Original Article

Study of Wrist Ratio and Wrist-to-Palm Index Radio in Individuals Suffering from Carpal Tunnel Syndrome

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Abstract

Background: Carpal tunnel syndrome (CTS) is the commonest median nerve entrapment neuropathy, with preponderance in females. **Aims and Objective:** The aim of the present study was to find out wrist ratio (WR) and wrist/palm ratio (WPR) in clinically diagnosed patients of CTS. **Methodology:** One hundred individuals (fifty patients of CTS and fifty as control group) aged between 30 and 50 years were recruited for the study. Early confirmation of clinically suspected patients of CTS was done by performing electrodiagnostic tests of median and ulnar nerves. Motor and sensory conduction velocities, distal motor and sensory latencies, and F-wave latencies were performed in the recruited volunteers. **Results:** The values for mean wrist ratio in control groups were 0.694, 0.703 respectively, and in patients with carpal tunnel syndrome, it was 0.704 and 0.719 respectively in moderate and severe type. The mean wrist to palm ratio (WPR) in control group was 0.371, while in patients with CTS, it was 0.374, 0.382, 0.387, and 0.401 based on progression of severity. Both were statistically significant for the last two groups (wrist to index finger [WIF] >4.4 m/s, moderate, and WIF nonrecordable, severe). Statistically significant ($P < 0.001$) decrease of motor conduction velocities for median nerve was seen in the CTS group as compared to control group. Statistically significant ($P < 0.001$) increase in distal motor and sensory latencies was observed for both median and ulnar nerves in CTS group with more increase in distal motor latency than sensory latency. Increase in F-wave latencies of both nerves was seen in CTS group. **Conclusion:** The study results confirm selective slowing of sensory and motor conduction within wrist-to-palm segment in patients of CTS. Both WR and WPR have a progressive correlation with the severity of CTS, but statistically significant changes were seen in the groups with moderate and severe CTS. Thus, WR/WPR can act as one of the essential parameters in the diagnosis of CTS with moderate-to-severe CTS.

Keywords: Carpal tunnel, distal latencies, electrophysiological diagnosis, nerve entrapments, wrist ratio

Introduction

Carpal tunnel syndrome (CTS), also known as tardy median palsy, is one of the commonest median nerve entrapment neuropathies, which results from median nerve compression within the carpal tunnel. It is due to compression of the median nerve as it passes beneath the transverse carpal ligament and a majority of patients present with nocturnal numbness, paresthesia, and pain in hands.[1,2] It occurs most often in the age group between 30 and 60 years and is five times more common in women than men.[3-5] Many factors are responsible for the cause and aggravation of CTS. Old, overweight, and physically inactive people and any condition that crowds or reduces the capacity of the carpal tunnel can initiate the symptoms. Conditions such as misaligned Colles' fracture, edema from infection or trauma, posttraumatic arthritis, or tumorous conditions such as ganglion, lipoma, or xanthoma are among the most common causes of CTS. Systemic conditions such as obesity, diabetes, thyroid dysfunction, amyloidosis, and Raynaud's syndrome are sometimes associated with the syndrome.[5-9] Aberrant muscles of forearm and thrombosis of the median artery contribute to median nerve compression.[10] The sensory and motor axons show a comparable incidence of abnormalities, often encountering selective involvement of motor fibers, with normal sensory conduction or vice versa.[9-12] Electrophysiological procedures not only confirm the clinical diagnosis in most of the patients, but also detect incidental findings in some asymptomatic patients.[13] The American Academy of Neurology has defined the standards, guidelines, and options for electrodiagnostic studies of CTS based on a formal literature review. Johnson *et al*. in 1983 correlated wrist dimensions with median sensory latencies in CTS cases and suggested that the squarer the wrist, the longer the latencies.[1] As the wrist depth-to-width ratio (wrist ratio [WR]) approaches 0.70, the median sensory peak latency (wrist to third digit, 14 cm) is likely to surpass 3.7 ms, the upper limits of the usually considered normal latency.[2,9] Measurement of WR would be recommended as a part of the physical examination for CTS and its presence is supportive of CTS in most cases. The present study was carried out for early confirmation of

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DOI: 10.4103/aian.AIAN_343_18

clinically diagnosed patients of CTS by electrodiagnostic tests which included motor conduction, sensory conduction, and F-wave studies and to study WR and a new wrist-to-palm index in CTS and controls.

