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Can High Resolution Ultrasonography be Used in the Diagnosis of Ulnar Nerve Neuropathy in Diabetic Patients?

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Abstract

Background: Diabetic peripheral neuropathy (DPN) is the most common complication of diabetes. Early diagnosis of DPN is essential for prognosis and treatment because early treatment decreases both short-term and long-term morbidity.

Aim of Study: The aim of this study is to analyze the diagnostic value of high-resolution ultrasound of the ulnar nerve in diabetic patients with symptoms and signs of peripheral neuropathy and diabetic patients without peripheral neuropathy (DWPN)by measuring the cross-section area and correlating the results with nerve conduction parameters.

Patients and Methods: This is a prospective study highlighting the role of NCS and US in the detection of ulnar nerve measurements in diabetic patients The study included patients with diabetes; 60 with peripheral neuropathy and 40 without peripheral neuropathy along with 30 control patients who attended our ultrasound radiology imaging unit during the period from December 2021 to August 2022.

Results: We found that there is a statistically significant increase in the cross-sectional area (CSA) among diabetic patients with DPN in comparison with control subjects (<0.0001) as well as in comparison with diabetic patients without peripheral neuropathy (<0.0001). Also, we found a statistically significant negative correlation between the ulnar nerve CSA and nerve conduction parameters at most of the measurement sites (0.04-0.002).

Conclusion: High-resolution ultrasonography (US) could detect early diabetes mellitus with peripheral neuropathy and could assess the prevalence of subclinical neuropathy thus considered a valuable modality in the diagnosis of diabetic peripheral neuropathy. Moreover, ultrasound is a safe and accurate method for detecting DPN and separating it from DWPN.

Key Words: *Diabetic peripheral neuropathy — Ultrasound — Cross-sectional area — Nerve conduction study.*

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Introduction

DIABETES is a heterogeneous group of metabolic diseases characterized by hyperglycemia due to defects in insulin secretion, insulin action, or both. The chronic hyperglycemia of diabetes results in long-term damage, dysfunction, and failure of different organs, such as the eyes, kidneys, nerves, heart, and blood vessels [1].

Diabetic neuropathy is a syndrome that includes both the somatic and autonomic divisions of the peripheral nervous system. And so, neuropathy is a major factor in abnormal wound healing, erectile dysfunction, and cardiovascular dysfunction. Advanced neuropathy caused by nerve fiber deterioration in diabetes is characterized by altered sensitivities to thermal thresholds and vibrations, which leads to loss of sensory perception. Pain is also seen

List of Abbreviations:

AE : Above Elbow.
AUC : Area under curve.
BE : Below Elbow.
BMI : Body mass index.
CI : Confidence interval.
CMAP : Compound Muscle Action Potential.
CV : Conduction Velocity.
DML : Distal Motor Latency
DPN : Diabetic with Peripheral Neuropathy.
DWPN : Diabetic without Peripheral Neuropathy.
DSA : Distal Sensory Amplitude.
GT : Guyon's Tunnel.
ICT : Inlet of Cubital Tunnel.
NCS : Nerve Conduction Studies.
NCV : Nerve Conduction Velocity.
OCT : Outlet of Cubital Tunnel.
OLE : Olecranon.
ROC : Receiver operating curve.
UME : Upon Medial Epicondyle.
US : Ultrasonography.

in some diabetic individuals without clinical evidence of neuropathy (10-20%), which can seriously impede quality of life. Other than the optimization of glycemic control and management of neuropathic pain, there are no major therapies approved in either the United States or Europe for the treatment of diabetic neuropathy **[2].**

Accurate diagnosis of peripheral neuropathies is possible with the use of clinical assessment, in addition to laboratory findings and electrophysiological tests **[3].** The identification of early DPN allows for proactive multi-factorial intervention to limit the progression of nerve damage **[4].**

Nerve conduction studies (NCS) are noninvasive, sensitive, and objective procedures **[5]** which is one of the gold standard techniques for diagnosing DPN **[6].** But it is relatively expensive and therefore not feasible for all patients. Also, NCS together with signs and symptoms are not sensitive to identifying subclinical DPN **[7].** Although NCS findings are useful as endpoints in clinical trials and in documenting the severity of DPN, the results of these studies have inherent variability for technical and physiological reasons. Such variability does not impart significant asymmetry in reference subjects, but it is unknown whether the symmetry of NCS findings is maintained in different stages of DPN **[8].** Therefore, international scientific associations do not recommend the performance of NCS, as a routine method for diagnosis **[9].** In recent years with improved technology, the US has been regarded as a promising inexpensive, reproducible, and more comfortable diagnostic tool, and it can be utilized as an alternative method for detecting neuropathies **[5].**

Aim of the work: The aim of this study is to analyze the diagnostic value of high-resolution ultrasound of the ulnar nerve in diabetic patients with symptoms and signs of peripheral neuropathy and diabetic patients without peripheral neuropathy by measuring cross-section area and correlating it with nerve conduction parameters.

Patients and Methods

Patients:

The current study has been approved by our university Research and Ethical Committee. Informed consent was taken from the patients and has been approved by the ethical committee. We obtained IRB approval from our research and ethical committee (Protocol number MS-158-2021).

This is a prospective study highlighting the role of NCS and US in the detection of ulnar nerve measurements in diabetic patients.

The study included patients with diabetes; 60 with peripheral neuropathy and 40 without peripheral neuropathy along with 30 control patients who attended our ultrasound radiology imaging unit during the period from December 2021 to August 2022. No specific age group selection was applied.

