The Importance of Ultrasound in the Diagnosis of Carpal Tunnel Syndrome in Iraqi Subjects

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Abstract:

Background: Carpal tunnel syndrome, a common peripheral entrapment neuropathy, is recognized as one of the most important causes of workplace morbidity. Diagnosis of carpal tunnel syndrome is usually based on a combination of clinical signs and nerve conduction studies. Magnetic resonance image MRI and high-resolution sonography have emerged as feasible, noninvasive imaging tools for evaluating the median nerve in the carpal tunnel.

Objective: This study was designed to evaluate the use of ultrasound in diagnosis carpal tunnel syndrome.

Setting: The study was held at Consulting Clinic (Rheumatology clinic) in Al Yarmouk Teaching Hospital in cooperation with Radiology department and Neurophysiology section at the period from December 2008 till May 2009.

Patients & Methods: This study enrolled 50 patients with symptomatic carpal tunnel syndrome and 100 healthy volunteers as a control, with age & sex matched. Diagnosis of carpal tunnel syndrome was based on the American Academy of Neurology clinical diagnostic criteria .Electro diagnostic evaluations of nerve conduction study of median nerve for all patients group were done .Wrist sonography done by an expert radiologist who unaware of diagnosis for both patients & controls groups.

Results: We found the mean of cross section area of median nerve in patients group is 0.161 cm^2, while in control group is 0.072 cm^2. This study showed the cut off value of cross sectional area of median nerve equal to or more than 0.092cm^2 give us a sensitivity equal to 90.8% , which is highly suggestive of carpal tunnel syndrome in all symptomatic subjects with carpal tunnel syndrome. The other findings of carpal tunnel syndrome detected by ultrasonography were decrease in echogenicity of median nerve with flattening of median nerve & flexor retinaculum bowing at wrist.

Conclusion: From the end results we can conclude that ultrasonography may be used as the first diagnostic procedure considered in subjects with typical clinical features of carpal tunnel syndrome.

Keywords: *Carpal tunnel syndrome, ultrasound, nerve conduction study, median nerve.*

Introduction:

Carpal tunnel syndrome (CTS), a common peripheral entrapment neuropathy, is recognized as one of the most important causes of workplace morbidity [1,2].

Diagnosis of carpal tunnel syndrome is usually based on a combination of clinical signs such as the Tinel sign (tapping over the median nerve producing dysesthesias) and the Phalen sign (wrist flexion producing dysesthesias), and nerve conduction studies [3]. However, the clinical signs are moderately sensitive and specific, and false-negative and false-positive results of nerve conduction studies have been reported [4-6].

Magnetic resonance image MRI [7,8] and high-resolution sonography [9,10] have emerged as feasible, noninvasive imaging tools for evaluating the median nerve in the carpal tunnel. Both techniques permit perception of nerve compression characteristics, including altered signal, increased cross-sectional area, flattening of the median nerve, and bowing of the flexor retinaculum.

Like peripheral nerves, the median nerve is well vascularized with epineural and endoneural microvasculature [11]. Nerve compression caused by elevated pressure in the carpal tunnel is believed to provoke a three-stage process that is initiated with venous congestion of the median nerve followed by nerve edema and then by impairment of the venous and arterial blood supplies. Investigators in recent studies evaluated the blood flow in the median nerve and emphasized the vascular cause of carpal tunnel syndrome [12].

Material & Methods:

The purpose of this study was to retrospectively assess the accuracy of ultrasound in the diagnosis of carpal tunnel syndrome. We conducted a case control study of 1: 2 during a period of 6 months (between December 2008 and May 2009) in Al-Yarmouk Teaching Hospital. All of the patients were attending our rheumatology clinic. . Nerve conduction studies were assessed by using the Micromed Electromyographic machine while the ultrasonic examinations were done by using high resolution sonography of 5-13 MHz linear array transducer Siemens.

Diagnosis of CTS was based on the American Academy of Neurology clinical diagnostic criteria (1993)[13], summarized here: paraesthesia; pain; swelling, weakness or clumsiness of the hand provoked or worsened by sleep; sustained hand or arm position; repetitive action of the hand or wrist that is mitigated by changing posture or by shaking of the hand; sensory deficit or hypotrophy of the median innervated thenar muscle; symptoms elicited by the Phalen test (1 min passive forced flexion of the wrist), performed on each patient , also we do the Tinel`s & compression test.

