Role of Ultrasonography and color Doppler in Evaluation of Carpel tunnel Syndrome

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Abstract

Background: Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy, as compression of the median nerve in the carpal tunnel under the flexor retinaculum; it is more frequent in middle aged women and mostly occurs bilateral.

Objectives: Prospective case control study of Evaluation of ultrasound and color Doppler accuracy in diagnosis of carpel tunnel syndrome.

Patients and methods: Prospective –case control clinical study was conducted during the time period from august 2019 to June 2020. Thirty subjects were included in the study (60 wrists) 20 were females and 10 males. They were referred to the radiology department at south valley university hospital from orthopaedic and rheumatology departments of south valley university hospital for ultrasound examination of the carpal tunnel after taking oral consent.

Results: Out of 30 wrists with CTS, 5 (16.7%) of them had detected intraneural abnormal hypervasculature in Color duplex and power duplex of median nerve. In case of control group, only one wrist had detected intraneural abnormal hypervasculature in color and power duplex of median nerve. The significant cut off value for CSA of the median nerve in ultrasound (p-value <0.001) at the pisiform level (tunnel inlet) is >9mm2 with a sensitivity of93%, specificity32%and at quadratus level is >8mm2 with sensitivity84.31%, specificity78.5%.

Conclusion: From all above discussed results we will establish and recommend a scheme for diagnosis of CTS based on ultrasound. Lastly this study used US with Doppler study to diagnose CTS ,US is easy ,rapid ,less costly and more comfortable method to patients suspected CTS and so it can be preliminary in diagnosis of CTS and grading.

Keywords: Carpal tunnel syndrome; Neuropathy; Color duplex; Median nerve; Ultrasound; Intraneural, duplex.

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Introduction

Carpal Tunnel Syndrome (CTS) is the most frequent compressive syndrome and is defined by compression with or without traction of the median nerve at wrist level (**Paget, 2007**). Its first description belongs to Paget, who reported on a case of compression of median nerve consequent to a fracture of the distal radius (**Drasko, 2000**). In 1913, Marie & Foix published the anatomical and histopathological description of an hourglass-shaped lesion of median nerve with neuroma, proximal to the flexor retinaculum. In the 1950s, studies by Phalen established principles of CTS **(Phalen 1966).**

The carpal tunnel is a small canal in front of the wrist joint and formed by the carpal bones and the rigid fibrous transverse carpal ligament. The carpal tunnel contains the nine flexor tendons and the Median nerve (**Dorwart 1984**), which enters the tunnel in the midline or slightly radial to it (**MacDermid ,2004) .**

Compression of the median nerve in the carpal tunnel causes neuropathic pain sensation along the area supplied by the median nerve which is the palmar aspect of the later three and half fingers which may be also caused by compression of the Sixth and Seventh cervical nerve roots proximally (**StatPearls 2020).**

Nerve Conduction Studies (NCS) have been developed as a result of the discovery in 1956, that median nerve conduction times are slowed across the wrists of hands in CTS patient, (**Simpson, 1956).**

NCS is the gold standard in the diagnosis of CTS, because it is an objective test that provides information on the physiological health of the median nerve across the carpal tunnel. However, false negative results and false positive results can still occur (**Knibb, 2009**) possibly due to decrease standardized diagnostic criteria, resulting in 16-34% of clinically defined CTS being missed with NCS (**Witt, 2004**). Moreover, blanket referrals for NCS are an expensive and inefficient approach to the diagnosis of CTS (**Boland ,2009) .**

Another important fact is belong to that many studies have reported that NCS does not change the probability of diagnosing CTS, emphasizing importance of clinical history and examination **(Graham 2008).**

Ultrasound (US) has an important role in the diagnosis of CTS with thickening of the median nerve, flattening of the nerve within the tunnel and bowing of the flexor retinaculum are the diagnostic features of CTS.Many studies have concluded that cross sectional area is the most predictive measurement **(Sarria, 2000)**. The Cross-Sectional Area (CSA) of the median nerve has been used in US to classify the degree of severity of CTS as normal, mild, moderate and severe **(Karadag, 2010).**

Recently, Magnetic Resonance Imaging (MRI) has more advantageous value than electrophysiological testing. (**Hersh,2019**) CT-MRI can see the median nerve at high resolution and has an effective imaging method for visualization of internal structure like, tendons, ligaments, carpal bones, muscles, and other wrist morphological content (**Ikeda, 2017**).

