Zagazig University Medical Journal
www.zumj.journals.ekb.eg

DOI 10.21608/zumj.2019.8099.1047 *Radiodiagnosis*

ORIGINAL ARTICLE

Role of High Frequency Ultrasound in Diagnosis of Entrapment Neuropathy at Wrist

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Submit Date: 06-03--2019
Revise Date: 01-06-2019
Accept Date: 08-06-2019

ABSTRACT

Background: Entrapment neuropathy at wrist is devastating and causes pain, numbness, and muscle weakness at the site of the nerve affected consequences of high-energy trauma. Immediate recognition of the presence of entrapment neuropathy at wrist and determination of causes can be avital component of the evaluation of the entrapment neuropathy. Ultrasound has become standard practice in entrapment neuropathy evaluation. MRI imaging also provide additional information not available from ultrasound scans, potentially improving the capacity for accurate diagnosis.The aim of the study is to assess the role of high frequency ultrasound with magnetic resonance in assessment of entrapment neuropathy at wrist. **Methods**: This study was carried out at Radio diagnosis Department, Zagazig University Hospitals, the present study was carried on 16 patients of entrapment neuropathy at wrist. Written informed consent was obtained from all participants and the study was approved by the research ethical committee of Faculty of Medicine, Zagazig University. The work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans. **Results:** The ultrasound and MRI axial source images were evaluated in terms of entrapment neuropathy at wrist was done for all patients. Ultrasound was able to detect entrapment neuropathy of 16 patients, with female predominance, the commonest cause was idiopathic in 7 cases. **Conclusion:** Our results indicate that the Ultrasound provides valuable, effective, and satisfactory modality in diagnosis information for the assessment of entrapment neuropathy at wrist. However, MRI has an advantage of soft tissue and to determine the exact point of nerve entrapment. For diagnosis in the case of ambiguous symptoms, it is useful for revealing the cause of nerve compression or elongation

INTRODUCTION

Nerve compression syndrome occurs when a nerve is squeezed or compacted. It typically occurs at a single location. Nerves in the torso, limbs, and extremities may be affected. Common symptoms include pain, numbness, and muscle weakness at the site of the nerve affected **[1].**

Most common type of nerve compression syndromes is Carpal tunnel syndrome. It occurs when the median nerve is compressed at the wrist. The median nerve extends from the upper arm to the thumb. At the wrist, it passes through a structure called the carpal tunnel. Excess pressure on the wrist may cause swelling, which can lead to carpal tunnel syndrome **[1].**

Rare Type is Guyon's canal syndrome. This syndrome affects the ulnar nerve and can impact function in the hand **[2].** Nerve compression syndrome is often caused by repetitive injuries. These injuries may occur in the workplace due to repeated movements related to the job duties. For example, repeated overextension of the wrist while typing on a keyboard, using a mouse, or playing the piano can lead to carpal tunnel syndrome.Accidents such as sprains, fractures, and broken bones can also cause nerve compression syndrome.In addition, certain medical conditions can trigger or make you more susceptible to nerve compression syndromes. These include:

- Diabetes,Autoimmune disorders, such as rheumatoid arthritis,Thyroid dysfunction,High blood pressure, Tumors and cysts,Pregnancy or menopause,Obesity,Congenital (birth) defects,Neural disorders,Repetitive injuries, accidents, and medical conditions may lead to:
- Reduced blood flow to the nerve
- Swelling in the nerve and surrounding structures
- Damage to the nerve's insulation (the myelin sheath)
- Structural changes in the nerve. **[٣]**

The development of high-frequency linear array transducers has led to an improvement in the resolution of ultrasonography (US), Therefore, US has been widely used, along with magnetic resonance imaging (MRI) and a nerve conduction study, in cases of common nerve compression syndromes or other neuropathic conditions including trauma **[4].**

Although MRI is very accurate and superior for imaging soft tissues and nerves, it is expensive, takes more time, and may have artifacts. More importantly, MRI may not be practical when a number of nerves need to be examined over the long course **[5].**