We did the electro-diagnostic evaluations of NCV of median nerve for all patients group. Wrist sonography were done by an expert radiologist who was unaware of the diagnosis for both patients & controls groups.

Fifty patients enrolled the study, 15 patients were having bilateral CTS (30%), 24 patients were right sided CTS (48%) & 11 patients were left sided CTS

(22%) and treated by classic conservative treatments.

Hundred (100) healthy volunteers' age and sex matched were chosen as controls and sonography of their carpal tunnel was performed for them too. Because dimensions of carpal tunnel might be different according to the body mass, so we tried to match the control subjects with regard to sex, age and body mass index with CTS patients as could as possible. The measurements of cross section, echogenicity, flatting of the median nerve & flexor retiniculum bowing of wrists were performed in two groups. Exclusion criteria were: (1) previous treatment of CTS with splinting or surgery; (2) a history of wrist fracture or surgery.

The most common symptoms were numbness in 65 wrists (100%), pain in distal area in 65 wrists (100%) , night pain in 62 wrists (95.4%) ,weakness in 52 wrists (80%) , tingling in 17 wrists (26.2%) ,& we have no atrophy in any patient. Nine patients (18%) had diabetes mellitus, 9 patients (18%) had hypertension & 7 patients (14%) had other (allergy, spondylosis, rheumatoid arthritis & peripheral neuropathy)). Phalen test was positive in 53 wrists (81.5%), Tinel`s test was positive in 29 wrists (44.6%), & compression test was positive in 56 wrists (86.2%)

Electrodiagnostic testing:

Subjects with CTS are divided into three categories (by EMG & NCS) according to the following criteria [14]:

1- Mild CTS: prolongation of distal sensory latency of median nerve more than 3.5 mille second or relative prolongation of median compared to ulnar distal sensory latencies over identical distance by 1 mille second.
2- Moderate CTS: reduced median sensory nerve action potential SNAP amplitude less than 50% compared to unaffected side or less than 25 µ.v. or prolonged distal motor latency more than 4.5 mille second.
3- Severe CTS: reduced median compound motor action potential CMAP amplitude less than 50%compared to unaffected side or less than 4 µ.v., dennervation of median innervated muscles on needle examination. Normal NCS finding was found in 7 wrists (10.8%), mild CTS in 27 wrists (41.5%), moderate CTS in 21 wrists (32.3%), & severe CTS in10 wrists (15.4%).

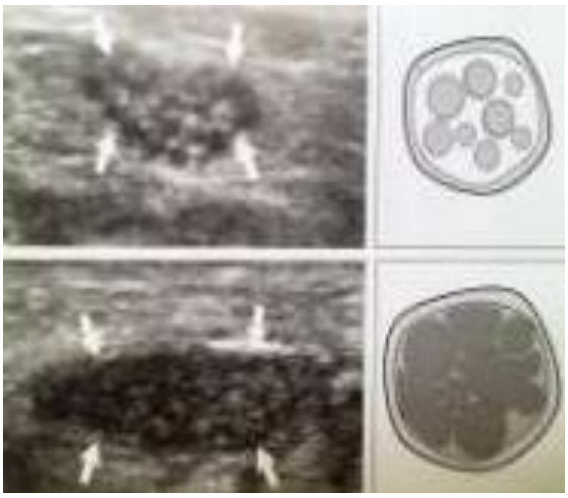
High-resolution sonography

We performed sonography of the median nerve in the forearm and blinded to the clinical and NCS data, using a 5–13 MHz linear-array transducer Siemens. Transverse images of the median nerve with measurements of the cross-sectional area were obtained at levels at the carpal tunnel inlet at the wrist crease.

The upper image shows the normal median nerve, while lower image shows the median nerve in CTS.

We assessed the presence of nerve swelling and nerve flattening. Nerve swelling was defined as an enlargement of the cross-sectional area of the nerve to 0.09 cm^2 or more within or proximal to the carpal tunnel. The cross-sectional area of the nerve was defined as the area of the nerve bundles in the perineural fibrous tissue [10].

