yesildag, et al. [12] for the diagnosis of carpal tunnel of CSA >10.5 mm² (89% sensitivity and 94% specificity) at the carpal tunnel inlet many of our subjects had a value above this level. As per the findings of Duncan, et al. [13] median nerve CSA of 9 mm²
(82% sensitivity and 97% specificity), however, lies close to the mean CSA in our study and would result in lower threshold for the diagnosis of carpal tunnel syndrome. Mani B, et al. [10] reported a flattening ratio of 2.6 at the level of carpal tunnel inlet. Buchberger, et al. [14] reported a flattening ratio 4.6 (SD 0.5) at the level of carpal tunnel outlet in patients with carpal tunnel syndrome. Sarria L, et al. [15] observed that flattening ratio is highly variable and thus poor indicator of carpal tunnel syndrome. It is believed that the dimensions of median nerve may be influenced by the body mass index and hand physiognomies (small versus strong wrists). So, our study reveals a comparatively large mean CSA of median nerve in our population compared to other studies.

**Conclusion**

We found a higher mean cross sectional area (CSA) of 9.2 mm^2^ of median nerve in our population. There was a significant difference in the cross sectional area of median nerve between right and left wrists. However, we did not find statistically significant difference in the CSA and FR between the males and females. Carpal tunnel syndrome may be diagnosed using ultrasonography. However, the two commonly used criteria of cross sectional area and flattening ratio in USG vary widely which necessitates that normative data for different populations should be procured which will aid in correctly diagnosing CTS by ultrasonography.

**References**

11. Iannicelli E, Chianta GA, Salvini V, et al. Evaluation of bifid median nerve with...