The mean age of the DPN group was 57.1±9.9 years, of DWPN was 46±8.7 and that of the control group was 53.6±12.6. Females were 36 (27.7%), and males were 94 (72.3%) of the included patients. Among cases, the mean duration of diabetes was 19.8 years in the DPN group and 8.7 in the DWPN group. 52 (52%) patients were on Insulin, 36 (12%) patients on oral hypoglycemic treatment, and 12 (12%) patients on oral hypoglycemic and insulin

Detailed history taking was obtained. All diabetic patients included in our study were asked about the duration of diabetes mellitus, symptoms of diabetic peripheral neuropathy as numbness, tingling, weakness, foot pain, or ataxia and any associated chronic disease like hypertension.

The referring physician was asked about signs in keeping with ulnar neuropathic pattern in the form of abnormal sensations in the little finger and part of the ring finger, usually on the palm side, weakness, loss of coordination of the fingers, claw-like deformity of the hand and wrist as well as pain, numbness, decreased sensation, tingling, or burning sensation in the areas controlled by the nerve.

Patients with peripheral neuropathy other than diabetic peripheral neuropathy. (i.e., Guillain-Barre syndrome, chronic inflammatory demyelinating polyneuropathy and vasculitis, traumatic nerve injuries, and cubital tunnel syndrome), were excluded from our study.

Methods:

Ultrasound technique:

Ultrasound cross-sectional area and the maximum thickness of the ulnar nerve were measured using Toshiba Aplio 500 with a linear probe of 7-14 MHz frequency.

Patient positioning:

All US examinations were performed while the subjects were lying in the sitting position. The forearms and hands were positioned in slight elbow flexion. The position of all participants was standardized to allow comparison and to avoid any movement that increased soft-tissue pressure. The subjects were cautioned not to move their hands or forearms during the US examination. The ultrasound was performed by two experienced consultant radiologists, with more than 10 years' experience in musculoskeletal ultrasound imaging.

Cross-section area measurements:

The CSA of the ulnar nerve was measured at three sites upon the medial epicondyle (UME), 6cm from the wrist crease, and the Guyon tunnel (GT). The CSA of the ulnar nerve was measured by tracing along the hyperechoic rim of the nerve. Also,

the maximum thickness of the nerve fascicles was measured at the same three sites.

Nerve conduction studies:

Patients included in the study were subjected to NCS in the neuro-physiology department prior to US examination and the operator was blinded from the results during the study.

The following nerve conduction protocol was followed:

(A) Motor nerve conduction study of the ulnar nerve, with recording from the abductor digiti minimi and stimulation at the wrist, below the elbow (3-4cm distal to the medial epicondyle) and above the elbow (10cm from the below elbow stimulation site).

(B) Sensory conduction study of the ulnar nerve with recording from the ring and little fingers, and stimulation at the wrist, below the elbow and above the elbow.

(C) F-wave study of the ulnar nerve to assess the proximal roots.

The patient was diagnosed as having ulnar neuropathy if the motor nerve conduction velocity (NCV) or distal sensory amplitude (DSA) were reduced or if the distal motor latency (DML) was increased.

Results

A total of 100 patients (200 nerves) with diabetes were recruited in the current study, 60 (45 males and 15 females) of them had clinical signs and symptoms of DPN (group I) with mean age (of 57.1±9.9) and 40 (29 males and 11 females), DWPN (group II) with a mean age of 46±8.7, along with 30 (20 males and 10 females) controls (group Ill) with mean age 53.6±12.6. The mean duration of diabetes was 19.8 and 8.7 years in the group I and II respectively (Table 1).

Ulnar nerve measurements (CSA and the maximum thickness of the nerve) were compared between the right and left sides of ulnar nerves in the control group and showed no statistically significant difference at the measuring sites except for the maximum thickness of nerve fascicles UME and GT (p-value.05 and <0.0001, respectively) where there was a significant increase in the left ulnar nerve maximum thickness UME and the GT in comparison to the right side. Also, no statistically significant difference was shown between males and females apart from the maximum thickness of nerve fascicles 6 cm upon wrist where the maximum thickness was higher in the males than in females in control groups (Table 2).

No statistically significant difference was found between males and females apart from the maximum thickness of nerve fascicles 6cm upon wrist as well as upon the medial epicondyle where the maximum thickness was higher in males than in females in DPN and DWPN groups (Table 3, Figs. 1,2).

A high statistically significant difference was found between the control group (group III) and DPN group (group I) (Figs. 1,2) regarding the ulnar nerve CSA and maximum thickness of nerve fascicles at different measuring sites, except for the maximum thickness of nerve fascicles 6cm upon the wrist. Also, a statistically significant difference was found between the control group (III) and the DWPN group (group II) (Fig. 3) regarding the ulnar CSA at the GT as well as the maximum thickness of nerve fascicles at different measuring sites. A high statistically significant difference was found between the DPN group (II) and the DWPN group (group II) regarding ulnar nerve CSA UME and 6cm from the wrist (Table 4).

No statistically significant correlation was found between ulnar nerve measurements by US and nerve conduction parameters among the DPN group; apart from statistically significant negative correlation between motor NCV from above elbow (AE) to below elbow (BE) as well as the compound muscle action potential (CMAP) above elbow on one hand and the ulnar nerve CSA UME and 6cm above wrist crease. Also, statistically significant negative correlation was found between DSA above elbow and ulnar nerve CSA 6cm above wrist crease in the same group (Table 5).

No statistically significant correlation was found between ulnar nerve measurements and nerve conduction parameters among the group of patients with DWPN (Table 6).

Statistically significant negative correlation was found between CMAP above elbow as well as the DML above elbow and disease duration in patients with DPN. Also, a high statistically significant negative correlation was found between motor NCV from below elbow to wrist and CMAP below elbow on one hand and disease duration on the other hand in patients with DWPN. No correlation was found between the ulnar nerve CSA measurements at different sites and disease duration in both groups (Table 7).