Nerve flattening was defined as a decrease in the minor axis combined with an increase in the major axis of the median nerve in the carpal tunnel at the



pisiform level. In addition, the presence of increased palmer bowing of the flexor retiniculum was determined to be displacement of the palmer apex of the retiniculum [10].

Statistical Analysis:

Analysis of data was carried out using the available statistical package of SPSS-16 (Statistical Packages for Social Sciences- version 16) with independent student-t-test and chi-square test (χ^2-test). Statistical significance was considered whenever the P value was equal or less than 0.05.

Results:

50 patients [47 (94%) female and 3(6%) male] with mean age of (42.76±10.8) years (ranging from 22-65), and 100 healthy controls [94 (94%) female and 6 (6%) male] with the mean age of 42.57±10.66 years (ranging from 22 to 65) entered the study. Nerve Conduction study (NCS) of the median nerve in all of the patients was performed as a routine for diagnosis. The duration of symptoms of 29 patients (58%) were <6 months, 6 patients (12%) were 6-11 months, 15 patients (30%) were >12 months). We found the cross sectional area (CSA) in CTS patients range from 0.08 to 0.58 cm^2 & in the control range from 0.05 to 0.09 cm^2 as we see in Figure1.

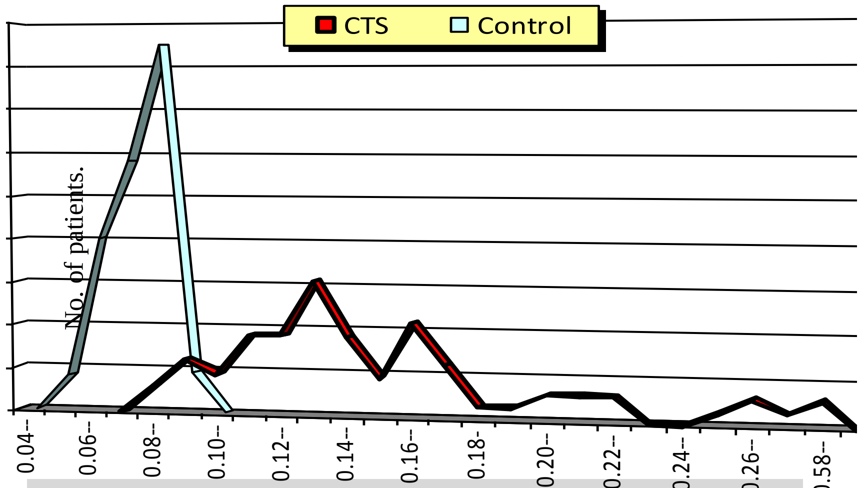


Figure 1: Cross sectional area (CSA) in patient & control groups.

The mean of the CSA of median nerve in the CTS is 0.161 cm^2 & in the control is 0.072cm^2. The standard deviation of CSA of median n. in CTS is 0.088 & in the control is 0.010.The minimum of CSA of median nerve in CTS is 0.080cm^2 & in the control 0.050cm^2. The median (percentile 50) CSA of median n. in CTS is 0.140cm^2 & in control is 0.080cm^2.The maximum of CSA of median n. in CTS is 0.580cm^2 & in the control is 0.090cm^2. So the mean of control + 2 SD; 0.072 + (2* 0.010) = 0.092cm^2 as cut-of value (see Table 1).

Table 1: Cross sectional area in both groups

cut-off value for cross sectional area (cm^2)	**Groups**			
	Patients		**Control**	
	No.	%	No.	%
Positive (>0.092)	59	90.8	-	-
Negative (<0.092)	6	9.2	200	100
Total	65	100	200	100

Mean of Control+2SD; 0.072+ (2x0.010)→0.092 as cut-off value; Sensitivity=90.8%, Specificity=100%

Table 2: Patients characteristics in comparison to cross sectional area

		cut-off value for cross sectional area (cm^2)				
		Positive (>0.092)		**Negative (<0.092)**		
		No	**%**	**No**	**%**	**P value**
Age (years)	<30	5	71.4	2	28.6	0.128
30—39		11	91.7	1	8.3	
40—49		21	87.5	3	12.5	
=>50		22	100	-	-	
Gender	Male	5	8.5	-	-	-
	Female	54	91.5	6	100.0	
BMI (Kg/m2)	Normal (BMI 18.5-24.9)	4	6.8	1	16.7	0.599
Overweight (BMI 25-29.9)		16	27.1	2	33.3	
Obese (BMI 30-34.9)		25	42.4	1	16.7	
Morbid obesity (BMI=>35)		14	23.7	2	33.3	

The Pearson Chi-Square statistic is significant at the 0.05 level.