Although US has a few limitations like a small field of view, limited penetration, and an anisotropic effect when imaging nerve **[6].**

❖ The clinical staging was classified into 6 stages according to the historical-objective (Hi-Ob) clinical scale as follows;

Stage 0 NO Symptoms

Stage 1 Paresthesia only at night

Stage 2 Paresthesia even for short time in the daytime

Stage 3 Hypersthesia in the fingers of the median nerve distribution

Stage 4 Accompanying weakness or thenar muscle atrophy

Stage 5 Thenar muscle complete atrophy or paralysis

The second valuates the presence or absence of pain as dichotomous score obtained by the patients answer YES/NO. The Hi-Ob score was indicated by the number 1-5 that was linked to the letter P (P = PAIN) in patients who has pain **[7-8]**

METHODS:

From February 2018 to Octobre 2018, patients with entrapment neuropathy (2 males and 14 females with ages range from 26 years- to 58 years) were referred from Rheumatology and Orthopedics department to Radio-diagnosis department; Zagazig University Hospitals and recruited for this study. Written informed consent was obtained from all participants and the study was approved by the research ethical committee of Faculty of Medicine, Zagazig University. The work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

All patients were subjected to the following:

1- Full clinical history: Personal history (name, age, sex). Present history: The main clinical presentation of these patients

2-Radiological Imaging:

a. Ultrasonographic examination: All subjects were examined with GE p7 -ultrasound machine using a 12.5 MHz linear probe (Frame Rate up to 2399 F/s, Displayed Imaging Depth: 0 – 33 cm, Minimum Depth of Field: 0 – 1 cm (Zoom, probe dependent).

b. MRI examination: Each patient included in the study underwent imaging on a 1.5T superconducting **MAGNET (Achieva,Philips,Medical systems , Nertherland, B.V)** scanner on amovable tabletop and tabletop extender,generating alongitudina field of view of 200 cm at the radiology department of Zagazig University Hospital

Ultrasound Technique:

- The sonographic examinations were performed with the patient seated in a comfortable position facing the sonographer.
- The wrist is supported and placed in a slightly hyper extended position.
- The sonographic probe is placed at the level of the distal skin crease.
- In the axial plane, the ulnar artery is easily located medially and can ensure that the orientation of the axial images remains consistent.
- The sonographic beam needs to be perpendicular to the surface of the flexor tendons.
- The median nerve is seen as an elliptical shaped structure of hypoechoic nature located superficial to the echogenic flexor tendons. Its size, shape, echogenicity and relationship to the underlying tendons and the overlying retinaculum are noted.
- The ulnar nerve in the Guyon's tunnel is located intimately related to the ulnar artery at the level of the pisiform.
- Finger and wrist movements can be performed to assess the mobility of the median nerve.

Interpretation Data:

At the carpal tunnel:

a) Cross sectional area
- Calculated at the proximal carpal tunnel (scaphoid-pisiform level) by means of the ellipse formula [(maximum AP=antro-posterior diameter) × (maximum TS diameter) × (∏/4)]
- Normally, it should not exceed 10 mm^2.

b) Flattening of the median nerve
- Calculated as the ratio of the nerve's major to its minor axis (flattening ratio) (D1/D2).
- A normal flattening ratio should be less than 2.

c) Bowing of the flexor retinaculum
- The bulging of the ligament can be appreciated with US and is measured at the distal tunnel (hamate-trapezium level).
- Once the tubercle of the trapezium and the hook of the hamate are identified, a line is drawn tangential to them and the distance between this line and the most anterior portion of the transverse carpal ligament is calculated:
- Normally the distance is less than 4 mm.

d) Echo textural changes in the compressed median nerve
- The nerve becomes uniformly hypoechoic with loss of the fascicular pattern.

e) The amount of the synovial fluid and the presence or absence of masses should be noted MRI Technique

f) Patient position
- The patients were scanned in the supine position, with the arm by the side of the body
- The dorsum of the hand parallel to the coronal plane of the magnet.
- Circular coil was used (C 200) placed over the wrist joint and was wrapped and fixed by rubber bands.
- Protocol of MR imaging: Preliminary scout localizers in axial, coronal and sagittal planes were done.

