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Original Research

## Magnetic Resonance Imaging—Measured Cross-Sectional Area of the Median Nerve



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**Purpose:** The size of the median nerve may serve as a useful parameter to predict carpal tunnel syndrome (CTS) in a subset of patients. The purpose of this study was to evaluate magnetic resonance imaging–based measurements of median nerve cross-sectional area (CSA) to examine trends between patient subgroups and CSA that may assist in predicting the individuals who are most likely to develop CTS symptoms.

**Methods:** A retrospective chart review of 1,273 wrist magnetic resonance images was performed, and the images were analyzed to evaluate the median nerve CSA at the level of the pisiform and the hook of hamate. The age, sex, height, weight, and body mass index (BMI) of the patients were collected from their medical records.

**Results:** The median nerve size correlated with patient BMI. Additionally, patients with CTS had larger median nerves at the hook of hamate and pisiform than those without CTS. When subdividing patients on the basis of BMI, obese patients with CTS had larger median nerve CSA at the pisiform than those without CTS.

**Conclusions:** This study demonstrated that increased BMI is associated with increased median nerve CSA at the hook of hamate and pisiform in patients with or without CTS. Additionally, patients with CTS had larger median nerve CSA than those without CTS. Measurements at these locations may help predict individuals who are likely to experience median nerve impingement.

**Type of study/level of evidence:** Prognostic III.

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Carpal tunnel syndrome (CTS) accounts for 4 million office visits and over 600,000 surgeries per year in the United States alone.<sup>1</sup> Symptomatic management includes the use of braces, nonsteroidal antiinflammatory drugs, steroid injections, and carpal tunnel release.<sup>2</sup> Numerous tests exist to diagnose CTS, including the CTS-6, which is a diagnostic tool that uses findings from the history and physical examination, and electrodiagnostic testing.<sup>3,4</sup> Electrodiagnostic testing, a combination of nerve conduction studies and EMG, is often performed in patients considering surgery. Ultrasound has increasingly been used to confirm clinical diagnosis of CTS through the measurement of the cross-sectional area (CSA) of

the median nerve. Prior studies have found a significant positive correlation between the median nerve CSA and CTS-6 results, making it an acceptable alternative to electrodiagnostic testing.<sup>5–7</sup> The magnetic resonance images of median nerves can also be used to measure the average median nerve CSA, although they are not typically obtained in the management of CTS. Nevertheless, magnetic resonance images obtained for reasons other than the evaluation of CTS can be used to determine baseline CSA values for a large cohort of patients. It was hypothesized that considerable differences in average median nerve CSA would be found between subgroups of patients.

### Materials and Methods

An internal radiology database was queried, and 1,273 wrist magnetic resonance images obtained for any reason at our institution between 2013 and 2017 were identified. The medical records

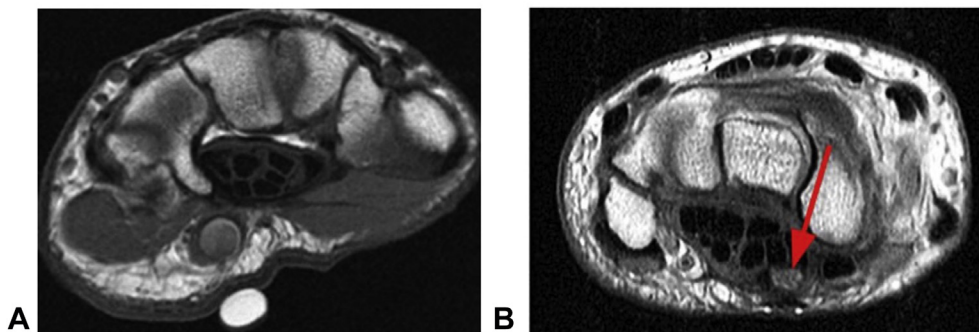
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**Figure 1.** Magnetic resonance images of median nerve at the level of pisiform **A** and the hook of hamate **B**. Red arrow indicates median nerve.