Table 3: Ultrasound finding in patients & control groups

Ultrasound Findings		**Patients**		**Control**	
		No.	**%**	**No.**	**%**
CSA (cm^2)	> 0.092	59	90.8	–	–
	< 0.092	6	9.2	200	100.0
Echogenicity of median	Yes	61	93.8	5	2.5
	No	4	6.2	195	97.5
Flatting of median	Yes	52	80.0	–	–
	No	13	20.0	200	100.0
Flexor retiniculum bowings of wrist	Yes	47	72.3	–	–
	No	18	27.7	200	100.0

Table 4: NCS finding & positive cut-off value in the patients

NCS Findings	Patients		Positive Cut-off value (>0.092) cm^2	
	No.	**%**	**No.**	**%**
Normal	7	10.8	3	42.9
Mild	27	41.5	25	92
Moderate	21	32.3	21	100
Severe	10	15.4	10	100

Discussion:

CTS are usually diagnosed by clinical evaluation and electrodiagnosis, and the therapeutic plan is decided on its severity. In this regard, various scales have been developed. In recent times, ultrasonography emerged as a promising diagnostic tool for entrapment neuropathies, particularly CTS. In the case of CTS, local swelling of the median nerve is observed at the proximal carpal tunnel on ultrasonography, and CSA is useful to diagnose CTS and is highly correlated with clinical symptoms [(9)].

Diagnostic criteria for CTS on MRI are similar to those on ultrasound: namely, bowing of the flexor retinaculum, enlargement of the median nerve at the level of the pisiform, and flattening of the nerve at the level of the hook or the hamate. Additional MRI criteria include loss of fat within the carpal tunnel and edema or so-called pseudoneuroma of the median nerve, seen as increased size and signal of the nerve on water-sensitive sequences [(10)].

An electrodiagnostic study remains an expensive and time-consuming procedure not readily accessible to many physicians who are encountering the disease. Compared with MR imaging, sonography has the potential advantages of lower cost, shorter examination time and the possibility of sonographically guided intervention and treatment [(15)].

Almost all published studies on the sonographic diagnosis of carpal tunnel syndrome agree that nerve swelling is the main sonographic criterion indicating carpal tunnel syndrome, the swelling position (i.e., proximal to the carpal tunnel or at the tunnel inlet or outlet) and the critical threshold for nerve cross- sectional area differ considerably among those studies[(9,10,15)].

We found that the swelling of median nerve was the earlier & most reliable test in diagnosis of CTS, An increase in cross sectional area of median n. at the level of pisiform bone by sonography reaching to a cutoff value equal to or more than 0.092 $mm^2$was highly suggestive of CTS. Out of the 65 wrists studied 59 were having cutoff value for cross sectional area more than 0.092 mm^2 giving sensitivity of 90.8% and specificity of 100% ,while NCS have sensitivity of 89.2% and specificity of 100%.Those with mild CTS proved by NCS according to the dependents criteria, had 92.6% of them having a cross sectional area equal to or higher than 0.092 cm^2,while those with moderate & severe form of CTS (by NCS) had 100% cross sectional area more than 0.092 cm^2 as shown in figure 2 .Seven out of 65 wrists studied had normal NCS in spite of abnormal US criteria of CTS . Three out of seven (42.9%) had cutoff value equal to or more than 0.092 cm^2 indicating that US technique is more sensitive in diagnosis of CTS than NCS.