Ultrasound is available, cost effective and less invasive compared with electrophysiological testing and other imaging techniques, such as MRI, **(Beekman , 2003)**. color Doppler sonography has agood role in detecting intraneural circulatory disturbance in patients with suspected carpal tunnel syndrome has not yet been investigated, although color Doppler sonography has been used to evaluate the presence of a persistent median artery in the carpal tunnel and a variety of peripheral nerve abnormalities (**Gassner, 2002).**

Basically, there are three Doppler techniques to detect blood flow: color, power, and spectral Doppler. Color Doppler maps flow by encoding frequency shifts at each point on the image using a color scale (**Tchelepi , 2009**). Intraneural flow is typically slow and requires optimal adjustment of the pulse repetition frequency. For example, a low frequency is required for slow flow. However, aliasing (ambiguity in the Doppler signal) will occur if the pulse repetition frequency is set too low or when higher velocities are encountered (**Huda, 2010**). Power Doppler is not hampered by aliasing, because the volume of blood (rather than its velocity) is measured (**Evans, 2010**).

Power Doppler is more sensitive in slow flow, (**Tchelepi, 2009**). Spectral Doppler seems to be more subject to noise contamination and is even worse for detecting slow flow and looking at smaller or deeper vessels. Thus, Power Doppler seems to be the best way to detect intraneural flow **(Visser, 2011).**

The current prospective case control study aimed to evaluate the role of ultrasound and color Doppler accuracy in diagnosis of carpel tunnel syndrome.

Patients and methods

Prospective –case control clinical study was conducted during the time period from august 2019 to June 2020. Thirty subjects were included in the study (60 wrists) 20 were females and 10 males. They were referred to the radiology department at south valley university hospital from orthopaedic and rheumatology departments of south valley university hospital for ultrasound examination of the carpal tunnel after taking oral consent.

Subjects were classified into two groups: Group (I) includes 15 symptomatic patients with 30 wrists. Group (II) includes 15 volunteers with 30 wrists of asymptomatic persons considered as control group.

Inclusion criteria: includes patients who were suffering from finger numbness and pain mainly in the medial three fingers radiating to wrist and arm, this pain mainly nocturnal and these patients were clinically diagnosed as CTS or with abnormality in nerve conduction study.

Exclusion criteria: Age less than 18 years old, previous carpal tunnel release surgery, history of wrist fracture or surgery, clinical evidence of other cervical radiculopathy, polyneuropathy or mononeropathy and secondary causes of carpal tunnel syndrome such as rheumatoid arthritis and hypothyroidism were excluded from the study.

All patients had electro diagnostic tests

Pre Procedure Evaluation

A. Clinical questionnaire for the diagnosis of CTS: A scored questionnaire can replace nerve conduction studies in the initial assessment of patients with CTS. The results gave a sensitivity of 85% for the scored questionnaire compared to 92% for nerve conduction studies. Importantly the positive predictive value was 90% for the questionnaire and 92% for the nerve conduction studies.

B. Electro-physiological study (nerve conduction) was done for patients. The nerve conduction studies (NCSs) were performed as motor and sensory nerve conduction to diagnose and grade CTS in all patients (**Yasser El Miedany, 2015**).

The patients with abnormal NCS were classified according to electrodiagnostic grading into:

- Grade 0: Normal standard and comparative tests.
- Grade 1: Very mild CTS: Normal standard tests, abnormal comparative tests or reduced nerve conduction velocity of the median nerve across the carpal tunnel.
- Grade 2: Mild CTS: Abnormal sensory with a normal motor response that is, prolonged antidromic distal sensory latency (DSL) >3.6 ms to the second digit.
- Grade 3: Moderate CTS: Abnormal of median sensory and motor response that is, prolonged distal motor latency to abductor pollicis brevis (APB) is >4.2 ms but <6.5 ms, and prolonged antidromic distal sensory latency with decreased amplitude sensory nerve action potential.
- Grade 4: Severe CTS: Absence of sensory response, abnormal distal motor latency to APB but still <6.5 ms with decreased amplitude of compound muscle action potential and abnormal EMG activity in abductor policis brevis muscle.
- Grade 5: Very severe CTS: Terminal latency to APB >6.5 ms.
- Grade 6: Extremely severe CTS: Absence of median motor and sensory responses (surface motor potential from APB <0.2 mV amplitude).

Procedure Evaluation: Ultrasonography assessment: Gray scale ultrasonography and Power and color Doppler examination.