Receiver operating curve (ROC) analysis was performed to evaluate the usefulness of NCS for the diagnosis of ulnar neuropathy among diabetic patients. Motor NCV AE to BE at the cut-off value of <52, showed sensitivity of 100% and specificity of 85% with areas under curve (AUC) was 0.950 (p<0.001, 95% CI 0.908-0.992), motor NCV BE to wrist at the cut-off value of <49.5, showed sensitivity of 96.7% and specificity of 100% with AUC was 0.999 (p<0.001, 95% CI 0.997-1.001). CMAP AE at the cut-off value of <6.5, showed sensitivity of 55% and specificity of 85% with areas under curve (AUC) was 0.647 (p43.007, 95% CI 0.540-0.754),

CMAP BE at the cut-off value of <6.5, showed sensitivity of 51.7% and specificity of 85% with AUC was 0.624 (p=0.026, 95% CI 0.515-0.733). DSAAE at the cut-off value of <17.5, showed sensitivity of 100% and specificity of 95% with areas under curve (AUC) was 0.969 (p<0.001, 95% CI 0.921-1.018), DSA BE at the cut-off value of <17.5, showed sensitivity of 100% and specificity of 95% with AUC was 0.970 (p<0.001, 95% CI 0.922-1.018). (Fig. 6).

A separate ROC was performed to evaluate the usefulness of DML and the significant ulnar nerve measurements by US for the diagnosis of ulnar neuropathy among diabetic patients & that of DML showed a cut-off value of >3.1, showed a sensitivity of 86.7% and specificity of 52.5% with areas under the curve (AUC) was 0.762 (p<0.001, 95% CI 0.669- 0.855). Mean CSA ME showed a cut-off value of >7.5, showed a sensitivity of 86.7% and specificity of 90% with areas under the curve (AUC) was 0.963 (p<0.001, 95% CI 0.34-0.993) while CSA at the wrist showed a cut-off value of >8.5, showed a sensitivity of 73.3% and specificity of 100% with areas under the curve (AUC) was 0.945 (p<0.001, 95% CI 0.906-0.984). (Fig. 7).

Statistical analysis:

Statistical analysis was conducted using SPSS 22nd edition, qualitative variables were presented in frequency and percentages, and it was compared between groups using Fisher exact test. Quantitative variables were presented in mean, standard deviation, and range, and mean comparison was conducted using the student t-test for parametric data and the Mann-Whitney U test for non-parametric data. Any p-value <0.05 was considered significant. The calculated sample size was 50 patients accounting for a 10% dropout rate. ROC curve was constructed with area under curve analysis performed to detect best cutoff value of significant nerve conduction parameters & ulnar nerve measurements by US for detection of ulnar neuropathy.

Table (1): Demographics and diabetic status of the included groups.

Characteristics	DPN (group I)	DWPN (group II)	Control (group III)
N	60	40	30
Age (years)	57.1±9.9	46±8.7	53.6±12.6
Sex (male/female)	45/15	29/11	20/10
Height (cm)	164.1±7.1	160.3± 6.2	163±8.9
Weight (kg)	54.1±6.1	53.4±7.6	50.1±6.8
Handiness (right/left)	60/60	40/40	30/30
Duration of DM (years)	19.8	8.7	

Table (2): Comparison of ulnar nerve measurements between both sides & different gender in the control group.

Control group	CSA ME (mm^2)	CSA 6cm wrist (mm^2)	CSA Guyon (mm^2)	Max thickness of nerve fascicles upon medial epicondyle (mm)	Max thickness of nerve fascicles 6 cm upon wrist (mm)	Max thickness of nerve fascicles upon Guyon (mm)
RT side	5.2±0.8	6 .2±1 .3	4.4±0.9	2.6±0.2	2.1±0.2	1.9±0.3
LT side	5.2±0.8	6 .2±1 .3	4.1±0.8	2.7±0.2	2.1±0.2	2.5±0.5
p-value	1	1	0.1	0.05	1	<0.0001
Male	5.2±0.8	6 .4±1 .1	4.2±0.7	2.7±0.7	2.2±0.7	2±0.8
Female	5.4±1.6	5 .8±1 .4	4 .5±1.6	2.4±0.5	1.8±0.6	1.8±0.6
p-value	0.5	0.07	0.3	0.06	0.02	0.2

Table (3): Comparison of ulnar nerve measurements between different genders among DPN and DWPN groups.

Group	CSA ME (mm^2)	CSA 6cm wrist (mm^2)	CSA Guyon (mm^2)	Max thickness of nerve fascicles upon medial epicondyle (mm)	Max thickness of nerve fascicles 6 cm upon wrist (mm)	Max thickness of nerve fascicles upon Guyon (mm)
DPN:						
Male	10.5±2.4	9±3.1	6±1.5	3.3±0.2	2.6±0.2	2.6±0.6
Female	10.3±2.2	8.9±3	5 .8±1.4	2.7±0.1	2±0.3	2.4±0.5
p-value	0.5	0.07	0.3	0.03	0.03	0.2
DWPN:						
Male	5.79±1.4	6.1±1.15	5 .6±1.31	3±0.3	2.5±0.4	2.5±0.5
Female	5.68±1.4	6±1.12	5.5±1.1	2.5±0.2	2±0.2	2.4±0.6
p-value	0.5	0.06	0.3	0.02	0.02	0.2

Table (4): Comparison of ulnar nerve measurements among the included groups.

Group	N	CSA ME (mm^2)	CSA 6cm wrist (mm^2)	CSA Guyon (mm^2)	Max thickness of nerve fascicles upon medial epicondyle (mm)	Max thickness of nerve fascicles 6 cm upon wrist (mm)	Max thickness of nerve fascicles upon Guyon (mm)
Control (III)	30	5 2±0 .8	62±1.2	43±1.2	2.6±02	2.1±0.2	1 .9±0 3
DPN (I)	60	10.5±2.4	10.1±3.7	6±1.5	2.9±02	2 3±0 .3	2 .7±0 .6
p-value		<.0001	<0.0001	<0.0001	0.001	034	0 .0001
DWPN (II)	40	5.7±1.3	6.1±1.3	5.6±1.3	2.8±02	2 2±0 .2	2.6±0.6
p-value		0.06	0.7	0 .0001	0.0001	0.04	< 0.0001
p-value between DPN and DWPN		p<0.0001	p<0.0001	l'1.17	1:1.016	1:1.06	=0.41

Table (5): Correlation between ulnar nerve measurements & nerve conduction parameters among the DPN group.

