Can ultrasound replace MRI in assessment of nerve entrapment in osteofibrous tunnels in the upper extremity

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Purpose

Assess the efficiency of US compared to MRI (standard) in the assessment and diagnosis of the possible etiology of nerve entrapment in the osteofibrous tunnels of the upper extremity.

Methods and materials

This study included forty patients; 28 females, 12 males with age range from 27 to 63 years (mean age 47 years). Thirty three patients were complaining of chronic refractory unexplained wrist pain, three patients were complaining of medial elbow pain, sensory symptoms in the ring and little fingers, three patients were complaining of pain in the posterior aspect of the shoulder, one patient was complaining of sensory deficits over the ulnar portion of the palm and wasting of the hypothenar eminence.

Patients were subjected to the followings:

• History taking and clinical provisional diagnosis.

• Electrophysiological studies (36 patients)

• Radiological investigations:

Conventional unenhanced MRI.

Ultrasonographic examination.

· Surgical relief was done for thirty two patients while eight patients had medical treatment and physiotherapy.

ULTRASOUND EXAMINATION:

All subjects were examined with GE logic 400-ultrasound machine using an 11MHz linear probe.

TECHNIQUE:-

The sonographic examinations were performed with the patient seated in a comfortable position facing the sonographer.

1. **At the shoulder:**

In the supraspinous fossa, the suprascapular nerve is visualized as a small rounded hypoechoic structure lying between the scapula and the supraspinatus muscle. In the spinoglenoid fossa, the nerve is identified in a shallow depression of the scapula, the spinoglenoid notch, filled with hyperechoic fat.

2. At the elbow:

The elbow is supported and placed in a flexed position.

The sonographic probe is placed at the level of the medial epicondyle.

The ulnar nerve at the cubital tunnel is identified as elliptical shaped structure of hypoechoic nature located superficial and posterior to the medial epicondyle.

3. At the wrist:

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 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:

1. At the suprascapular and spinoglenoid notches

Depict the cause of compression which is most commonly ganglion cyst.

2. At the cubital tunnel:

a. Nerve cross-sectional area at the epicondyle: Normally, it should be no more than 7.5 mm^2

b. Echo textural changes in the compressed ulnar nerve : The nerve becomes uniformly hypoechoic with loss of the fascicular pattern

c. The presence or absence of masses should be noted

3. At the Guyon's tunnel:

a. Echo textural changes in the compressed ulnar nerve: The nerve becomes uniformly hypoechoic with loss of the fascicular pattern

b. The presence or absence of masses should be noted.

4. 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 diameter) × (maximum LL diameter) × (Õ/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). Normal flattening ratio should be less than 2.

c. Bowing of the flexor retinaculum : 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 EXAMINATION:

MRI was performed using GYROSCAN INTERNA 1.5T MAGNET (PHILIPS) TECHNIQUE OF EXAMINATION

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, elbow and shoulder joints, and was rapped and fixed by rubber bands.

Protocol of MR imaging

Preliminary scout localizers in axial, coronal and sagittal planes were done.

1. At the shoulder:

Sequence	FOV	Matrix/ Nex	Slice	TR	TE	TI
Axial proton FSE Fat Sat	10	512x256 2	4/0.5	3000	20	-
Coronal Oblique STIR	16-18	256x192 3	4/0.5	>1500	40	120
Coronal Oblique T1 SE Non Fat Sat	16-18	256x256 1	3/0.5	400-800	400-800	-
Sag oblique T2 FSE Non Fat Sat	16	256x256 2	3/0.5	>2000	110	-

2. At the elbow:

Pulse sequence	**TR** *(msec)*	**TE** *(msec)*	**Gap** *(mm)*	**Slice Thickness** *(mm)*	**FOV** *(cm)*	**Matrix**	**TI**
T1 WI FSE **(axial)**	400-600	20	0.5	4	12-14	256x192	-
T2 WI FSE **(axial)**	2000-4000	80	0.5	4	12-14	256x192	-
STIR **(coronal)**	2000-6000	20-40	0.5	4	12-14	256x192	150
T2WI FSE **(sagittal)**	2000-4000	80	0.5	4	12-14	256x256	-

3. At the wrist:

Pulse sequence	**TR** *(msec)*	**TE** *(msec)*	**Gap** *(mm)*	**Slice Thickness** *(mm)*	**FOV** *(cm)*	**Matrix**
T1 WI SE (axial)	400-600	11-16	0.5	3	10-14	256x256 256x224 256x192
T2 WI SE (axial)	3000-4000	85-102	0.5	3	10-14	256x256 256x224 256x192

· *TR: repetition time,*

· *TE: echo time*

· *TI: time of inversion recovery*

· *FOV: field of view*

MRI INTERPRETATION DATA:

The following items were assessed

1. At the suprascapular and spinoglenoid notches:

• Detect the cause of compression which is commonly ganglion cyst.