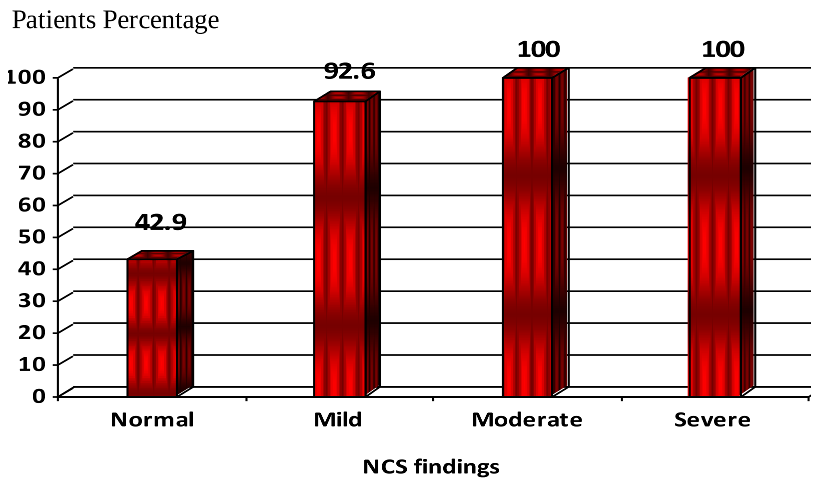


Figure 2: The NCS and cross-sectional echo finding (P=0.001).

While this sensitivity was ranging from 57% to 89% in the finding 0f Duncan et al, Swen et al, Keberly et al, Sarria et al Buchberger et al & Nakamichi et al studies [(10,16-20)]. The range of n. cross sectional area indicating CTS in our study was 0.092 -0.58 cm^2 while it was 0.090-0.150 cm^2 is found by Duncan et al study [(10)].

While El Miedany et al found out increase of the median nerve cross sectional area to more than 10 mm^2 is highly compatible with clinical and NCV findings in CTS patients. They concluded that ultrasonography is a new and valuable tool in diagnosis and follow up of CTS [(21)]; our finding can give rise to diagnosis of CTS much earlier than they dose.

Also our findings are in harmony with Yesildag et al conclusion and findings as they measured the median nerve cross sectional area at three points (before, through and after the transverse retinaculum). The mean value of three mentioned measurements had 88 % sensitivity and 94 % specificity in diagnosis of CTS [(22)].

While Serria et al gave only 60 % specificity of median nerve cross sectional area in diagnosis of CTS, their figure may not be as conclusive as they took smaller size of controls and patients compared to our studied groups [(18)].

Other US parameters can serve in diagnosis CTS in symptomatic subjects. The role of median n. flattening & flexor retiniculum bowings of wrists showed variations among different studies. In our study 52 out of 65 wrists had flattening of median nerve while the rest of symptomatic subjects had no flattening of median n. giving rise to 80% sensitivity in diagnosis CTS subjects, while only 47 out of 65 subjects showed positive bowing in their flexor retiniculum of wrists by US with 18 wrists showed negative bowing giving only 72.3% sensitivity of this test.

Buchberger et al [(19)] & Duncan et al[(10)] showed that the sensitivity of median n. flattening by US showed only 38-65% sensitivity while this figure rises to 45-81 % for the bowing of median n. at wrist as mentioned by Sarria et al study[(18)]. The decreased echogenicity were detected in 61 wrists giving sensitivity of 93.8% in this study. All subjects having symptomatic CTS with specificity of 100%.

So we can conclude that the decrease of echogenicity of median nerve have significant associated with NCS finding in diagnosis CTS and in our study the p value was less than 0.004 rather than other entrapment parameter studied by US. Up to our knowledge the accuracy of nerve edema compared to other US parameter in diagnosis CTS compared to NCS has not yet been reported.

Ultrasonography is a noninvasive cost effective diagnostic tool that takes much less time than NCV without unpleasant sense of electrode usage in NCV and EMG for patients. It is especially useful in diagnosis of some carpal tunnel causes such as abscess and space occupying lesions, this same conclusion that reached to it in the Buchberger et al study. [(9)]

Therefore, we believed that US should be the first diagnostic procedure considered in patients with typical clinical features of CTS.