Results

Patients group: Mean age (±SD) of the studied patients was 34.40 ±10.5 years with range between 19 and 60 years. Control group: Mean age of the control group was 38± 6.7 with range between 23 and 50 years. Patients group: It is formed of 30 wrists of 15 patients (all patients were bilaterally affected) with carpal tunnel syndrome. Control group: it is formed of 30 wrists of 15 healthy subjects with Clinical questionnaire ≤ 3. All controls are bilaterally examined. As regarding age and sex of both control and patients groups, there were no significant differences between both (P> 0.05). **Table (1)**

Clinical evaluation of the patients showed 19 (63.3%) wrists had positive Phalens and 16 (53.3%) wrists had positive Tinel test respectively. Mean (± SD) of clinical questionnaire score was 7.2 ± 0.83 with range between 6- 9. Nerve edema is subjectively evaluated by comparison with the typical normal nerve.. It is absent in 19 (63%) wrists and presented in mild and moderate form in 8 (26.6%) and 9 determined subjectively. Nerve mobility is subjectively evaluated. It is absent in

8(26.6%), mild in 9 (30%) and moderate in 13 (43.33%). **Table (2)**

Mild, moderate and severe carpal tunnel syndrome were reported in 11 (36.7%), 11(36.7%) and 8 (26.7%) patients respectively but all wrists in control group had clinical questionnaire ≤ 3 and so, no need to do nerve conduction study (P< 0.001). **Table (3)**

Swelling ratio had insignificant difference between both groups (1.25 ± 0.38 versus 1.3 ± 0.01; P= 0.7). CSA inlet had 71.5% sensitivity and 63% specificity for detection of CTS with area under the curve was 0.73 and P= 0.03 at cut off point > 1.22. **Table (4)**

Flattening ratio at rest had 79.2% sensitivity and 38.9% specificity for detection of CTS with area under the curve was 0.62 and P< 0.001 at cut off point > 2.53. While dynamic flattening ratio had 39.6%% sensitivity and 71.43% specificity for detection of CTS with area under the curve was 0.5 and P< 0.001 at cut off point ≤ 2.88. **Table (5)**

There were no significant differences between degrees of CTS as regarding bowing of forearm (dynamic and at rest) and flattening of median nerve (dynamic and at rest). Patients with severe and moderate CTS had significant higher CST inlet and outlet (P< 0.001) in compared to those with mild affection. Although patients with severe CTS had higher CSA inlet and outlet than those with mild CTS, only CSA inlet had significant difference (P<0.001) between moderate and sever CTS. **Table (6)**

Out of 30 wrists with CTS, 5 (16.7%) of them had detected intraneural abnormal hypervasculature in Color duplex and power duplex of median nerve. In case of control group, only one wrist had detected intraneural abnormal hypervasculature in color and power duplex of median nerve. **Table (7)**

Table 1. Demographic and Clinical Data of the studied patients

Variables	Patients group (= 15 patients)	Control group (n= 15 healthy subject)	*P* value
Age (years) Range	43.40 ± 10.5 19- 60	38.6 ± 6.7 23- 50	0.83
Sex Male Female	5 (33.3%) 10 (66.6%)	5 (33.3%) 10 (66.6%)	0.07

Table 2. Clinical data among the studied groups

Clinical data	Patients group (n= 30 wrist)	Control group (n= 30 wrist)	*P* value
Positive Phalen`s test	19 (63.3%)	0	----
Positive Tinel`s test	16 (53.3%)	0	----
Clinical questionnaire score	7.2 ± 0.83 (6- 9)	3	**0.00**
Nerve edema (subjectively) Absent Mild Moderate	 1 9 (63.3%) 8 (26.6%) 3 (6.7%)	 30 (100%) 0 0	**0.00**
Mobility restriction (subjectively) **None** **Mild** **Moderate**	 8 (26.6%) 9 (30%) 13 (43.33%)	 30 (100%) 0 0	**0.00**

Table 3. Nerve conduction study among the Patient group

Nerve conduction	Patients group (n= 30 wrist)
Mild CTS	11(36.7%)
Moderate CTS	11 (36.7%)
Severe CTS	8 (26.7%)

Table 4. Cross sectional area at carpal tunnel inlet and P.Q in studied wrists

Nerve conduction	Patients group (n= 30 wrist)	Control group (n= 30 wrist)	*P* value
CSA inlet (mm²)	13.42 ± 3.29 (9- 19)	10.21 ± 0.43 (9- 11)	**< 0.002**
CSA P.Q (mm²)	10.6 ± 2.25 (6- 15)	8.8 ± 0.27 (8- 9)	**< 0.001**
Swelling ratio	1.25 ± 0.38 (1.19- 1.28)	1.3 ± 0.01(1.2- 1.24)	**0.7**