of these patients were reviewed. The exclusion criteria included known CTS, history of carpal tunnel release, patients younger than 18 years, lack of T2-weighted images, and/or poor quality images. After the exclusion criteria were applied, 283 participants were identified as eligible for the study. The most common exclusion parameters were the lack of T2-weighted images or images in which the median nerve CSA could not be adequately measured. A secondary analysis included 24 additional patients with CTS. Carpal tunnel syndrome was diagnosed using a combination of clinical symptoms and CTS-6 results. For each participant, the median nerve CSA was measured 3 times on T2-weighted images at the level of the pisiform and 3 times at the level of the hook of hamate in alternating fashion using digital calipers on the digital x-ray picture archiving and communication system. These landmarks were chosen as they are the radial borders of the carpal tunnel and allow for the measurement of 2 distinct levels of axial magnetic resonance imaging cuts. All measurements were performed by a medical student after they received training from a hand surgery resident who is now pursuing a hand fellowship. The CSAs of the median nerve (in mm<sup>3</sup>) at both levels of the wrist were averaged, and the age, sex, height, weight, and body mass index (BMI) of the patients were then collected from their medical records (Fig. 1). All patient data were collected in a manner compliant with the Health Insurance Portability and Privacy Act. Independent sample Mann-Whitney U test was performed to investigate differences in the median nerve CSAs across sexes. The Kruskal-Wallis test was performed to detect differences between the median nerve CSAs and patient BMI categories of normal weight, overweight, and obese. Statistical *t* tests were performed to detect the BMI groups that were significantly different from each other. A post hoc power analysis was conducted for all groups.

**Results**

A total of 283 patients (37 ± 14.8 years; 99 men and 184 women) were included in the primary analysis of patients without CTS. There were 132 patients in the normal weight group (BMI, 18.5–24.9 kg/m<sup>2</sup>), 86 in the overweight group (BMI, 25–30 kg/m<sup>2</sup>), and 60 in the obese group (BMI, >30 kg/m<sup>2</sup>). Given that only 5 patients (all women) were in the underweight group, they were excluded from the BMI category analysis. A secondary analysis included 24 additional patients with CTS to compare with those without. Patient demographics are presented in Table 1.

No differences in the median nerve CSAs were found between men and women at the level of the hook of hamate (*P* = .17) or the pisiform (*P* = .13) (Table 2). When subdividing patients based on BMI, statistically significant differences were found at both the level of the hook of hamate (*P* = .01) and the pisiform (*P* = .01) (Table 3 and Fig. 2).

**Table 1**  
Patient Demographics

	N (%)	Mean ± SD
Men	99 (35)	
Women	184 (65)	
Race (white)	239 (84)	
Age, y		
Mean		37 ± 14.8
Median		35 ± 14.8
BMI		
Mean		27 ± 6.1
Median		25 ± 6.1

**Table 2**  
Comparison of Median Nerve CSA (in mm<sup>3</sup>) Based on Patient Demographics

	Hook of Hamate		Pisiform	
Men	11.1 ± 3.5	<i>P</i> = .17	11.4 ± 3.5	<i>P</i> = .13
Women	10.6 ± 2.7		10.8 ± 3.0	

**Table 3**  
Comparison of Median Nerve CSA (in mm<sup>3</sup>) Based on BMI Category

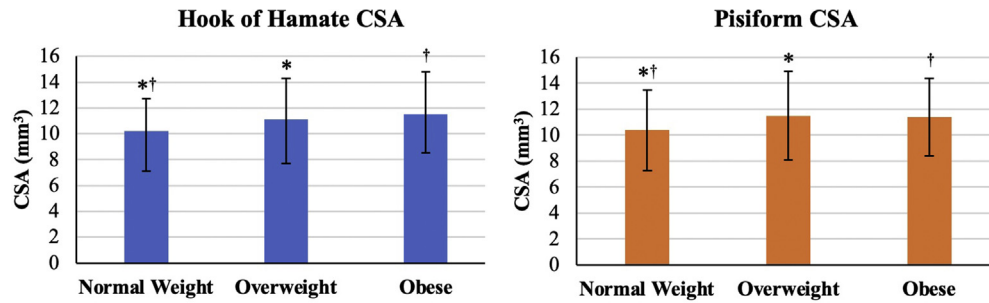
	Hook of Hamate		Pisiform	
Normal weight	10.2 ± 2.5 <sup>†</sup>	<i>P</i> = .01	10.4 ± 3.1 <sup>†</sup>	<i>P</i> = .01
Overweight	11.1 ± 3.2 <sup>*</sup>		11.5 ± 3.4 <sup>*</sup>	
Obese	11.5 ± 3.3 <sup>†</sup>		11.4 ± 3.0 <sup>†</sup>	

<sup>\*</sup> Indicates significant difference between normal weight and overweight groups.  
<sup>†</sup> Indicates significant difference between normal weight and obese groups.