References:

1. National Institute for Occupational Safety and Health. Elements of ergonomic programs: a primer based on workplace evaluations of musculoskeletal disorders. Cincinnati, OH: National Institute for Occupational Safety and Health, 1997; (DHHS[NIOSH]) publication 97-117
2. Ruess L, O' Connor SC, Cho KH, Husain FH, Howard WJ, Slaughter RC, Hedge A. Carpal tunnel syndrome and cubital tunnel syndrome: work-related musculoskeletal disorders in four symptomatic radiologists. AJR 2003; 181:37-42
3. Rempel D, Evanoff B, Amadio PC, de Krom M, Franklin G, Franzblau A, Gray R, Gerr F, Hagberg M, Hales T, Katz JN, Pransky G. Consensus criteria for the classification of carpal tunnel syndrome in epidemiologic studies. Am J Public Health 1998; 88:1447-51.
4. Katz JN, Simmons BP. Clinical practice: carpal tunnel syndrome. N Engl J Med 2002; 346:1807-12.
5. Hamanaka I, Okutsu I, Shimizu K, Takatori Y, Ninomiya S. Evaluation of carpal canal pressure in carpal tunnel syndrome. J Hand Surg [Am] 1995; 20:848 -854.
6. Ferry S, Silman AJ, Pritchard T, Keenan J, Croft P. The association between different patterns of hand symptoms and objective evidence of median nerve compression: a community-based survey. Arthritis Rheum 1998; 41:720 -724.
7. Jarvik JG, Yuen E, Haynor DR,Bradley CM,Fulton-Kehoe D, Smith-Weller T, Kliot M, Kraft G,Wang L, Heagerty PJ, Franklin GM. MR nerve imaging in a prospective cohort of patients with suspected carpal tunnel syndrome. Neurology 2002; 58:1597-160.
8. Britz GW, Haynor DR, Kuntz C, Goodkin R, Gitter A, Kliot M. Carpal tunnel syndrome: correlation of magnetic resonance imaging, clinical, electrodiagnostic, and intraoperative findings. Neurosurgery 1995; 37:1097-1103.
9. Buchberger W, Judmaier W, Birbamer G, Lener M, Schmidauer C. Carpal tunnel syndrome: diagnosis with high-resolution sonography. AJR 1992; 159:793-798.
10. Duncan I, Sullivan P, Lomas F. Sonography in the diagnosis of carpal tunnel syndrome. AJR 1999; 173:681-684.
11. Hiramatsu Y. Stereoscopic observation of the microvasculature of peripheral nerves. Acta Med Okayama 1982; 36:263-275
12 Boland RA, Adams RD. Vascular factors in carpal tunnel syndrome. J Hand Ther 2002; 15:22-30.
13 AAN, AAEM, AAPMR. Practice parameter for carpal tunnel syndrome (summary statement). Neurology 1993; 43:2406–9.

14 Pease William S., Lew, Henry L, Johanson Ernest W. Text book of Johnson`s. Practical Electromyography 4th edition 2007.
15 Rempel D, Evanoff B, Amadio PC, de Krom M, Franklin G, Franzblau A. Consensus criteria for the classification of carpal tunnel syndrome in epidemiologic studies. Am J Public Health 1998; 88:1447–51.
16 Swen WA, Jacobs JW, Bussemaker FE, de Waard JW, Bijlsma JW. Carpal tunnel sonography by the rheumatologist versus nerve conduction study by the neurologist. J Rheumatol 2001; 28:62-69.
17 Keberle M, Jenett M, Kenn W, Reiners K, Peter M, Haerten R, Hahn D. Technical advances in ultrasound and MR imaging of carpal tunnel syndrome. Eur Radiol 2000; 10:1043-50.
18 Sarria L, Cabada T, Cozcolluela R, Martinez-Berganza T, Garcia S. Carpal tunnel syndrome: usefulness of sonography. Eur Radiol 2000; 10:1920 -1925.
19 Buchberger W, Schon G, Strasser K, et al. High-resolution ultrasonography of the carpal tunnel. J Ultrasound Med 1991; 10: 531–7.
20 Nakamichi K, Tachibana S. Ultrasonographic measurement of median nerve cross-sectional area in idiopathic carpal tunnel syndrome: Diagnostic accuracy. Muscle Nerve 2002; 26: 798–803.
21 . EL. Miedany YM, Aty SA, Ashours: ultrasonography versus nerve conduction study in patients with carpal tunnel syndrome: rheumatology. (Oxford), Epub Apr 2004; 887-95.
22 Yesildag A, Kutiuhan N, Koyuncuogiu HP, el: the role of ultrasonography in the diagnosis of carpal tunnel syndrome. Clini-racliol, Oct 2004; 59(10):910-5.

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