Comparison of Median Nerve Cross-sectional Area on 3-T MRI in Patients With Carpal Tunnel Syndrome

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Abstract

This study correlated morphologic abnormalities of idiopathic carpal tunnel syndrome (CTS) with the severity of CTS using 3-T magnetic resonance imaging (MRI). The relationship of the severity of CTS and the cross-sectional area of the median nerve (CSA) was assessed at several levels. Seventy wrists of 35 patients (27 women and 8 men) with unilateral idiopathic CTS underwent nerve conduction study and 3-T MRI of the wrist. The CSA at 4 levels (distal radioulnar joint, body of scaphoid, tubercule of scaphoid, and hook of hamate) and the thickness of the transverse carpal ligament at 3 levels in both affected and unaffected hands were measured using 3-T MRI and correlated with the severity of CTS assessed with distal motor latency. The CSA in the affected hand at the scaphoid body level was significantly higher than in the unaffected hand. The CSA in the scaphoid body level was positively correlated with distal motor latency in the affected hand. The CSA in the affected hand at the scaphoid tubercule level was significantly lower than in the unaffected hand. The CSA had a negative correlation with distal motor latency at the scaphoid tubercule level. The CSA at the scaphoid body level was highest in 4 levels. [Orthopedics. 2017; 40(1):e77-e81.]

Carpal tunnel syndrome (CTS) is the most frequent peripheral nerve entrapment syndrome. Magnetic resonance imaging (MRI) has made progress as a diagnostic tool for CTS, and new evidence related to the carpal tunnel has been reported.1-4 In these studies, swelling of the median nerve inside the carpal tunnel compared with that seen in normal individuals could be identified with 0.5 or 1.5-T MRI.

Because recent technologic advances have led to improved MRI quality, clinical use of 3-T MRI is becoming widespread in orthopedic surgery.5,6 The use of 3-T MRI provides better visualization of the ligaments and cartilage surface and better clinical diagnostic accuracy compared with 1.5-T MRI.6

Previously, 1.5-T MRI was used mainly for studies of CTS. However, 3-T MRI provides further detail of the pathophysiology of the carpal tunnel in CTS as well as the relationship between morphology and the severity of CTS. The purpose of this study was to evaluate pathology inside the carpal tunnel using 3-T MRI in both the affected and unaffected hands in patients with CTS to assess the details of the cross-sectional area of the median nerve (CSA) and the thickness of the transverse carpal ligament (T-TCL), as well as to compare the CSA with the...
severity of CTS assessed by distal motor latency.

**Materials and Methods**

A total of 70 wrists of 35 consecutive patients (27 women and 8 men; mean age, 66 years; age range, 37-85 years) diagnosed with idiopathic unilateral CTS from 2009 to 2011 were prospectively studied. Exclusion criteria were: (1) bilateral CTS; (2) history of any surgery or wrist fracture; (3) rheumatoid arthritis; (4) chronic renal failure; and (5) tumors in the carpal tunnel.

All patients were diagnosed with idiopathic CTS by clinical examination and nerve conduction studies, and underwent 3-T MRI of bilateral wrists. Clinical examination included Phalen test, pinch and grip strength, Tinel sign on the carpal tunnel, and determination of the area of sensory disturbance with the Semmes-Weinstein monofilament test and the 2-point discrimination test.

Nerve conduction studies were performed using Neuropack M1 (Nihon Kohden, Tokyo, Japan) to determine distal motor latency. The recording surface disk electrode was placed over the abductor pollicis brevis muscle, and the indifferent electrode was placed just distal to the metacarpophalangeal joint of the thumb. The median nerve was stimulated supra-maximally at the wrist, 7 cm proximal to the recording electrode. The compound muscle action potential was recorded, and distal latency was measured. A distal latency greater than 4.5 milliseconds was defined as indicating CTS.

The protocol for MRI was as follows: T2-weighted; field strength, 3-T (Philips Achieva, Eindhoven, The Netherlands) using a SENSE Knee coil (8 ch); wrist in neutral, forearm in neutral; repetition time of 3000, echo time of 20; imaging direction, axial; and section thickness, 3 mm from the distal radioulnar joint to the carpometacarpal joint level. Four axial image slices at 4 levels perpendicular to the longitudinal line of the median nerve were identified, and the CSA at each level was measured (Figure 1). The distal radioulnar joint (DRUJ) level was at the position of the ulnar head relative to the radial sigmoid notch. The body level was at the level of the largest scaphoid body section. The tubercule level was at the level of the largest tubercule of the scaphoid. The hamate hook level was the level of the longest hook of the hamate. The CSA and T-TCL were measured with a freehand region-drawing tool using VirtualPlace Liberty (AZE, Tokyo, Japan). The T-TCL was not present at the DRUJ level.

Differences in median nerve CSA and T-TCL at various anatomic levels were examined using the Student t test. The level of significance was set at $P<.05$. To compare the CSA with the severity of CTS, the correlation between distal motor latency and CSA at each level was calculated using Pearson correlation analysis.