Methodology

The present study was carried out at the Department of Neurophysiology, King Abdullah Hospital, Bisha, Saudi Arabia, from February 2013 to September–October 2013 on 100 individuals (fifty clinically diagnosed patients of CTS and fifty normal individuals as control group). Consent was obtained from each participant before the study.

Inclusion criteria

The study participants were clinically diagnosed patients of CTS (cases). Healthy individuals of different age groups (20–60 years) were considered as controls and were categorized according to the body mass index (BMI) in similar range of the patients with CTS and were free of any neurological disorder or problem or any history of it.

Exclusion criteria

Individuals suffering from diabetes mellitus, nerve injuries, and wrist fractures were excluded from the study. Only the dominant hand was studied in the control group and the symptomatic hand in the CTS group. Electrodiagnosis of CTS was made using standard criteria as described by the previous literature.[1,8,9]

Nerve conduction study

Nerve conduction studies were performed on CTS patients using Medtronic Keypoint @ 2EMG EP software inc Germany. The motor and sensory nerve conduction studies were performed for median and ulnar nerves, with temperature in the study room maintained constant at 22°C–26°C.

Measurement of nerve conduction velocity

Data of distal motor latency (DML), motor nerve conduction velocity, and compound muscle action potentials from the distal stimulation were analyzed for each participant, followed by recording of SNAP and sensory nerve conduction velocity (SNCV). Surface electrodes were used for the study. F-waves were recorded from the dorsal muscle by giving supramaximal stimulus to the median and ulnar nerves.

Wrist/palm dimensions and body mass index

These parameters were measured at the distal flexor wrist crease using a standard sliding caliper. A WR was calculated dividing depth by width (Johnson's index). Palm length measure in millimeter was taken from the distal flexor wrist crease to the third digit metacarpophalangeal crease. A new ratio was calculated dividing wrist depth by palm length (new index proposed, wrist-palm ratio [WPR]). The anteroposterior dimension (depth in mm) of the wrist depth was 3.6 (0.4) cm (controls) and in case of CTS patients, it was 4.1 (0.4). The mediolateral dimension (width in mm) of wrist depth was 5.6 cm (0.9) cm in controls and in case of CTS patients, it was 6.9 (1.1) cm (0.9).

Wrist to index finger

The stimulus (0.05 ms duration) was applied at the wrist, 14 cm proximal to the active recording at the index finger (ring electrodes). The sweep speed was set at 2 ms/div with the gain at 10–20 µV/div. The latency was measured to the peak of the evoked sensory nerve action potential and values ≥3.70 ms were considered abnormal.

Median-to-ulnar peak difference

The peak latency difference between median and ulnar-evoked sensory nerve action potentials was calculated and values ≥0.50 ms were considered abnormal.

Median palmar latency

The latency was measured to the peak of the evoked mixed nerve action potential and values ≥2.30 ms were considered abnormal. Wrist to index finger (WIF) was used to define CTS severity, and four groups were constituted according to peak latency as described above: incipient: 2.9–3.6 ms (normal WIF values); mild: 3.7–4.4 ms; moderate: >4.4 ms; and severe: unrecordable sensory nerve action potential. The data were analyzed by the Student's *t*-test; $P < 0.05$ was taken as the level of significance.

Results

In this study, all the fifty patients with CTS fulfilled the criteria set for nerve conduction studies. Tables 1 and 2 summarize the mean ± standard deviation of all conduction studies of all parameters in meter/second in the wrist segment. Statistically significant ($P < 0.001$) slowing of motor conduction velocities for both median and ulnar nerves was seen in the CTS group as compared to the control group, the values of *t*-tests (unpaired) for all parameters in wrist segment comparing control with CTS group. Increase in distal motor and sensory latencies was observed for both median and ulnar nerves in the CTS group as compared to the control group, with more increase in DML than sensory latency. Increase in F-wave latency of both median and ulnar nerves was also recorded. Table 3 shows that CTS cases have a mean WR ranging from 0.697 to 0.719 and a WPR ranging from 0.374 to 0.401, according to WIF severity. On both indexes, there was a significant progressive correlation with the severity of CTS. Control individuals had a WR of 0.694 ± 0.034 and a WPR of 0.371 ± 0.031. $P < 0.001$ was found in moderate and severe groups. WR ≥0.70 was found in 51.7% of CTS patients and 45.9% of the control group, respectively (comparison of proportion, $P = 0.164$). WR ≥0.75 was found in 15.1% of CTS and 7.4% of the controls (comparison of proportion, $P = 0.002$). Mean BMI, another personal risk factor described for CTS, was also higher in CTS group. BMI showed a slight progression following WR increase: WR ≥0.75 (BMI = 29.1), WR <0.75 and ≥0.70 (BMI = 28.4), and WR < 0.70 (BMI = 27.9), which shows that increase in BMI or obesity may be responsible for canal narrowing [Table 4].