Nerve conduction parameters DPN group	CSA 'VIE		CSA 6cm wrist		CSA Guyon	
	r	p-value	*r*	p-value	*r*	p-value
Motor NCV AE to BE	- 0.3627	.004	- 028	.03	- 0.1	0.4
Motor NCV BE to wrist	- 0.106	0.4	- 0.007	0.9	- 02	.12
CMAP AE	- 0.46	.0002	- 0.4	.001	- 0.15	025
CMAP BE	- 0.25	0.05	- 0.16	02	- 025	0.05
CMAP WRIST	- 0.33	0.1	- 03	0.1	- 0.18	0.16
Distal motor latency	0.009	.94	0.05	0.7	0.07	0.5
Distal sensory amplitude AE	- 0.23	0.07	- 027	0.03	- 0.14	028
Distal sensory amplitude BE	- 0.130	.32	- 0.13	03	- 0.08	0.54

Table (6): Correlation between ulnar nerve measurements & nerve conduction parameters among the group with DWPN.

Nerve conduction parameters DWPN group	CSA ME		CSA 6cm wrist		CSA Guyon	
	r	p-value	*r*	p-value	*r*	p-value
Motor NCV AE to BE	-0.004	0.98	-0.10	0.35	-0.01	0.95
Motor NCV BE to wrist	-0.19	024	-036	0.22	-022	.17
CMAP AE	-0.12	.46	-0.16	32	-022	0.17
CMAP BE	-0.12	0.46	-0.17	0.29	-021	0.19
CMAP WRIST	-0.15	035	-023	0.15	-0.11	0.49
Distal motor latency	0.38	.15	0.40	0.10	0.37	0.18
Distal sensory amplitude AE	-0.14	0.8	-0.05	0.75	-0.11	0.49
Distal sensory amplitude BE	-0.12	0.46	-0.05	0.75	-0.09	0.58

Table (7): Correlation between nerve conduction parameters among the DPN group & those with DWPN.

Parameters	Disease duration in DPN		Disease duration in DWPN	
	r	p-value	*r*	p-value
Motor NCV AE to BE	- 0.15	0.25	- 0.54	.0003
Motor NCV BE to wrist	- 0.21	0.10	- 0.008	0.96
CMAP AE	- 0.59	0.002	- 0.008	0.96
CMAP BE	- 0.006	0.96	- 0.98	<.00001
CMAP WRIST	- 0.11	0.40	- 0.21	0.19
Distal motor latency	0.61	0.001	0.16	032
Distal sensory amplitude AE	- 0.15	0.25	- 0.08	0.62
Distal sensory amplitude BE	- 0.06	0.64	- 0.14	038
CSA 'VIE	020	0.12	0.04	0.80
CSA 6cm wrist	0.19	0.14	0.14	0.46
CSA Guyon	- 0.023	0.07	- 0.019	90

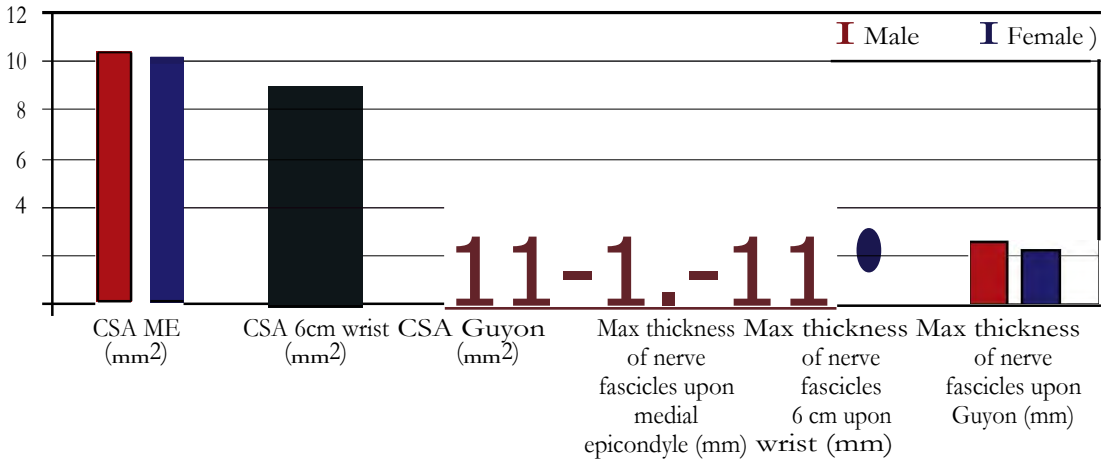

Fig. (1): Comparison of ulnar nerve measurements between different genders among DPN group.