Table 5. Flattening ration of median nerve in studied wrists

State	Patients group (n= 30 wrist)	Control group (n= 30 wrist)	*P* value
At rest	2.6 ± 0.9 (1- 4.11)	2.06 ± 1.1 (1.1- 4.55)	0.08
Dynamic	3.33 ± 1.81 (1.5- 5.5)	3.36 ± 1.12 (1.45- 5.32)	0.87

Table 6. U/S parameters based on degree of CTS

U/S parameters	Degree of CTS based on nerve conduction			*P*1	*P*2	*P*3
	Mild (I) (n= 11)	Moderate (II) (n= 11)	Severe (III) (n= 8)			
CSA inlet	10.57 ±	12.50 ± 2.99	14.34 ± 1.56	<	<	**< 0.001**
	2.34			**0.001**	**0.001**	
CSA outlet	9.01 ± 2.01	11.09 ± 1.91	11.11 ± 2.87	<	<	0.98
				0.001	**0.001**	
Wrist ratio	1.19 ± 0.67	1.18 ± 0.94	1.21 ± 0.92	0.55	0.65	0.99
Flattening of median nerve						
At rest	3.22 ± 1.05	3.09 ± 1.03	4.01 ± 1.1	0.11	0.34	0.23
Dynamic	3.67 ± 1.11	3.11 ± 1.32	3.67 ± 0.98	0.34	0.35	0.37
Palmar bowing						
At rest	5.1 ± 1.32	4.9 ± 1.21	5.5 ± 1.08	0.27	0.09	0.82
Dynamic	5.33 ± 1.23	5.52 ± 2.01	5.55 ± 1.56	0.34	0.19	0.07

Table 7. Doppler findings of median nerve in studied wrists

	Patients group (n= 30 wrist)	Control group (n= 30 wrist)	*P* value
Abnormal vasculature			
Color duplex	5 (16.7%)	1 (3.33%)	**0.02**
Power duplex	5 (16.7%)	1 (3.33%)	**0.02**

Data was expressed in form of frequency (percentage). P value was significant if < 0.05(by Chi² test)

Case presentation

49 years old male patient is suffering from bilateral hand burning sensation and nocturnal pain.

US examination:

1- The mean cross sectional area of the median nerve is at the tunnel inlet LT

(13) Mm²fig A: transverse US image of left median nerve (mn) (outlined) at level of carpal tunnel inlet. The CSA is 0.13cm squared (13mm squared).

2- Normal fascicular pattern and echogenicity of median nerve. (Left– no decreased echogenicity of median nerve) (**Fig. A**).

3- The mean cross sectional area of the median nerve is at the pronator quadratus muscle lt (11) mm² with WFR LT (1.5) (**Fig.B**) transverse US image of

left median nerve (MN) (outlined) at level of quadrats muscle (PQ) (proximal to carpal tunnel) the CSA is 0.11cm squared (11mm squared)

4- The flattening ratio of the nerve (transverse diameter divided by AP diameter) (**Fig.C**): transverse US image of left median nerve (MN) at level of carpal tunnel inlet at rest. The transevers diameter is 0.59cm and longitudinal diameter is 0.42cm with flattening ratio (FR) is 1.4.

Fig.D: transverse US image of left median nerve (MN) at level of carpal tunnel inlet at dynamic. The transvers diameter is 0.52cm and longitudinal diameter is 0.22cm with flattening ratio (FR) is 2.3.

5- Volar bulging of the flexor retinaculum is LT (1.1mm) at rest, at dynamic LT (1.3mm) (**Fig.E**): transverse US image of left median nerve (MN) at level of carpal tunnel inlet at rest(1.4) and the longitudinal diameter (1.2) with Palmer bowing of left flexor retinaculum at rest is (1.1mm).