Table 1: Mean±standard deviation of conduction studies (motor) in the wrist segment (carpal tunnel syndrome and control group)

Parameters	CTS group		Control group		*P*	
	Median	Ulnar	Median	Ulnar	Median	Ulnar
MCV (m/s)	48.2±7.12	48.24±4.19	57.32±5.20	57.4±5.5	0.001	0.001
DML (ms)	5.2±0.74	2.63±0.51	3.38±0.37	2.55±0.47	0.253	0.238
F-wave latency (ms)	37±8.0	31±7.4	31±5.1	29±4.2	0.05	0.926

Unpaired *t*-test. $P \leq 0.05$: Significant; $P \leq 0.01$: Highly significant. CTS=Carpal tunnel syndrome group, DML=Distal motor latency, MCV=Motor conduction velocity

Table 2: Mean±standard deviation of conduction studies (sensory) in the wrist segment (carpal tunnel syndrome and control group)

Parameters	CTS group		Control group		*P*	
	Median	Ulnar	Median	Ulnar	Median	Ulnar
SNCV (m/s)	39.56±9.26	39.04±8.8	52.56±4.86	52.48±4.46	0.001	0.001
DSL (ms)	4.18±1.74	2.60±1.13	2.72±0.55	2.55±0.55	0.001	0.001

Unpaired *t*-test. $P \leq 0.05$: Significant; $P \leq 0.01$: Highly significant. CTS=Carpal tunnel syndrome, DSL=Distal sensory latency, SNCV=Sensory nerve conduction velocity

Table 3: Wrist ratio and wrist-palm ratio in controls and carpal tunnel syndrome patients

	Controls		CTS	
	WR (mean±SD)	*P*	WPR (mean±SD)	*P*
Controls	0.694±0.034	-	0.371±0.031	-
WIF 2.9–3.6 ms	0.697±0.037	0.312	0.374±0.032	0.639
WIF 3.7–4.4 ms	0.701±0.036	0.050	0.382±0.027	0.038
WIF>4.4 ms	0.704±0.041	0.009	0.387±0.035	0.003
WIF unrecordable	0.719±0.035	0.003	0.401±0.037	0.000

WR=Wrist ratio, WPR=Wrist-palm ratio, SD=Standard deviation, CTS=Carpal tunnel syndrome, WIF=Wrist to index finger ratio (median sensory peak latency, 14 cm)

Discussion

The present study results show decrease in median motor and sensory nerve conduction across the wrist. Decrease in sensory conduction velocity was statistically significant and more pronounced in the CTS group, similar results were mentioned by the authors in their previous studies as the sample size or the subjects used for this study and the previous study were the same. Kuhlman & Hennessey found that, the square-shaped wrist (WR ≥ 0.70) as the most sensitive (69%) among six signs in detecting CTS; the specificity of this sign was 73%.[1] The contradictory effects for canal size are found between this and other studies may indicate that another anatomical risk factor, independent of carpal canal size may underlie CTS. Johnson *et al*. (1983) were the first to correlate wrist dimensions with carpal tunnel syndrome and suggested that a 0.7 wrist ratio may be the critical shape of the wrist at which latencies tend to reach the upper limits of normal. They suggested that higher sensory latencies are associated with squarer wrists and emphasized that a wrist ratio of 0.65 (rectangular wrist) was usually associated with normal nerve conducting studies while one above 0.7 (square wrist) was usually associated with abnormal neurophysiology.[2] These observations support our data that CTS patients have statistically significantly greater wrist ratios than controls. Winn & Habes studied the carpal tunnel area as a risk factor for CTS in 27 CTS cases and 34 control subjects, their results failed to report smaller canal area in CTS patients; in fact, CTS had larger carpal canal areas than controls regardless hand (right/ left), gender or slice.[3] Bleecker *et al*. studied the role of carpal canal size as a risk factor for CTS found in a computer tomography images a cross-sectional area of 1.75 cm^2 in affected 14 males workers, significantly smaller than the controls subjects (2.53 cm^2).[4] Canale *et al*. in their study found, that 24% of employees with WR less than 0.70 developed CTS compared with 74% of the employees with WR ≥ 0.70.[5] Statistically significant increase in the difference between distal sensory latency of median and ulnar nerves was observed, which is consistent with the results of author's work and with Mishra *et al*. [6,7,14] General observations suggested that a 0.70 WR may be the critical shape of the wrist at which latencies tend to reach the upper limits of normal.[8,9,15-19] The cause for prolonged latencies of F waves and conduction velocities in ulnar nerve were not common, it may occur due to underlying lesions. Our findings are consistent with the observations of Melvin *et al*.,[9] Thomas *et al*,[10] Buchthal *et al*.,[11] Murthy *et al*.[12] and Padua *et al*.[13] the difference between the median and ulnar motor nerves latency measurement with palmar stimulation in patients with CTS is another parameter of diagnostic value. Normally the difference is 1.1 m/sec but in the CTS group, this Difference exceeds 1.1 msecs. The above observation correlates well with the findings of Mishra *et al*.[14] and Kuntzer.[20] The distal median motor latency is more as compared to ulnar nerve in the CTS group in the present study, which is consistent with the results Mills *et al*.[21] Palmar wrist conduction refers to the comparison of sensory latencies of median and ulnar nerves following stimulation of the nerves in palm with recording from the