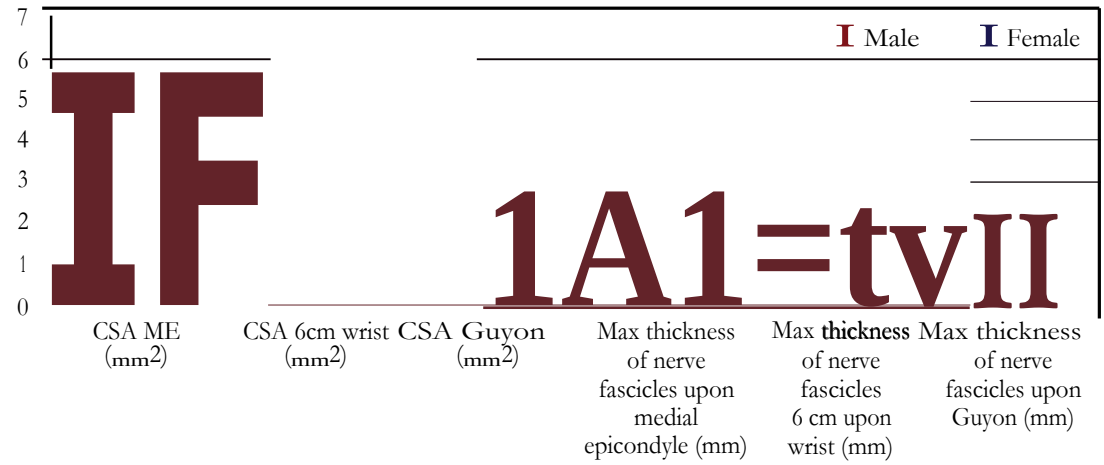

Fig. (2): Comparison of ulnar nerve measurements between different genders among DWPN group.

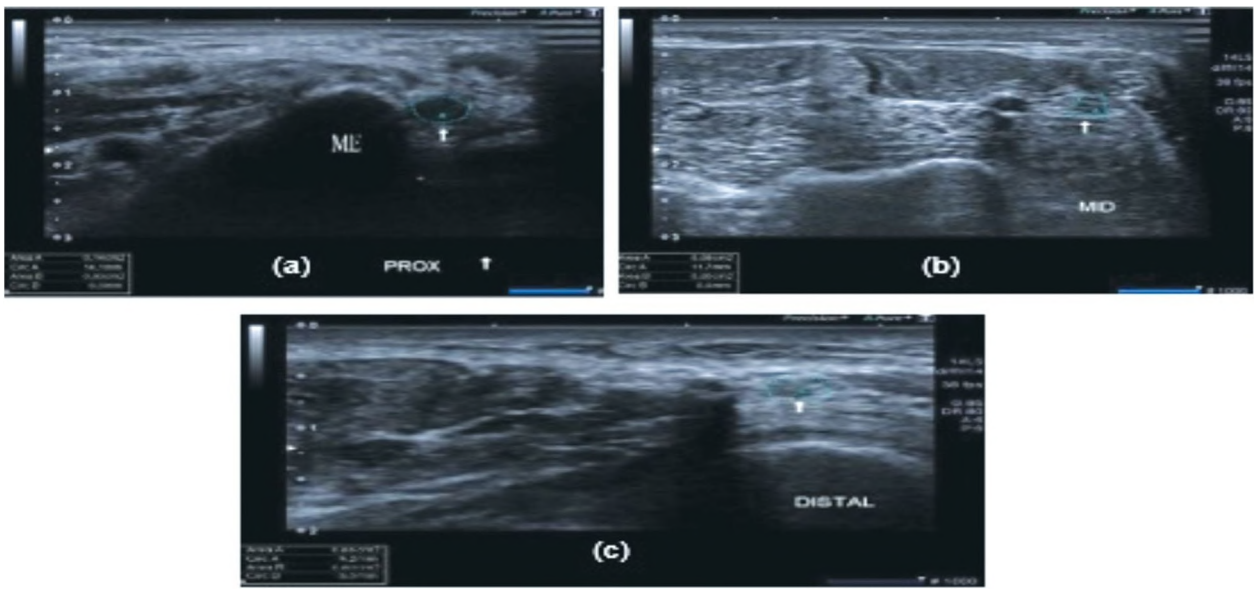

Fig. (3): 58-year- old femalepatient diabetic for 15 years with clinical signs of peripheral neuropathy showing increased CSA of the right ulnar nerve at all measured sites. (a) The right ulnar nerve upon medial epicondyle in relation to the medial epicondyle (ME) with its CSA (A) measuring about 14 mm^2. (b)The right ulnar nerve upon 6 cm upon wrist crease with its CSA (A) measuring about 8 mm^2. (c) The right ulnar nerve upon Guyon canal with its CSA (A) measuring about 6 mm2.