Fig. F: transverse US image of left median nerve (MN) at level of carpal tunnel inlet at dynamic (1.4) and longitudinal diameter at dynamic (1.07) Palmer bowing of flexor retinaculum (FR) is 1.3.6- Color and power Doppler Doppler: no abnormal intraneural hypervascularity could be detected. **Fig. G** axial US image of left median nerve at level of

carpal tunnel with color Doppler showing no abnormal intraneural hypervascularity

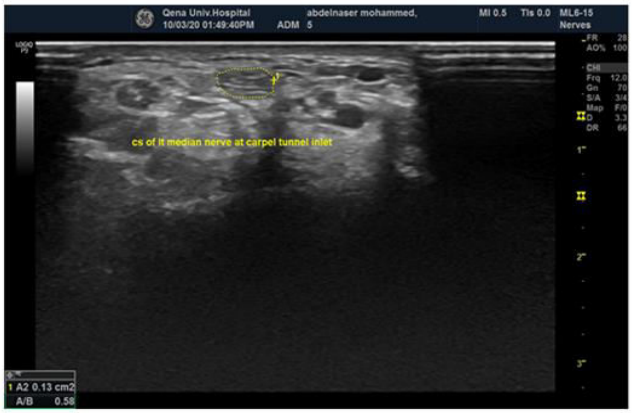

Fig A

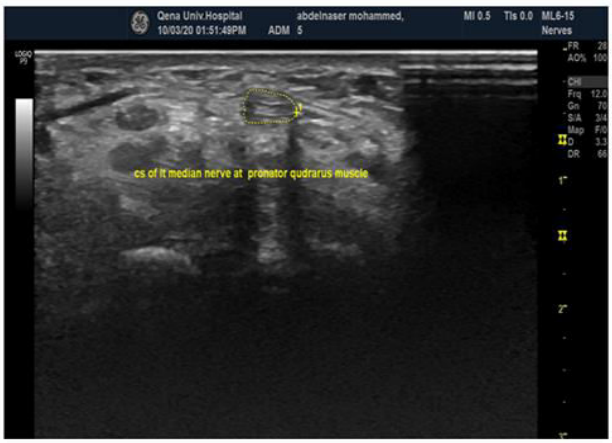

Fig B

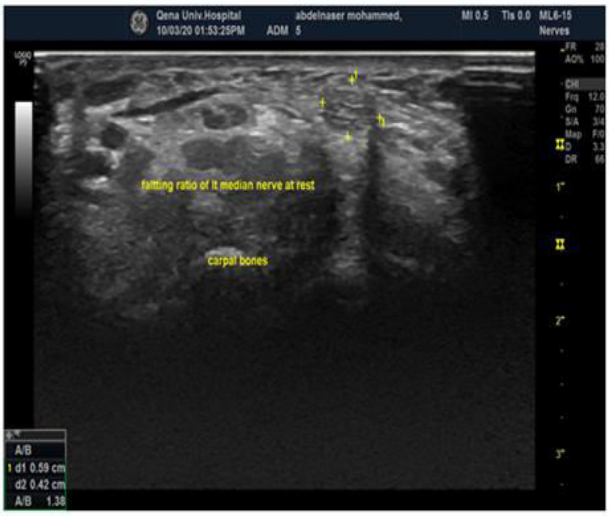

Fig C

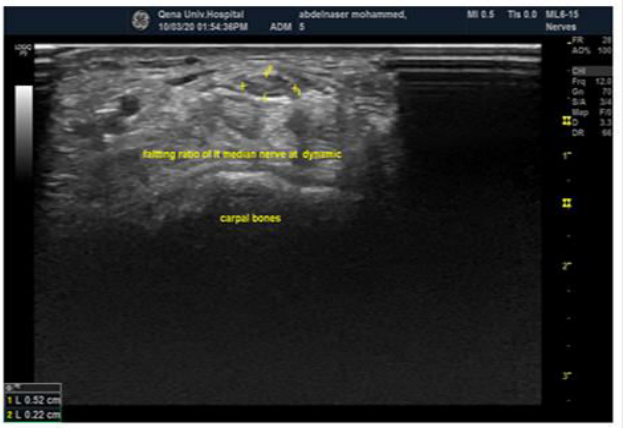

Fig D

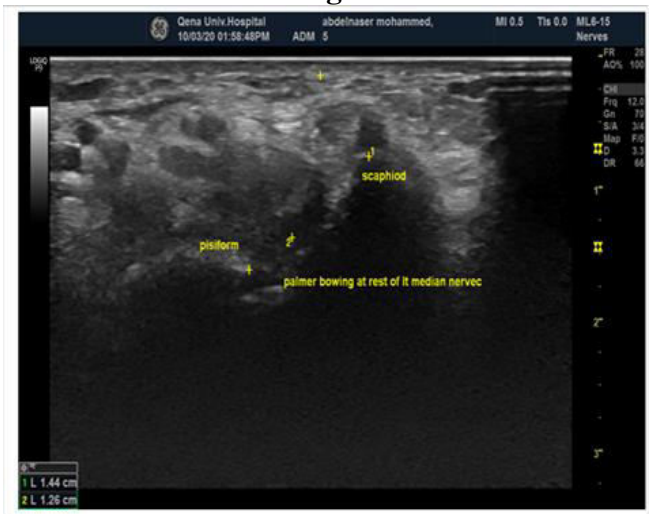

Fig E

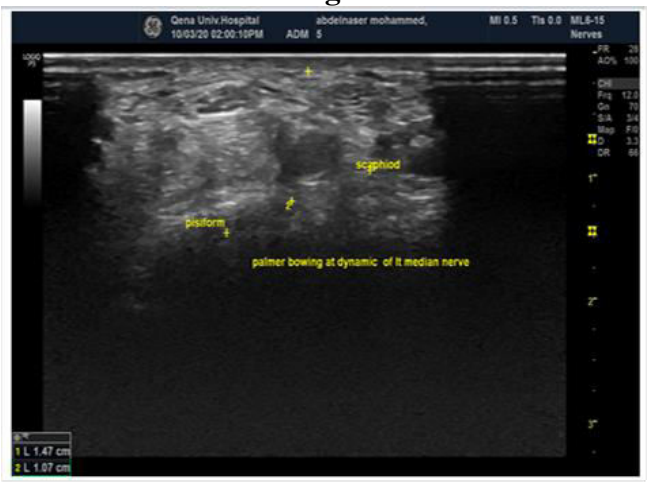

Fig F

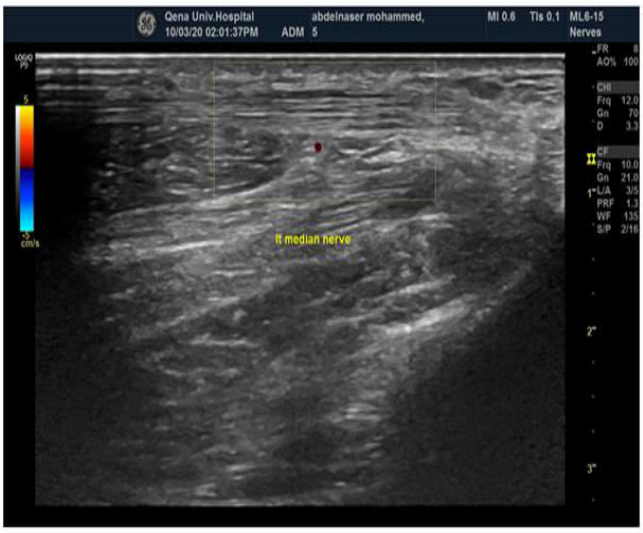

Fig G

Discussion

CTS symptoms are pain or paresthesia (numbness and tingling) in a distribution that includes the median nerve territory, with involvement of the first three fingers and the radial half of the fourth finger. . The most important of these are nocturnal pain or paresthesia in the distribution of the median nerve. The symptoms of CTS increase at night and often awaken patients from sleep. In order to decrease symptoms patients, shake their hands or place them under warm running water. CTS is a clinical diagnosis (**Azami ,2014**).