2. At the cubital tunnel:

a. Ulnar nerve signal alteration in T2 WI's.

b. Nerve swelling.

c. Muscles signal alteration due to edema or fatty atrophy.

3. At the Guyon's tunnel:

a. Ulnar nerve signal alteration in T2 WI's.

b. Nerve swelling.

c. Edema and atrophy of the hypothenar, the third and fourth lumbricals, and interossei muscles

4. At the carpal tunnel:

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:

• It is distance of palmar displacement of the flexor retinaculum from a straight line drawn between the hook of hamate and the trapezium (X1) divided by the distance between the hook of hamate and the trapezium (X2).

• Equation used was Bowing ratio= (X1/X2)X 100

• 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.

ELECTROPHYSIOLOGICAL STUDIES:

Nerve conduction studies were done with the site of stimulation selected according to the patient's complaint and the clinical provisional diagnosis as follows:

1. Suprascapular nerve:

The site of stimulation was at Erb's point (2 cm above the midcalvicular point)

2. Ulnar nerve

The site of stimulation was at the level of the wrist and around the elbow (below and above the elbow joint)

3. Median nerve

The site of stimulation was at the level of the wrist

SURGICAL INTERVENTION:

1. **In Suprascapular nerve entrapment:**

As the entrapment was caused by ganglion cysts in all our studied cases, arthroscopic excision of the cyst was performed as the method of decompression.

2. In ulnar nerve entrapment:

a) At the elbow:

Two cases underwent surgical decompression while one case was subjected to physiotherapeutic treatment.

b) At the wrist:

One case underwent surgical decompression.

3. In median nerve entrapment:

26 cases underwent surgical decompression while seven patients had medical treatment and physiotherapy

Results

All the cases included in the study presented by pain, 65% of cases had paresthesia in addition, 15% showed muscle wasting while 82.5% of the studied cases were diagnosed as carpal tunnel syndrome as shown in table 1.

Table (1): Distribution of the studied cases as regards the presenting symptoms

%	No	Variables
100%	40	**Pain**
65%	26	**Paresthesia**
15%	6	**Muscle wasting**
60% 40%	24 16	**Side** Right Left
82.5% 7.5% 7.5% 2.5%	33 3 3 1	**Site** Carpal tunnel Cubital Suprascapular Guyon's

Regarding the electrophysiological studies results 35% of the studied cases were diagnosed as mild cases while 25% were diagnosed as severe cases as presented in table 2.

Table (2): Distribution of the studied cases as regards the results of electrophysiology

%	No	Variables
10%	4	**Not done**
35%	14	**Mild**
27.5%	11	**Moderate**

2.5%	1	**Moderate to severe**
25%	10	**Severe**

Ultrasound was overall positive among 82.5% of the studied cases; while 17.5% of the studied cases were non positive (negative and border line cases) as presented in table 3.

Table (3): Distribution of the studied cases as regard ultrasound results

%	**No**	**Variables**
94.6%	35	**Decreased echogenicity**
17.5% 82.5%	7 33	**Conclusion** Non positive (negative-border line) Positive
Range	**Mean±SD**	
1.8-4.7	2.9±0.5	**Flattening**
2-6	4.2±1.08	**Bowing**
6.5-30	20.4±5.2	**Cross sectional area**

Positive MRI study represents 85% of the studied cases as presented in table 4.

Table (4): Distribution of the studied cases as regards MRI results

%	**No**	**Variables**
92.5%	37	**Increased T2 signal**
92.5%	37	**Increased cross sectional area**
15%	6	**Muscle signal alteration**
85%	34	**Conclusion**
Range	**Mean±SD**	
1.6-4	2.8±0.6	**Flattening**
0.11-0.30	0.19±0.04	**Bowing**

Idiopathic etiology was found among 60% of the studied cases as presented in table 5.

Table (5): Distribution of the studied case as regards disease etiology

%	No	Variables
2.5%	1	**Negative**
60%	24	**Idiopathic**
37.5%	15	**Extraneural compression**

There was highly significant difference as regards bowing by using paired t-test. No significant difference was detected as regards flattening as presented in table 6.

Table (6): Comparison between U/S versus MRI as regards different measures

P	t	MRI	U/S	Variables
>0.05 NS	1.9	2.8±0.6	2.5±0.93	**Flattening**
<0.001 HS	3	0.19±0.04	4.4±1	**Bowing**

Highly significant association was identified between U/S versus MRI in the diagnosis of nerve entrapment by using paired Fisher exact test as presented in table **7**.

