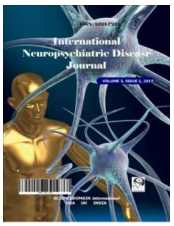

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Diagnostic Utility of MRI versus Nerve Conduction Studies in Carpal Tunnel Syndrome

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Authors' contributions

This work was carried out in collaboration between all authors. Authors AK and RK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AY and HD managed the analyses of the study. Authors AK and RK managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Objective: To prospectively and quantifiably compare Magnetic Resonance Imaging (MRI) findings and nerve conduction study (NCS) findings in clinically diagnosed carpal tunnel syndrome (CTS).
Methods: A total of 27 wrist of 15 with CTS and 24 wrists of 13 healthy controls selected from the same cohort were studied in the present study. The protocol included NCS of the median and ulnar nerves (distal motor latency, sensory conduction velocity from the third fingers to the wrist for the median nerve); electrophysiological severity scale; and T2 intensity measurement of the nerve at place just 2 cm distal to it at the level of hamate bone. Relationships between NCS findings, severity of median nerve damage and T2 intensities were calculated.
Results: In comparison of age and gender matched two groups, we found that T2 signal intensities were higher in the patient group ($p<0.001$). There was no relationship between T2 signal intensity and NCS findings, gender, and the clinical findings such as provocative tests, the presence of motor or sensory symptoms except age.
Conclusion: In patients with idiopathic carpal tunnel syndrome, T2 intensity of median nerve measured by wrist MRI may be considered as a valuable indicator but it is not superior to electrophysiological studies in grading the severity of disease.

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Keywords: MRI; nerve conduction studies; carpal tunnel syndrome.

1. INTRODUCTION

The compression of the median nerve called as Carpal tunnel syndrome (CTS) at the wrist is the most frequent entrapment mononeuropathy [1]. The clinical examination is usually sufficient for CTS diagnosis in moderate and severe stages of CTS. In mild stages, clinical examination is mostly normal so the most reliable method to confirm clinical diagnosis of CTS is electrodiagnostic testing i.e. nerve conduction studies (NCSs) [2-4]. Many authors accept nerve conduction studies as a gold standard but in some cases this kind of investigation may be equivocal or in discordance with severity assessed by clinical symptoms [2-4]. On the other hand, NCSs are painful and sometimes intolerated. In these cases, an instrumental confirmation of clinical diagnosis may be really helpful. Magnetic resonance imaging (MRI) have been shown to be a useful diagnostic tool in CTS previously [5,6]. More distally over the carpal tunnel at the level of the hamate, the nerve becomes flattened with bowing of the flexor retinaculum and a hyperintense signal of the nerve on T2-weighted imaging is often observed [6,7]. In the last few years, many reports have appeared that MRI is helpful in CTS diagnosis, but many of these articles considered only MRI as a diagnostic tool [2,5-7]. In reports, there was a lower degree of correlation between MRI parameters and findings obtained by clinical assessments and electrophysiological measurements with exception of median nerve area at hamate level [2]. MRI is not an alternative diagnostic tool to NCSs and vice versa in CTS, but they may be complementary; one provides anatomic information of the nerve and its surrounding structures while the other provides information on the level of the lesion and the severity of dysfunction of the nerve fibers. Study on the correlation of T2 intensity of median nerve measured by MRI and the severity of CTS based on clinical and/or electrophysiological evaluations is lacking in the literature although many studies shows characteristic findings with changes in the carpal tunnel area, the flexor tendon area and the configuration of the median nerve. It is logical that T2 signal changes identified by MRI may reflect on neurophysiology parameters and therefore the purpose of this report is to document the relationships between MRI T2 signal intensity and electrophysiological examination findings in the patients with idiopathic CTS.

2. PATIENTS AND METHODS

During study period, the patients who had a diagnosis of CTS and accepted the protocol were enrolled in the study. The CTS diagnosis was made according to American Academy of Orthopedic Surgery criteria [8], which include clinical history and symptoms. Physical examination consisted of evaluating muscular strength and trophism, sensory function, and provocative clinical tests (Phalen's and Tinel's signs). The patients with cervical radiculopathy, brachial plexopathy, and other upper limb mononeuropathies and polyneuropathies were not included in the present study. The presence of associated pathologies (diabetes mellitus, connective tissue and thyroid diseases, renal failure, body mass index > 30 and recent trauma or fractures of the wrist or hand) was other exclusion criteria's.

Our study protocol were in line with the guidelines of the American Association of Electro diagnostic Medicine [9]. NCS protocol included the measurement of motor conduction velocity (MCV), distal motor latency (DML) and compound muscle action potential amplitude (CMAP), sensory conduction velocity (SCV), and sensory nerve action potential amplitude (SNAP) of median nerves. Values that differed by at least 2 SDs from the mean of healthy controls/volunteers were considered abnormal for parameters mentioned above. These median nerve mean values were 52.8 m/s for SCV, 2.95 msec for distal sensory latencies in the third-finger segment and 55.3 m/s for MCV (elbow-wrist tract), 4.4 msec for DML in our laboratory.