Interpretation Data

a. Cross sectional area of the median nerve
- Measured at the level of the pisiform and at the level of the radioulnar joint.
- The size of the median nerve at the pisiform level is 1.6 to 3.5 greater than its size at the radioulnar joint in patients with carpal tunnel syndrome.

b. Flattening of the median nerve
- Determined at the level of the hook of hamate bone. The flattening ratio is defined as the ratio of the major axis of the median nerve to that of minor axis.
- The normal subjects demonstrate a flattening ratio less than 3 at the level of hamate.

c. The bowing ratio:
- Equation used for Bowing ratio= (X1/X2) X 100

Where (X1) is the distance of palmar displacement of the flexor retinaculum from a straight line drawn between the hook of hamate and the trapezium.

(X2) is the distance between the hook of hamate and the trapezium.

- The normal range measures 0-15%.

d. Signal pattern of the median nerve in T2-weighted images.

- Normally it has intermediate signal compared to the low signal intensity tendons.

e. Alteration of the signal intensity of the muscles due to edema or fat atrophy.

Table 1. Protocol of MR imaging

Pulse sequence	TR (msec)	TE (msec)	Gap (mm)	Slice Thickness (mm)	FOV (cm)	Matrix
T1 WI SE (axial)	450	11	0.5	3	12	256x256
PD FAT SAT	3000	20	0.5	3	12	256x256
T2 WI SE (axial)	3000	85	0.5	3	12	256x256

TR : repetition time, TE: echo time, FOV: field of view MRI

Statistical Analysis:

The findings of imaging studies were evaluated and correlated to clinical and EMG. Sensitivity, specificity, positive predictive value, negative predictive value, and accuracy with their respective 95% confidence intervals were calculated.

RESULTS:

In our study, 62.5% were affected in right hand 37.5% in left, regarding the suggested cause idiopathic etiology reprsents 43.8% followed by systemic 31.2% and finally local causes by 25%.as shown in **[Table 2].**

In addition, the mean CSA of the examined median nerves was 14.93±5.67, as shown in [**Table 3]**

Table 2. Side of affection and suggested cause and Co-morbidity

		N	%
Side	**Right**	10	62.5
	Left	6	37.5
Suggested cause	**Idiopathic**	7	43.8
	Local	4	25.0
	Systemic	5	31.3
Co morbidity	**No**	11	68.8
	DM	5	31.3
	Total	16	100.0

= 62.5% were affected in right hand 37.5% in left, regarding the suggested cause idiopathic etiology represents 43.8% followed by systemic 31.2% and finally local causes by 25%.

Table 3. US findings distribution among studied group

	CSA
Mean± SD	14.93±5.67
Median (Range)	14.0 (7-35)

The mean CSA of the examined median nerves was 14.93±5.67

Table 4. Diagnostic tests and signs:

		N	%
Tinel test	**-VE**	2	12.5
	+VE	14	87.5
Phalen test	**-VE**	0	0.0
	+VE	16	100.0
Carpal compression test	**-VE**	3	18.8
	+VE	13	81.3
Flattening	**-VE**	2	12.5
	+VE	14	87.5
Bowing	**-VE**	2	12.5
	+VE	14	87.5
	Total	16	100.0

Tinel test, flattening and bowing were positive in 87.5% of studied group, Phalen was poitive in 100% and carpal compression test was poitive in 81.3%.