Carpal tunnel syndrome (CTS) is the most common form of peripheral entrapment neuropathy in which compression of the median nerve at the wrist occurs. CTS may be higher in the industrial setting than in the general population, by 5–15% in the workplace (**Azami, 2014**).

The use of US in the diagnosis of carpal tunnel syndrome has many advantages for both the physician and the patient. Ultrasonography is noninvasive and allows for improved patient comfort. It allows physicians to perform the diagnostic examination in the office without needing to schedule the patient for electrodiagnostic studies, thereby facilitating timely care. A US evaluation for carpal tunnel syndrome is less time-consuming than electrodiagnostic studies (**Chen, 2016**).

In our study we evaluate the role of US and Doppler in diagnosisand grading of CTS using neurophysiological findings as a gold standard.

The most sensitive measurements were obtained at the level of the pisiform because of the increased diameter of the nerve due to edema is most remarkable at this level that matches with (**Serica, 2010**).

The CSA of the median nerve at the carpal tunnel inlet was significantly larger in patients than in controls (13.42 mm2 ± 3.29 mm2 vs. 10.11 mm2 ± 43 mm2, p<0.001 this nearly matches with Bong et al., (2008) study who states The CSA of the median nerve at the carpal tunnel inlet was significantly larger in patients than in controls (13.42 mm2 ± 3.29 mm2 vs. 10.21 mm2 ± 0.43 mm2, p<.002.