A CTS electrophysiological severity scale, with grades from mild, moderate and severe was used for statistical analysis. This grading evaluates presence/absence of SNAP and CMAP and normal/abnormal SCV and DML as follows: mild (slowing of the median digit-wrist segment SCV and normal/abnormal), moderate (abnormal SNAP in the digit-wrist segment and abnormal DML) and severe (SNAP absence).

All MRI examinations were performed on a 1.5-T MR imager (Siemens Medical System, Avanto, Erlangen, Germany) with an extremity coil. Both the wrists were imaged in the neutral position

and the measures were performed on axial scans. The slices were began at the distal radio-ulnar joint and extended distally throughout the carpal tunnel until the carpometacarpal level. The following parameters were used: slice thickness 4 mm, field of view 120 mm and matrix 256×160. T1-weighted (TR/TE:600/20) and T2-weighted (TR/TE 300/15) fast-spin echo sequences with fat suppression were used. T1-weighted MR images served as the anatomic reference. T2 signal intensities of median nerve were measured at place just 2 cm distal to flexor retinaculum at the level of the hamate bone [10]. All available images were interpreted by a single experienced radiologist who was blinded to clinical and electrophysiological findings.

The study was conducted at BAV University and Regional Ethic Committee has approved the study and the use of human subjects for this study (June 2012, 07/01). We have received written consent and an authorization-for-disclosure form from any participant.

2.1 Statistical Analysis

Collected data were transferred to electronic environment and analyzed with SPSS 16 statistical package program. Parametric (student's t-test) for age and non-parametric tests (Mann-Whitney U) were used for comparison of other quantitative data beside descriptive statistical methods (mean, standard deviation). At the second step, the relationships between presence of signal intensity and effected side NCS findings, age, gender, the clinical findings such as provocative tests (Tinel sign positivity, Phalen test results), motor loss or sensory symptoms were investigated with Spearman method in the patients. A p level of <0,05 was accepted as statistically significant. At the third step, we accepted SNAP and SNCV values as zero and distal sensory latency values of median sensory nerve as 7.1 ms (2 SD more than the highest value in this study) in the case of unresponsiveness, then relationships between NCV results of median nerve and T2 signal intensity. At the last step, we classified CTS cases such as mild, moderate and severe cases, then T2 mean signal intensities were evaluated among 3 groups.

3. RESULTS

A total of 27 wrist of 15 patients (8 female, 7 male) clinically and electro- physiologically diagnosed with CTS for the first time at the EMG service of Bezmialem Vakif University Medical Faculty and 24 wrists of 13 healthy controls (7 female, 6 male) selected from the same cohort were included in the present study. The socio demographical and clinical findings of the participants were summarized in Table 1. In about 85% of the patients, there was a sensory action potential abnormality of median nerve. As expected, the electrophysiological findings differed in the patient group (Table 1). T2 signal intensities were higher in the patient group ($p<0.001$, Picture 1). There was no relationship between T2 signal intensity and NCS findings, gender, and the clinical findings such as provocative tests, the presence of motor or sensory symptoms. There was a positive relationship between increased T2 signal intensity and age ($r=0.424$, $p=0.028$). When we accept SNAP and SNCV values as zero and distal sensory latency values of median sensory nerve as 7.1 ms (2 SD more than the highest value in this study) in the case of unresponsiveness, SNAP and NCV results of median nerve negatively and distal latency of median sensory nerve positively correlated with T2 signal intensity but these relationships were not statistically significant. In the evaluation of CTS cases such as mild, moderate and severe cases; we have found T2 signal intensities were similar among 3 groups although the sensory nerve action potential and the conduction velocity of median nerve were found different in comparison to each other ($p<0.001$).