Table (7): Comparison between U/S versus MRI as regards the diagnosis of nerve entrapment

P	**MRI** Negative Positive		**U/S**
<0.001 **HS**	3(7.5%)	4(10%)	**Negative**
	31(77.5%)	2(5%)	**Positive**

Comparing the ultrasound results to the MRI, True positive results were present in 77.5% of the studied cases as presented in table 8

Table (8): Validity of U/S compared to MRI results

No	Validity

31	**T+ve**
4	**T-ve**
2	**F+ve**
3	**F-ve**

Ultrasound shows high positive predictive value 89%, sensitivity 91% and overall accuracy 87.5% but shows low negative predictive value 58% and specificity 67% in diagnosis of nerve entrapment as presented in table 9.

Table (9) Validity variables of U/S versus MRI results among the studied cases

%	**Validity variables**
91%	**Sensitivity**
67%	**Specificity**
89%	**Positive predictive value**
58%	**Negative predictive value**
87.5%	**Overall accuracy**

Representative cases are shown in Fig 1-4

Images for this section:

Fig. 1: Case 1: Left suprascapular nerve entrapment due to ganglion cyst at the spinoglenoid and suprascapular notches

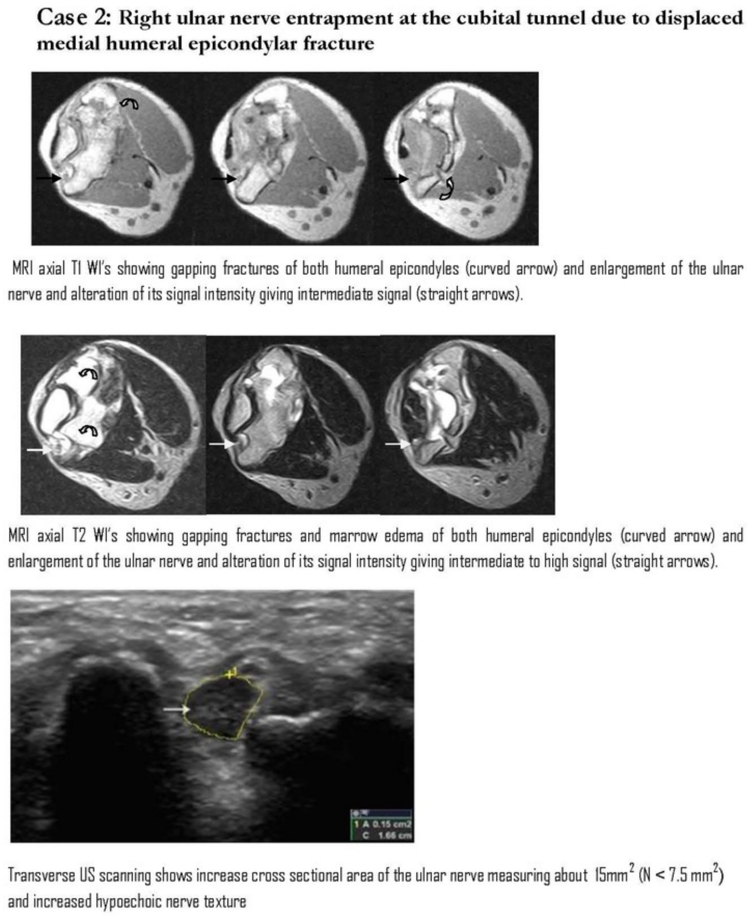
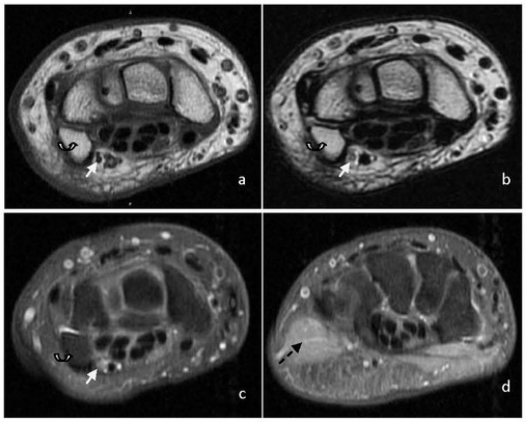
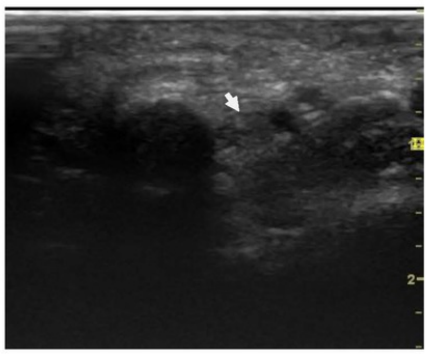


Fig. 2: Case 2: Right ulnar nerve entrapment at the cubital tunnel due to displaced medial humeral epicondylar fracture

Case 3: Idiopathic right ulnar nerve entrapment at the Guyon's tunnel with subsequent hypothenar muscles edema