The CSA inlet is the most commonly used parameter for diagnosing CTS. Many studies have reported CSA inlet cut-off values for diagnosing CTS, ranging from 9 to 15 mm^2 with 57–98% sensitivity and 51–100% specificity. (**Zhang, 2015**) in our study ROC analysis of the cross sectional area of the median nerve at tunnel inlet (level of bisiform bone)showed that cut off value over $9mm^2$ was diagnostic for CTS with sensitivity93% and specificity 32% our result matches with (**Tai,2012**) performed a meta-analysis and reported that a CSA-I ≥ 9 mm2 is the best single diagnostic criterion, and (**Zhang, 2015**) showed a cut-off value of 9.05 mm2 with 85.7% sensitivity and 55% specificity.

So we agree with (**McDonagh, 2015**) that standardization of the sonographic technique is needed before sonoraphy can be accepted as routine investigation. The nerve may occasionally be within normal limits when measured at a single location, resulting in the examiner underestimation or overlooking the enlargement so it is preferable to obtain CSA of median nerve at multiple levels (**Keles, 2005**).

The mean CSA at quadratus muscle in patient and control was statistical significance with p value <0.001 that agree with (**Keles, 2005**) that reported the proximal cross-sectional area of 11.57+_4.22mm2 in patient and 8.16+- 2.64mm2 in control with p value <0.001 but differ with (**Serica et al., 2010**)who stated that Mean PMNA at the level of the radiocarpal joint was 12,71±5,2 mm 2 in patients and6,97±1,09 mm2 in controls with p,0.001,the difference may be due their different number of patient and controls.

Focal swelling of the median nerve at the carpal tunnel assessed via the cross sectional area (CSA) and wrist –to-forearm ratio (WFR) has

considered as diagnostic criterion for CTS by many clinicians **(Hobson-Webb , 2008)**

The cut off value for swelling ratio in our patient >1.22 with low specificity and sensitivity. these results correlate with the cut off value of **(Zhang, 2015)** who reported the wrist-to-forearm ratio cut off value of 1.41 indicating low sensitivity and specificity (81.8% sensitivity and 68.2% specificity) and mismatching with **(Hobson-Webb , 2008)** who reported that a wrist-to-forearm ratio ≥ 1.4 gave 100% sensitivity for diagnosing CTS.in addition in our result no significant difference of mean value of swelling ratio between patients and controls this mismatching with **Zhang, (2015) and Hobson-Webb, (2008)** who reported significant difference of the mean value of swelling ratio between patient and controls ,this matching may be due low sample size and ultrasonography instrument.

In present study the flattening ratio measured at pisiform bone that correlate with **Serica,(2010),**but **El Miedany, (2004)** measured FR at distal tunnel (hamate level)and tunnel inlet. Our cut off value for FR a t rest was >2.53 with a high sensitivity and low specificity this agree with who reported the sensitivity of 79.2% and specificity of 38.9% for FR and with **Chan, (2011)** who reported cut off value of FR of 2.65 at the tunnel inlet gave a sensitivity 70.4% but a lower specificity of only 53.7%.and mismatching with **Mallouhi, (2006)** who reported FR>3 with low sensitivity 60%but high specificity 76%. Our results also correlate with **Sarria , (2000)** who reported no significant difference of FR between patient and controls.

There have been several studies which suggested that there may be some deformation of the shape of the median nerve during finger motion (**Yoshii , 2009**).

Since the carpal tunnel is a closed space, the median nerve gets compressed by other tendons .Normally, the median nerve and flexor tendons are connected by the multilayered connective tissue.

In carpal tunnel syndrome, the connective tissue is found to be fibrotic and this leads to decrease of the relative motion. This fibrosis may also therefore affect the ability of the median nerve to move out of the way of the tendons during finger motion, resulting in increased compression of the nerve when the hand is active. This may cause a change in the median nerve deformation (**Yuichi, 2013**).

So in our study atrial to evaluate the change in the median nerve deformation during dynamic (fingers flexion) we measure the FR in dynamic during finger flexion and found that mean values of FR during dynamic is more than FR at rest in both patients and controls and also the cut off value of FR is increased but of lower sensitivity and higher specificity.in our knowledge no previous studies correlate or mismatching with our result.

Assessment of the vascularity of the median nerve using color and power Doppler as an aid in the diagnosis of CTS is gaining popularity, but evidence of relevance and sensitivity is limited to date .Despite these encouraging findings, no validated scoring system has been created for assessing the vascularity of the median nerve, thus subjective measures are often used (**McDonagh , 2015**).