**Results**

The CSA for the different levels are shown in Figure 2. The mean±SD CSA was 15.1±4.6 mm$^2$ in the unaffected hand and 17.4±4.7 mm$^2$ in the affected hand at
the DRUJ level, 18.7±3.9 mm² in the unaffected hand and 21.4±6.7 mm² in the affected hand at body level, 19.0±2.2 mm² in the unaffected hand and 16.0±3.6 mm² in the affected hand at the tubercule level, and 15.6±3.3 mm² in the unaffected hand and 14.9±5.0 mm² in the affected hand at the hook level. The CSA was significantly higher in the affected hand at body level than in the unaffected hand (P<.05). The CSA was significantly lower in the affected hand at the tubercule level than in the unaffected hand (P<.05). The CSA at the DRUJ and hook levels showed no significant difference between the affected hand and the unaffected hand (DRUJ, P=.08; hook, P=.15). Of the 4 levels, the mean CSA of the affected hand was highest at the body level.

The mean±SD of the T-TCL was 0.7±0.1 mm in the unaffected hand and 0.7±0.1 mm in the affected hand at body level, 1.2±0.3 mm in the unaffected hand and 1.1±0.3 mm in the affected hand at tubercule level, and 1.4±0.2 mm in the unaffected hand and 1.3±0.3 mm in the affected hand at hook level. The T-TCL was not significantly different between the unaffected hand and the affected hand at all levels (Figure 3: body, P=.33; tubercule, P=.18; hook, P=.28).

The correlation of the CSA with distal motor latency as a measure of the severity of CTS also was examined at each level (Figure 4). Cross-sectional area at the body level (r=0.48, P<.05) had a positive correlation with distal motor latency. Otherwise, CSA had a negative correlation with distal motor latency at the tubercule level (r=−0.34, P<.05) and no significant correlation with distal motor latency at the DRUJ level (P=.08) and hook level (P=.15).

**Discussion**

The CSA and T-TCL were investigated with 3-T MRI at 4 levels in the affected and unaffected hands of patients with CTS. The CSA at body level was higher in the affected hand than in the unaffected hand and had a positive correlation with distal motor latency in the affected hand. T-TCL was not significantly different between the affected hand and the unaffected hand at all levels. At the level of the largest scaphoid body section, 3-T MRI is useful as a diagnostic tool for CTS and as a predictor of the severity of CTS.

Swelling of the median nerve and increased signal intensity on T2-weighted images have been identified with 1.5-T MRI.\(^2\) Swelling of the nerve trunk proximal to the compression site is due to an increase in the thickness of the perineurium and the amount of endoneural connective tissue.\(^7\) The diagnostic accuracy of 1.5-T MRI for 120 patients with CTS was moderate, and the CSA at the level of the DRUJ in patients with CTS was greater than in normal individuals.\(^2\) In the
In the current study, CSA at the body level was larger in the affected hand than in the unaffected hand, but CSA at the level of the DRUJ tended to be larger in the affected hand than in the unaffected hand. In addition, CSA at the body level had a positive correlation with distal motor latency. This discrepancy might have arisen from the higher resolution images of 3-T MRI, and the level of the largest scaphoid body section might be appropriate for the diagnosis of median nerve swelling.

Some studies evaluated CSA at the pisiform level and reported that CSA at the pisiform level showed high sensitivity and specificity. Therefore, in the current study, the pisiform level was divided into 2 points for detailed examination, the body and the tubercule of scaphoid level.

Other reports have used ultrasonography for detecting peripheral nerve pathology including CTS. Some reports mentioned superiority of ultrasonography compared with MRI. Certainly, ultrasonography is inexpensive and can be performed at the bedside, but MRI offers some advantages such as superior contrast between tissues. In addition, most of the previous reports used 1.5-T or lower MRI. In the current study, 3-T MRI was used for evaluation.

There are many reports of CTS evaluation using ultrasonography or MRI, and most of these reports mentioned the shape of the TCL. However, there have been no reports regarding the thickness of the TCL using MRI. In the current study, the detail of the T-TCL could be analyzed using 3-T MRI because of its higher resolution images. The T-TCL showed no significant difference between the affected hands and the unaffected hands in patients with CTS. The severity of CTS did not increase the T-TCL. This finding supports the previous report on the histology of the TCL with CTS, which showed that in idiopathic CTS, the TCL demonstrated normal histology with no typical or consistent changes and that the T-TCL was not increased in severe CTS. There has been a study of the T-TCL measured by ultrasonography. However, there have been no reports of T-TCL measurement by MRI. This is the first report analyzing the T-TCL in detail using 3-T MRI.

The current study has several limitations. First, a single examiner (M.I.) performed the measurements of the CSA and T-TCL once. Assessments of intra- and interobserver errors to check the accuracy of 3-T MRI and the measurement tool might be needed. Second, the unaffected hands were defined as normal hands, but they may have included hands with subclinical CTS. This might be the reason for the discrepancy between the CSA in unaffected hands in the current study and that of a previous study. The hand of a normal healthy volunteer may be a better control. Third, T-TCL was analyzed using only 3-T MRI; T-TCL measurement with 1.5-T and 3-T MRI in CTS was not performed, and a direct comparison might be necessary.

**CONCLUSION**

This study found that 3-T MRI was valuable for imaging the CSA of the median nerve. In addition, 3-T MRI has potential as a diagnostic tool for CTS.

**REFERENCES**

6. Schott F, Kraemer N, Niendorf T, Hohl C, Gunther RW, Krombach GA. Comparison...