DISCUSSION

Carpal tunnel is the most common fibro-osseous tunnel that is prone to neuropathies This is assumed to be due to the high prevalence of the carpal tunnel syndrome as being the most common entrapment syndrome of the upper limb with an estimated prevalence according to **Martinoli, et al.,** of approximately 125×10^{6} new cases per year **[7-8]**

CTS diagnosis is usually based on clinical history, typical clinical signs and symptoms (pain, parasthesia, numbness) and motor weakness of thenar and hypothenar muscles. Clinical evaluation is a gold standard for the diagnosis of CTS. Diagnosis is also based on electrodiagnostic testing and addition to recordings of somato sensory evoked potentials. The value of provocative physical tests such as Tinel's or phalens test for CTS is controversial and the results are often of doubtful significance **[9-10] .**

Beside they are considered painful test, and such diagnostic tests and studies actually do not provide special information regarding the median nerve and the surrounding structures, the information they provide is insufficient for full diagnosis. **[11-12]**

Carpal tunnel syndrome is due to any abnormality causing compression of the median nerve (e.g. ganglion /amylodosis). Usually the diagnosis is suspected clinically and the main role of imaging is to identify the abnormality causing the entrapment, such as masses, anomalous muscles and fibrous bands, or to show secondary findings that confirm or support the diagnosis. Secondary signs of carpal tunnel syndrome include the effects of the entrapment on the median nerve itself, such as focal flattening, proximal swelling, or hypoechogenicity on sonography as well as PD Fat sat in MRI. Sometime, sonography may provide an alternative diagnosis by showing abnormalities other than nerve entrapment that can account for the patient's symptoms (e.g. tenosynovitis) **[13].**

Our study included 16 patients, 14 females (87.5) and 2 males (12.5), with female predominance their age ranging from 26 – 58 years old. Mean age of our study is 44.93±9.7, while mean age according to **Roll et al**. **[14]** was 47.6 years old.

Coinciding with those studies, 16 cases (out of 16 cases,) of our study were clinically diagnosed including electro physiologically proved as carpal tunnel syndrome. All of them were presented clinically with pain at the distribution of median nerve and were suffering from hand parasthesia.

Ten patients had right sided lesions (62.5%) while six patients had left sided lesions (37.5%). The study done by **Roll et al. [14],** who stated right predominance of 93.2%. In addition, the associated medical conditions that were appreciated in our study were as follows: five cases were diabetic; two cases were known to have rheumatoid arthritis and one case known to be hypothyroidism as described by **Aroori and Spence [15].**

Comparison and correlation were performed in our work about the CSA grading; In our study, we have taken 10 mm ^{2} as a cutoff value for CSA of median nerve.; In our study, we have taken 10 mm ^{2} as a cutoff value for CSA of median nerve. The mean CSA in our study is **14.93 mm ^{2}**, which is very close to other similar study done by **Pauda et al.,** in 2008 and **Rao HB,et al 2012** who stated that mean **CSA =12.96 mm ^{2}**. A high significant positive correlation was found between the clinical grading and Hi-Ob grading scale system. Higher clinical grades were matched with higher Hi-Ob gradesas described by **Pauda et al. and Rao et al. [16-17]**. In our study, 3 patients' median nerve CSA was less than or equal 10 mm ^{2}, all of them were in mild group hand function scale as assessed by Hi-Ob scale grade 1 with minimal clinical severity. Seven patients who were in 2P of Hi-Ob scale showed >15 mm ^{2} CSA. Therefore, as the clinical severity with pain increases, the median nerve CSA also increased.

The overall specificity of ultrasound to MRI in the detection of carpal tunnel syndrome in 16 patients in our study was close to recent studies as found by **Henderson et al. [18],** that reported specificity ranging from 83-97% and overall sensitivity ranging from 87 -94%. This coincides with similar findings of **Fu et al. [19]** whose study was on evaluation of CSA measurement of the median nerve for the diagnosis of CTS with sensitivity of 91% & specificity of 93%.

CONCLUSION

We conclude this study had yielded a result that is sonography is sensetive as MRI in CTS diagnosis, as well as, both are specific to degree similar to electrodiagnsotic tests in CTS diagnosis.

Conflict of Interest: Nothing to declare.
Financial Disclosures: Nothing to declare.

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Cite This Article - VANCOUVER Style

boraey, O., Taema, M., Almassry, H., amin, M. Role of high frequency ultrasound in diagnosis of entrapment neuropathy at wrist. *Zagazig University Medical Journal*, 2020; (1014-1020): -. doi: 10.21608/zumj.2019.8099.1047