Table 4: Wrist ratio and body mass index in carpal tunnel syndrome patients and controls (dominant hands)

WR	CTS (%)	Controls (%)	BMI – CTS	BMI – controls
≥0.75	16.8	7.5	29.1±3.90 (21.6–36.1)	28.6±4.56 (16.0–34.9)
<0.75 and ≥0.70	34.3	35.6	28.4±4.90 (20.8–38.9)	28.1±4.69 (17.3–38.9)
<0.70	51.7	54.9	27.9±4.18 (19.6–41.2)	27.4±4.90 (16.2–43.9)

WR=Wrist ratio, CTS=Carpal tunnel syndrome, BMI=Body mass index

respective nerves at wrist at a distance of 8 cm, from the point of stimulation. The difference in latency between median and ulnar nerves is < 0.4 m/sec in a normal individual. In the instant study, this difference is > 0.4 m/sec in the CTS group which is in tune with the work of Jackson and Mills.[21,22] F wave has been found to be a sensitive measure of CTS. The present study also shows statistically significant increase in F wave latencies of median and ulnar nerves. This observation is consistent with the findings of author's[7,15,18] similarly; the results of the present study in relation to criteria for diagnosing CTS are similar to those of Mishra *et al*. and Nathan *et al*.[14,17] found that WR was the third risk factor (body mass index and age being the first and second, respectively) for slowing of sensory conduction of the median nerve in a longitudinal study of CTS in industry. Radecki in his study found that, an increased WR was associated with prolongation of median latencies regardless work- related complaints.[18] Nakamichi & Tachibana found in their study showed that height and hands/third metacarpal length small or short in CTS group when compared to control one.[19] The authors also found prolonged latencies of ulnar nerve which is very rarely seen in carpal tunnel syndrome which may be due to carpal ganglion irritation followed by occupational repeated trauma to the hypothenar area.[24] We could not find a critical WR of 0.70 between CTS and controls subjects (50.3% in CTS hands and 46.7% in control hands subjects). Only in high ratios (WR ≥ 0.75) the difference was significant, but we can suppose that at this level BMI also contribute to increase incidence in CTS as showed our results with BMI increasing proportionally to WR. The other ratio (WPR) proposed in our work was based on the possible suggestion that CTS patients could have small hands. If we hypothesized that wrist depth is larger in CTS patients and possibly palm length is shorter, then the ratio wrist depth/palm length could raise the sensitivity or at least add more precision to the classical Johnson's index (WR). Our results, as described above, showed that both ratios have about the same value with statistical significance. The factors responsible for the significant association between an increased WR and the median abnormality were still unclear.

Conclusion

Present study concludes that both wrist ratio and wrist-palm ratio have a progressive correlation with the severity of CTS but statistical significance was seen only in groups of moderate and severe CTS. BMI was surprisingly found to be one of the risk factor for canal narrowing and squarer hand and thus we believe that the latter could be a risk factor as important as WR/WPR in carpal tunnel syndrome.

Acknowledgements

The authors are deeply indebted to the subjects of the study without whose co-operation this endeavor would not have been possible and to the authorities of the hospital, our sincere thanks to Dr. Morris AL Dayoub, consultant neurologist King Abdullah Hospital, Bisha Saudi Arabia for his guidance and support.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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