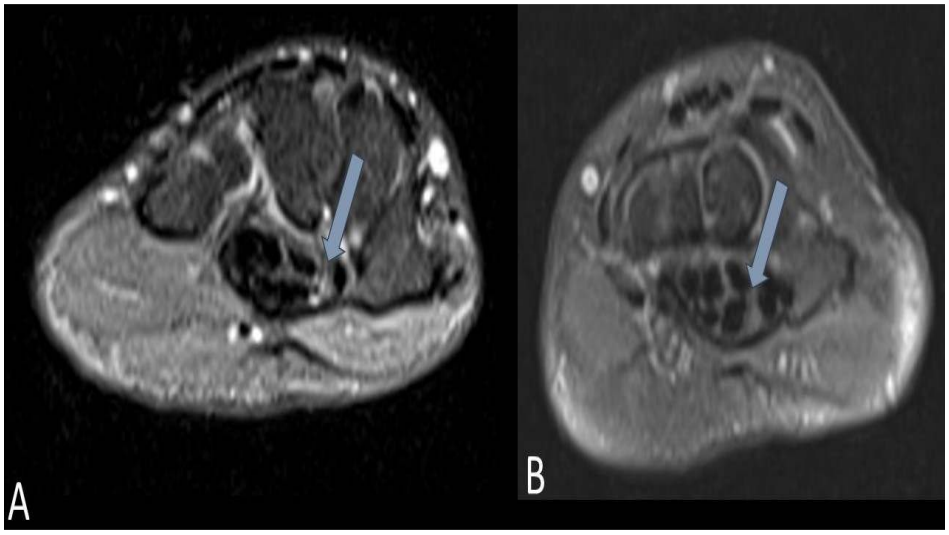
4. DISCUSSION

MRI and ultrasonography techniques can be used to detect the morphological changes in CTS [10-13]. MRI has been shown to be a valid and reproducible technique for severity of the disease could be judged by evaluating not only changes of signal intensity and configuration of the median nerve, but also by measuring carpal tunnel volume and the cross sectional area [14,15]. Quantitative analysis based on CTS studies showed that the enlargement of the carpal tunnel area and the flexor tendon area were characteristic findings with changes in signal intensity and in the configuration of the median nerve [13]. Enlargement of the cross sectional area of the median nerve at the entrance to the tunnel had a diagnostic value for idiopathic CTS [16,17]. Martins et al. [2] also reported that median nerve area at hamate bone level gives more frequently correlations with clinical and electrophysiological measures and should be considered as the more relevant in comparison.

Table 1. The study findings of patients and controls

Variable	Patients	Controls	p value
Age (Mean ± SD years)	34.48 ± 5.87	32.66 ± 5.77	0.22
Phalen test positivity (n)	19		
Tinnel test positivity (n)	18		
Severity of compression			
n with mild damage	4		
n with moderate damage	17		
n with severe damage	6		
T2 signal intensity (measured on distal to FCR)	39.61 ± 14.05	21.08 ± 4.73	<0.001
Distal Sensory Latency (msec)	4.76 ± 1.50	2.51 ± 0.23	<0.001
SNAP (microVolt)	6.76 ± 6.02	27.50 ± 8.69	<0.001
Sensory NCV (m/sec)	29.36 ± 16.97	59.98 ± 4.38	<0.001
Distal Motor Latency (msec)	4.94 ± 1.80	2.79 ± 0.31	<0.001
CMAP 8 (miliVolt)	6.13 ± 2.16	9.11 ± 2.19	<0.001
Motor NCV between wrist and elbow (m/sec)	55.47 2.89	55.99 3.72	0.57

SNAP: Sensory Nerve Action Potential Amplitude, CMAP: Compound Muscle Action Potential Amplitude, NCV: Nerve Conduction Velocity, n: Number, SD: Standard deviation



Picture 1. The abnormal and normal median nerve appearance on T2w-fat saturated images at the level of hamate bone. The blue arrows indicates the cross section of the median nerve. Enlargement and high signal intensity of the median nerve are seen in A and normal size and almost isointense median nerve to the adjacent muscle in the healthy control subjects in B

Isointensity is a normal image of median nerve in T2 MRI while a high signal intensity is seen in nerve damage or degeneration [18]. One of the most promising magnetic resonance signs in CTS is an increased T2-signal [5,7]. Does et al reported that the increased nerve signal of median nerve on T2 MRI may be a meaningful finding for idiopathic CTS with demyelinating features because it decreases after surgical decompression of the nerve [19,20]. It is also well known that the pathophysiology varies with the disease stage and disease severity can affect the imaging outcome [7,21]. Supporting this knowledge, T2 signal intensity can decrease in the advanced CTS because of fibrosis within the nerve [17]. All these findings discussed above says that increased intensity is an important finding and can be used to follow the patients with CTS [5,7,19,20,22,23].

Similarly to previous studies, we have found that T2 signal intensity increased in the patients and this difference was very significant as seen Table 1 [5,7,18-21]. In evaluation of the relationships between electrophysiological studies and the MRI findings, previous studies reported that they

have not found any relation but the results should be interpreted cautiously due to reduced number of subjects included in these studies [23,24]. Although there are some studies identified a relationship between severity of damage seen on MRI and electrophysiological findings, there is no numerical data and comparison [23,24]. In the present study, we have found that there was no relationship between T2 signal intensity correlated well with electrophysiological findings in regard of the severity of median nerve compression.

Our study had some limitations. First, we did not evaluate MRI findings at different wrist positions. Since the wrist postures influence the size and shape of the carpal tunnel [25]. Secondly, low number of the patients was another limitation. Nevertheless, our study was performed under constant conditions, we used 1.5 T MRI system and evaluated objective parameters. Additionally, there were standard measures acquired by MRI concerning parameters present in healthy nerves, as signal intensity in our study. Therefore we believe that our results are reliable.

5. CONCLUSION

MRI findings are similar among groups in comparison of the severity of idiopathic CTS. We concluded that T2 intensity of median nerve may be considered as a valuable indicator but it is not superior to electrophysiological study results.

CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the authors.

ETHICAL APPROVAL

As per international standard or university standard, written approval of Ethics committee has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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