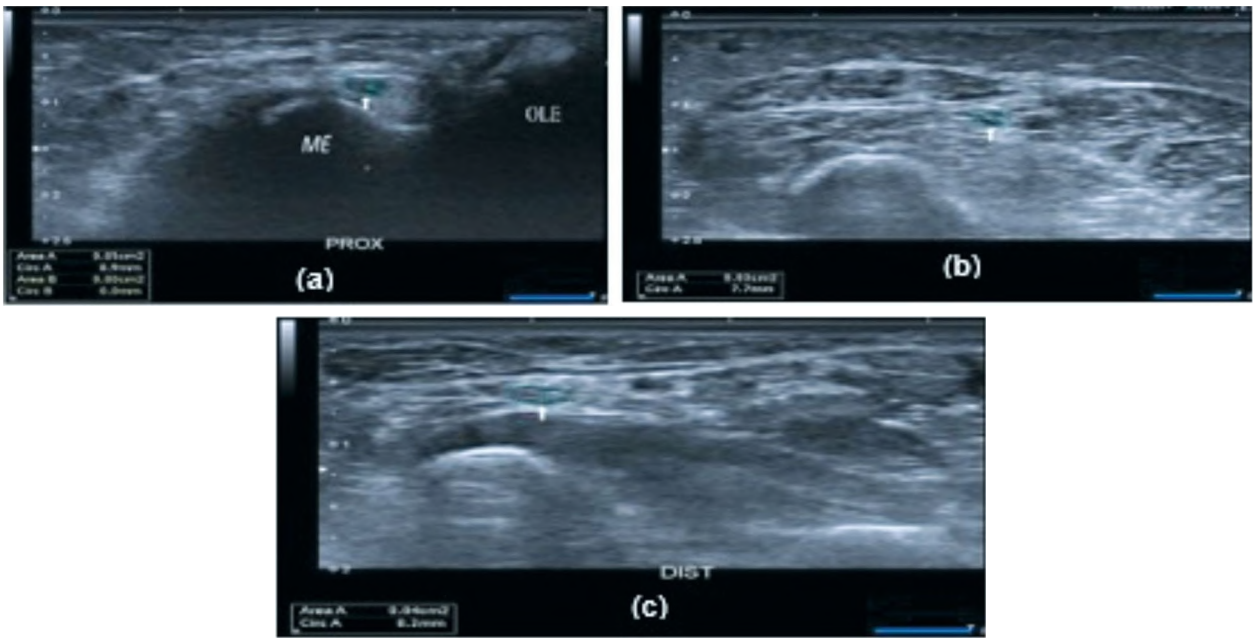

Fig. (4): 55- year- old femalenon-diabetic patient. (a) The right ulnar nerve upon medial epicondyle in relation to the medial epicondyle (ME) and olecranon (OLE) with its CSA (A) measuring about 5 mm^2. (b) The right ulnar nerve 6 cm upon wrist crease with its CSA (A) measuring about 3 mm^2. (c) The right ulnar nerve upon Guyon canal with its CSA (A) measuring about 4 mm^2.

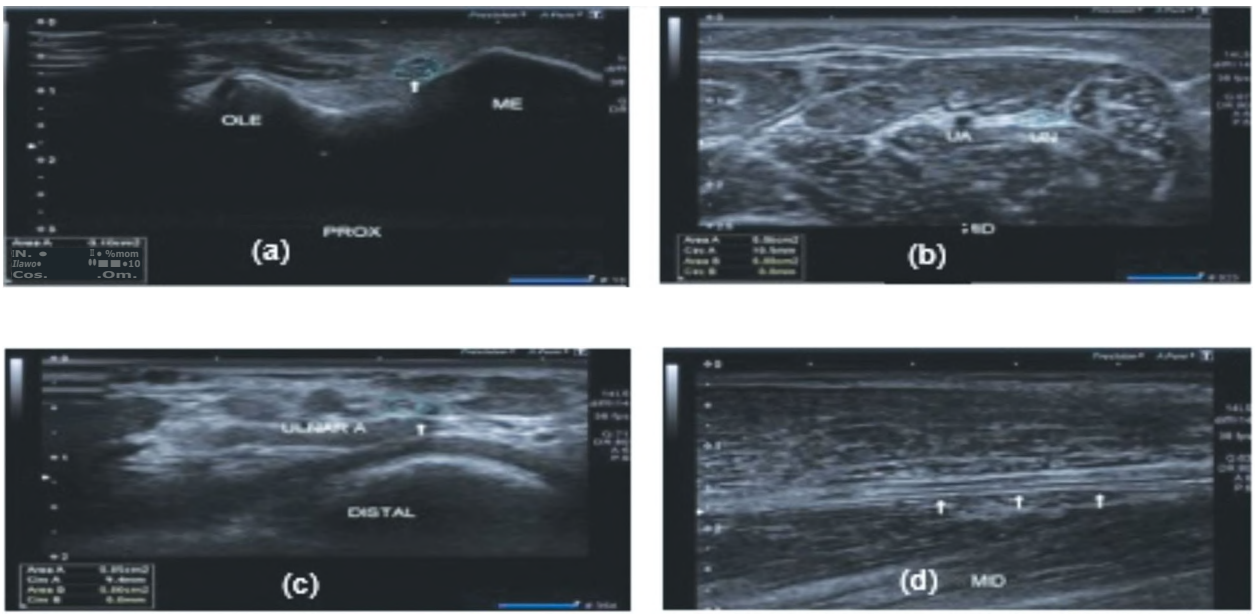

Fig. (5): 66—year-old male patient diabetic for 30 years without peripheral neuropathy showing increased CSA of the right ulnar nerve upon the medial epicondyle. (a) The right ulnar nerve upon medial epicondyle in relation to the medial epicondyle (ME) and olecranon (OLE) with its CSA (A) measuring 10 mm2 (b) The right ulnar nerve upon 6 cm upon wrist crease with its CSA (A) measuring about 6 mm2 (c) The right ulnar nerve upon Guyon canal with its CSA (A) measuring about 5 mm^2. (d) B-mode image shows the longitudinal axis of the right ulnar nerve.

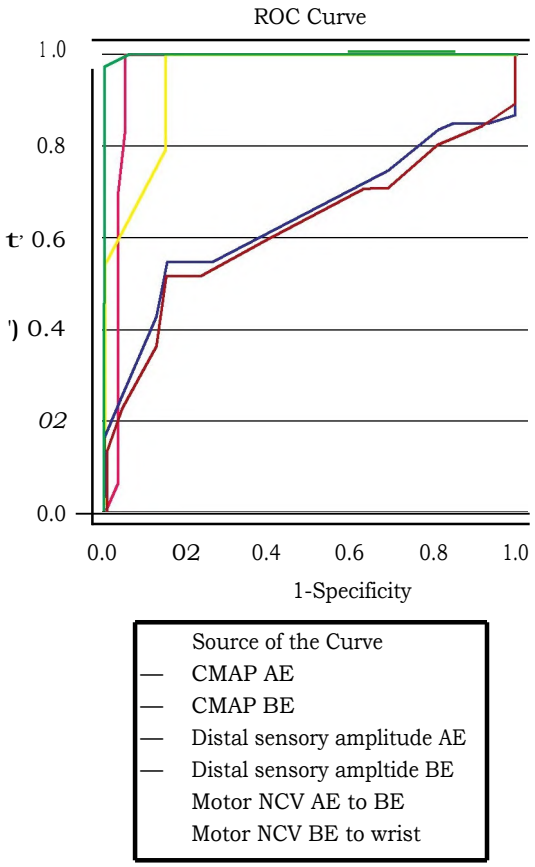

Fig. (6): ROC curve analysis for the evaluation of nerve conduction studies in DPN.