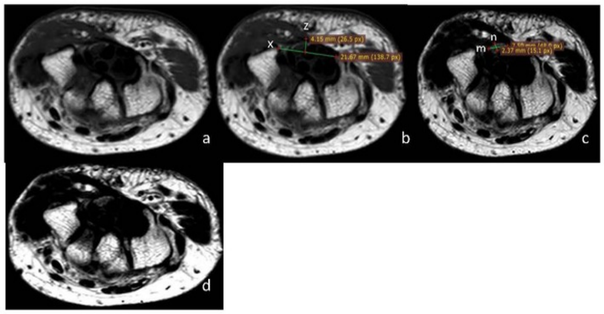
MRI axial TIWI (a), axial T2WI(b),axial STIR WI's (c-d) show enlargement of the ulnar nerve (arrows) and increased its intensity on T2 and STIR WI's at the level of the pisiform bone (curved arrow) and increased intensity of the hypothenar muscles in STIR WI's denoting edema (dashed arrow).



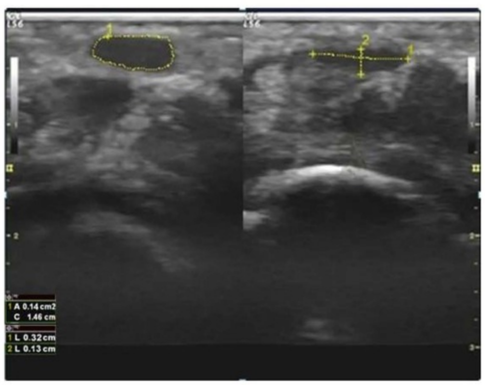
Transverse US scans show enlarged ulnar nerve (arrow) with relative increased nerve texture hypoechogenicity. UA: ulnar artery.

Fig. 3: Case 3: Idiopathic right ulnar nerve entrapment at the Guyon's tunnel with subsequent hypothenar muscles edema

Case 4: **Idiopathic right median nerve entrapment at the carpal tunnel**



MRI axial T1 WI's (a-c) showing compressed median nerve with flattening ratio 3.2 (c) (measured at the level of the hamate hook [m/n] with normal ratio less than 3) and bowing of the flexor retinaculum with ratio 0.18 (b) (measured at the level of the hamate hook by [z/x] with normal ratio less than 0.14). (d) Axial T2WI's shows altered signal of the median nerve being of bright signal.



Transverse US scanning showing compressed median nerve with increased hypoechogenicity, flattening ratio > 2 and increased cross sectional area>15mm^2.

Fig. 4: Case 4: Idiopathic right median nerve entrapment at the carpal tunnel

Conclusion

Discussion: Musculoskeletal ultrasound in comparison to the MRI is a reliable, noninvasive, bed side and inexpensive method that can investigate the peripheral nerves in the osteofibrous tunnels in the upper extremity as a possible site of nerve entrapment and can give a clue to the etiology of the entrapment.

Ultrasound criteria for diagnosing nerve entrapment in the osteofibrous tunnels at the upper extremity which were coinciding with those used by Bianchi and Martinoli, (2007):

· **Common features:**

- Echo textural changes where the compressed nerve becomes uniformly hypoechoic with loss of the fascicular pattern

- Increased cross sectional area (>7.5 mm^2 at the cubital tunnel, >10 mm^2 at the carpal tunnel)

- The presence or absence of masses

· **Specific features:**

• At the suprascapular and spinoglenoid notches:

- Depict the cause of compression which is most commonly ganglion cyst.

• At the carpal tunnel:

- Flattening of the median nerve with flattening ratio more than 2.

- Bowing of the flexor retinaculum with the distance equal or more than 4 mm.

MRI criteria for diagnosing nerve entrapment in the osteofibrous tunnels at the upper extremitywhich were coinciding with those used by Rodrigues and Rosenberg, (2004):

· **Common features:**

- Nerve signal alteration in T2 WI's

- Nerve swelling

- Muscles signal alteration due to edema or fatty atrophy

· **Specific features:**

• At the suprascapular and spinoglenoid notches:

- Detect the cause of compression which is commonly ganglion cyst.

• At the carpal tunnel:

- The size of the median nerve at the pisiform level is 1.6 to 3.5 greater than its size at the radio-ulnar joint in patients with carpal tunnel syndrome.

- Flattening of the median nerve with flattening ratio more than 3 at the level of hamate.

- The bowing ratio exceeding 15%

Conclusion: High-resolution ultrasonography can be used as an ancillary method to the electrophysiologic tests in diagnosing the patients in whom the median, ulnar or suprascapular nerves are compressed at the osteofibrous tunnels. Also, those patients who cannot be diagnosed electrophysiologically because of the false negativity of the NCS will be able to be diagnosed after establishing those criteria by ultrasonography where it can be used as an available and low cost diagnostic modality.

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