For the secondary analysis, patients with CTS had significantly larger median nerves at the level of the hook of hamate (*P* = .01) and the pisiform (*P* < .01) (Table 4). When subdividing patients based on BMI, obese patients with CTS had a larger median nerve CSA at the level of the pisiform (*P* < .01) than those without CTS (Table 5). A similar trend was found at the level of the hook of hamate for obese patients, although the result was not statistically significant (*P* = .10). No other differences were found in the median nerve CSA between patients with CTS compared to those without (Table 5).

**Discussion**

This study evaluated the magnetic resonance imaging–based measurements of the median nerve CSA to examine trends between patient subgroups and CSA. The present study demonstrated that an increased BMI was able to predict the increase in the CSA of the median nerve at both the hook of hamate and the pisiform in patients with or without CTS, supporting the hypothesis. However,



**Figure 2.** Comparison of the median nerve CSA (in mm<sup>3</sup>) at the hook of hamate and at the pisiform based on the BMI. \*,†Significant differences between the groups.

**Table 4**  
Comparison of Median Nerve CSA (in mm<sup>3</sup>) Based on CTS Status

	Hook of Hamate		Pisiform	
No CTS	10.7 ± 3.0	<i>P</i> = .01	11.0 ± 3.2	<i>P</i> < .01
CTS	12.3 ± 3.0		15.0 ± 6.0	

**Table 5**  
Comparison of Median Nerve CSA (in mm<sup>3</sup>) Based on BMI Category and the Presence of CTS

	Hook of Hamate			Pisiform		
	No CTS	CTS	<i>P</i> Value	No CTS	CTS	<i>P</i> Value
Normal weight	10.2 ± 2.5	11.4 ± 2.0	.34	10.4 ± 3.1	11.2 ± 2.7	.61
Overweight	11.1 ± 3.2	11.7 ± 3.8	.57	11.5 ± 3.4	13.2 ± 4.3	.13
Obese	11.5 ± 3.3	13.4 ± 1.9	.10	11.4 ± 3.0	18.7 ± 7.2	<.01

in patients with a diagnosis of CTS, the ability of BMI to predict increased CSA was found to be dependent on the location. Specifically, those with increased BMI were found to have an increased median nerve CSA at the level of the pisiform but not the hook of hamate. This finding could potentially be a result of natural differential distribution of fat resulting from higher BMI.<sup>6</sup> Additional studies examining this trend could guide pretest probability in physician decision making in the analysis of CTS and severity of future symptoms.

Advanced imaging techniques can be useful in guiding the assessment of the carpal tunnel anatomy and median nerve impingement and may aid in the confirmation of a CTS diagnosis.<sup>7–10</sup> The factors predictive of the median nerve CSA have prognostic value as the median nerve CSA is a reliable predictor of CTS severity.<sup>6</sup> Although obesity is a known risk factor for CTS, the exact mechanism of how this contributes to increased risk for CTS is unclear.<sup>2,11,12</sup> Additionally, to our knowledge, how obesity may predispose individuals to median nerve changes and where within the carpus this may occur were previously unknown. This study demonstrated that increased BMI in the general patient population is specifically associated with an increase in the median nerve CSA at the level of the hook of hamate and the pisiform, suggesting a likely source of CTS symptoms in this subset. This finding may aid in physicians' ability to reliably predict patients who are more likely to experience a median nerve impingement and subsequent paresthesia, pain, and weakness in the median nerve distribution. The measurements made by clinicians at these 2 sites may provide increased prognostic information.

There are multiple strengths of the present study, the most important of which is its objective nature. The median nerve CSA can be accurately assessed with magnetic resonance imaging and used to aid in the diagnosis of CTS. In addition, a relatively large number of patients are included in each BMI category. This provides

reasonable generalizability to other populations. Although there are numerous strengths, this study also has several limitations, including its retrospective nature. Given the limited number of patients with CTS, conclusions comparing this group to those without CTS should not be applied broadly. A post hoc power analysis indicates that more than 1,000 patients would be required to detect a significant difference between sexes. With a larger sample of magnetic resonance images corresponding to CTS patients, a better understanding of the median nerve CSA may be achieved. Additionally, the comorbidities of participants are not investigated.

In conclusion, this study demonstrated that increased BMI is associated with increased median nerve CSA at the hook of hamate and the pisiform in patients with or without CTS. Additionally, patients with CTS had a larger median nerve CSA than those without CTS. The measurements at these locations may help predict individuals who are likely to experience median nerve impingement.

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