In our study, Doppler was used to determine intraneural vascularization in CTS, power Doppler us is considered superior to color Doppler ultrasound in demonstration of vascular flow as aresult of high sensitivity slow flow, no angle dependency, and no aliasing, power gain was optimized by reducing gain just enough to suppress the noise with transverse image of median nerve as done by (**Akcar , 2010**).

In our study detected intraneural hyper vascularity in 5 wrists of patients and one wrist of control with significant difference between patients and control P value0.02this correlate with a study by (**Ghasemi-Esfe , 2011**) who reported that 5 % of their healthy control subjects had intraneural vascularity which was initially considered a false positive finding of color Doppler imaging.

On the other hand (**Akcar , 2010**) who declared that visualization of vessels by power Doppler US is avery limited signal ,not seen in the control group and seen only in patients.

In our study there was significant negative moderate correlation between CSA inlet and sensory nerve conduction velocity amplitude ,with a significant negative correlation between CSA inlet and motor nerve conduction velocity amplitude and this results correlate with who **El-Habashya , (2016)** reported. It a significant negative correlation with motor and sensory amplitudes ($r=-0.657$, $P<0.001$ and $r=-0.656$, $P<0.001$respectively).

Despite that **Mitraitė , (2017)** found no relations between sensory MN conduction

velocity and ultrasound measurements. Disability of the arm is related to nerve conduction changes but not with ultrasonographic measurements. It appears that changes in nerve physiology have more effect on function than changes in anatomy which is represented in these findings.

In our study CSA inlet had significant difference between mild, moderate and severe CTS at cut off value9-13mm2 for mild, 13- 15 mm^2 for moderate, ≥ 15mm^2 for severe CTS.

The results of our study were in agreement with the results obtained by **Karadag , (2010),** who stated that the US was useful in grading the severity of CTS. They concluded that US measurement of CSA could give information about severity of MN involvement and they set US cut-off points that discriminate between different grades of CTS severity as follows: 10.0–13.0 mm2 for mild, 13.0–15.0 mm2 for moderate, and ≥ 15.0 mm2 for severe symptoms, inspite of different cut off value but may be due to small sample size of our study in different grade of CTS.

Also, **El Miedany , (2004)** found that one can be confident of determining the level of severity of CTS based on US measurement of CSA of the MNs.

The delay in the diagnosis of CTS by NC studies is also reported by (**Wong , 2004**) who mention that some patients with CTS could have swelling of the median nerve detectable by sonography and not detected by NC which give false result. Also parathesia can occur before conduction impairment in the sensory fibers can be detected in NC tests (**Lundborg , 1982**).

So we also depend on clinical questionnaire for exclusion of patient of CTS and controls, in all patient clinical questionnaire > 3, in all control < 3. Also our study showed insignificant positive weak correlation between Clinical Questionnaire Score with CSA at level of inlet and at level of PQ.so symptoms severity has insignificant positive weak correlation with CSA at level of inlet and at level of PQ and this agree with **Padua , 2008** stated that symptom severity did not worsen with an increase in the proximal cross- sectional area, but the functional status (measured by nerve conduction study) was strongly related to the proximal area.

On the other hand, **Karadağ 2020,** revealed that the proximal cross-sectional area was positively correlated with Boston Carpal Tunnel Questionnaire symptom severity scores (resemble our clinical questionnaire but it more complicated) and not just electro physiologic severity. They reported that the degree of median nerve swelling reflected the degree of nerve damage and carpal tunnel syndrome symptom severity.

Finally we discussed many parameters for diagnosis of CTS by ultrasonography ,now we will choose the parameters of which high sensitivity, and accuracy and ask that if combination of these parameters will have added value in the form of increasing sensitivity , specificity and accuracy than used single parameter which is CSA inlet of highest sensitivity ,specificity and accuracy.

We found that combination of CSA inlet and wrist- forearm ratio (swelling ratio) will have highest sensitivity 71.5%and accuracy 63% than CSA inlet alone which have a sensitivity 93% and accuracy 32% and our result correlate with. **Hobson-Webb , (2008)** reported that a wrist-to-forearm ratio ≥ 1.2 gave 100% sensitivity for diagnosing CTS, while using only the median nerve area at the wrist resulted in a sensitivity of 45–93%.

Conclusion

From all above discussed results we will establish and recommend a scheme for diagnosis of CTS based on ultrasound. Lastly this study used US with Doppler study to diagnose CTS ,US is easy ,rapid ,less costly and more comfortable method to patients suspected CTS and so it can be preliminary in diagnosis of CTS and grading.

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