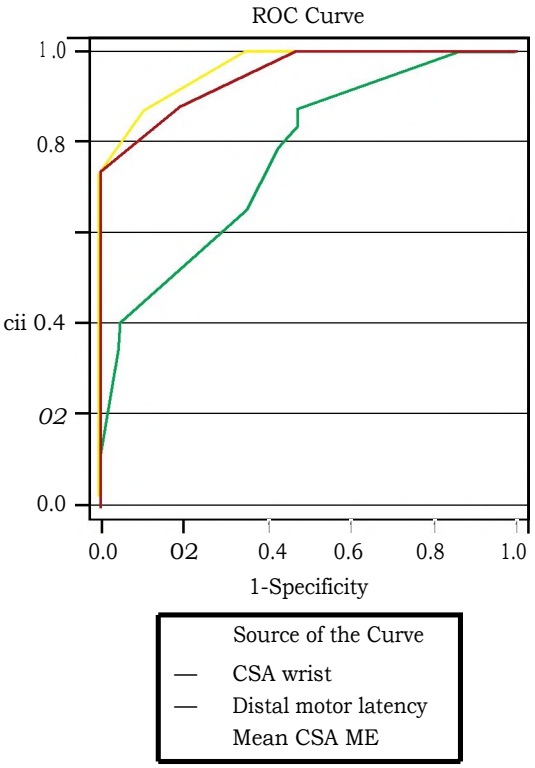

Fig. (7): ROC curve analysis for the evaluation of DML and some of the ulnar nerve measurements by US in DPN.

Discussion

Diabetic peripheral neuropathy occurs in up to 50% of individuals with diabetes and is the most common cause of neuropathy worldwide [10]. The development of diabetic neuropathy is strongly related to the duration of the disease and causes significant morbidity and disability, with manifestations such as pain, ulcer formation, poor sleep, and depression **[11].**

NCS sometimes fail to localize the lesion and cannot evaluate the architecture or the anatomical aspect of the nerves and their surrounding structures. Moreover, they are sometimes accompanied by false-negative and false-positive results **[12].**

We conducted a case-control study aiming to analyze the diagnostic value of high-resolution US of the ulnar nerve in diabetic peripheral neuropathy by measuring the cross-section area and thickness of the ulnar nerve and comparing the results with diabetic patients with no clinical signs and symptoms of peripheral neuropathy as well as normal healthy individuals.

A total of 100 patients with diabetes were recruited in the current study, 60 of them had clinical signs and symptoms of DPN (group I) with a mean age of (57.1±9.9) and 40 DWPN (group II) with a mean age of 46±8.7. These findings were consistent with several studies that demonstrated a high incidence of DPN among old age groups between 50-60 years (13 and 14).

The mean duration of diabetes was 19.8 and 8.7 years in groups I and II respectively. These findings were consistent with a study conducted on 125 patients with DPN, which stated that the onset of DPN was reported at the age of 50 years old among the included patients with a mean of 8 years from the onset of diagnosis **[14].** Another study showed that 9 years was the mean duration for the development of DPN **[15].**

We found high statistically significant negative correlation between the disease duration & BE amplitude of ulnar nerve CMAP in patients with **DWPN** in contrary to the study conducted by Bastawy EM, et al., **[16]** that showed no significant correlation between the disease duration and BE amplitude of ulnar nerve CMAP. Also, in our study no correlation was found between the ulnar nerve CSA measurements at different sites and disease duration in both groups which agreed with results of the same study **[16].**

Ulnar nerve measurements (CSA and the maximum thickness of the nerve) were compared between the right and left sides of ulnar nerves in the control group and showed no statistically significant difference at the measuring sites except for the max-

imum thickness of nerve fascicles UME and GT (p-value=0.05 and <0.0001, respectively). These findings were almost consistent with a cross-sectional study that included 60 arms of volunteers to assess normal average CSA at 7 predominate sites along the entire course of the nerve. The results of this study showed that there is no significant difference between dominant and non-dominant hands in CSA among the included healthy normal individuals **[17].**

Also, no statistically significant difference was shown between males and females apart from the maximum thickness of nerve fascicles 6cm upon wrist where the maximum thickness was higher in the males than in females. These findings were almost consistent with a study that included 100 volunteers to assess the normal CSA, the ulnar nerve CSA showed no statistically significant difference between males and females with p-values 0.19 and 0.05 at groove and wrist sites **[18].**

However, these findings were disagreeing with a study conducted on 100 healthy individuals and showed that ulnar CSA was significantly thicker among males compared to females, as well there was a statistically significant difference in mean CSA based on the age group 18-40 years versus 40 years old **[19].** Populations with different body mass index (BMI) values may account for some of the differences observed, as the body mass index (BMI) did influence the CSA in some nerve measurements. Also, the age distribution needs to be considered, because the ages of the published cohorts are variable [18].

No statistically significant difference was found between males and females apart from the maximum thickness of nerve fascicles 6cm upon wrist as well as upon the ME where the maximum thickness was higher in the males than in females in DPN and DWPN groups. This may be due to the less fat content in the medial aspect of the elbow and wrist in males compared to females involved in this study. Also, a smaller tubercle on the coronoid process in females compared to males provide another likely compression site for the ulnar nerve at the elbow **[20].**

A high statistically significant difference was found between the control group (group DI) on one hand and DPN and DWPN groups (group I and II) regarding the ulnar nerve CSA and maximum thickness of nerve fascicles at different measuring sites. These findings agreed with a study done by Chen J., et al., **[13]** which revealed that CSAs were larger in the DPN group in three sites (an inlet of the cubital tunnel (ICT), the outlet of the cubital tunnel (OCT) and GT compared with those in the control group).

In this study, a high statistically significant difference was found between groups DPN (I) and DWPN (II) regarding ulnar nerve CSA UME and 6cm from the wrist. This agrees with a study done by Chen J., et al., **[13]** which revealed that the mean CSA of the nerve in DPN is greater than that in DWPN at some sites.

In our study, we found among the DPN group a statistically significant negative correlation between motor NCV from AE to BE as well as the CMAP AE on one hand and the ulnar nerve CSA UME and 6cm above wrist crease on the other hand. This goes with the results of the study conducted by Bastawy EM., et al., **[16]** which showed a negative correlation between the maximum ulnar nerve CSA/mid-forearm CSA ratio and CMAP amplitude and conduction velocity (CV).

Also, a statistically significant negative correlation was found between DSA AE and ulnar nerve CSA 6cm above wrist crease in the same group, which agrees with a study done by Bastawy EM., et al., **[16]** which found a statistically significant negative correlation between ulnar CSA at BE and ulnar groove sites with distal amplitude.

The main limitations of our study were the small sample size, assessment of correlation between diabetes and severity of DPN, as well, assessment of the duration till the onset of DPN. Nonetheless, we didn't assess the correlation between other comorbidities and associated neurological diseases as a confounder of nerve thickness changes.

Conclusion:

High-resolution ultrasonography could detect early diabetes mellitus with peripheral neuropathy and could assess the prevalence of subclinical neuropathy thus considered a valuable modality in the diagnosis of diabetic peripheral neuropathy. Moreover, ultrasound is a safe and accurate method for detecting DPN and separating it from DWPN.

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هل يمكن استخدام الموجات فوق الصوتية عالية الدقة في تشخيص اعتلال العصب الزندى فى مرضى السكرى؟

تقدر منظمة الصحة العالمية أن أكثر من ١٨٠ مليون شخص فى جميع أنحاء العالم يعانون من مرض السكرى. اعتلال الأعصاب السكرى هو أكثر المضاعفات طويلة الأمد شيوعاً لمرض السكرى ويؤثر على أكثر من ٥٠٪ من المرضى وهو سبب رئيسى للمراضة وزيادة الوفيات. يبدأ تشخيص اعتلال االعصاب السكرى بتاريخ دقيق للأعراض الحسية والحركية. يمكن أن يؤثر على أى جزء من الجهاز العصبى البعيد أو القريب أو الكبير أو الصغير أو الحركى أو الحسى أو الجسدى أو اللاإرادى. يسبب اعتلال الأعصاب السكرى المتقدم مضاعفات خطيرة، مثل تقرحات القدم السكرية، والغرغرينا، وكلها تؤدى إلى تدهور نوعية حياة مرضى السكرى، وبالتالى فإن الكشف المبكر عن الخلل العصبى مهم لتوفير الرعاية المناسبة لمرضى اعتلال الأعصاب السكرى.

يعتمد التشخيص الدقيق لاعتلالات الأعصاب المحيطية فى المقام الأول على الأعراض المميزة السريرية ويتم تأكيده من خلال التقييم السريرى ودراسة التوصيل العصبى. فى السنوات الأخيرة، نظراً للتحسن التكنولوجى، ظهرت الموجات فوق الصوتية للأعصاب المحيطية كأداة إضافية فى تقييم اضطرابات الأعصاب الطرفية. لقد تم اعتباره أسلوباً غير مكلف وقابل للتكرار وأكثر راحة، ويمكن استخدامه كطريقة بديلة للكشف عن الاعتالالت العصبية.

أظهرت العديد من دراسات الموجات فوق الصوتية التي تم إجراؤها تضخم مناطق المقطع العرضى من الأعصاب فى مرضى اعتلالات الأعصاب المحيطية مقارنة بمجموعة التحكم. قامت معظم الدراسات بفحص الأعصاب الطرفية فى المواقع المعرضة للخطر، مثل العصب المتوسط فى النفق الرسغى والعصب الظنبوبى فى الكعب الإنسى فى مرضى السكرى.

حتى الآن، لايوجد سوى عدد قليل من الدراسات التي قيمت أعصاب الأطراف العلوية فى مواقع متعددة فى مرضى السكرى. وبالتالى، كان هدف هذه الدراسة هو تقييم فائدة الموجات فوق الصوتية للأعصاب الطرفية للطرف العلوى لتشخيص الاعتلال العصبى لدى مرضى السكرى.

وفقاً لذلك قمنا فى هذه الدراسة بتضمين٦٠ مريضاً مصاباً باعتلالات السكرى و٤٠ مريضاً غير مصاباً باعتلالات الأعصاب السكرى، وتم تجنيد مجموعة ضابطة مكونة من ٣٠ مريضاً.

وقد تم أخذ التاريخ؛ مدة مرض السكرى، التاريخ المرضى الذى يشير إلى مضاعفات مرض السكرى. قياسات المنطقة المقطعية للعصب الزندى باستخدام Aplio Toshiba ٥٠٠ مع مسبار خطى بتردد ١٤-٧ ميجا هرتز وتم ربطتلك النتائج مع معلمات التوصيل العصبى.

تم العثور على دلالة إحصائية فى دراستنا فى منطقة المقطع العرضى للعصب الزندى بين مرضى اعتلال الأعصاب السكرى والمجموعة الضابطة كما وجدناعلاقة سلبية ذات دلالة إحصائية بين قياسات المنطقة المقطعية للعصب الزندى باستخدام الموجات فوق الصوتية النتائج مع نتائج معلمات التوصيل العصبى.

أظهرت الدراسة أن الموجات فوق الصوتية للأعصاب الطرفية للطرف العلوى يمكن أن تكون بمثابة أداة تشخيصية مفيدة فى تشخيص اعتلال الأعصاب السكرى.