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DIAGNOSTIC VALUE AND FEASIBILITY OF ULTRASONOGRAPHY IN ULNAR NEUROPATHY AT THE ELBOW

Original Article

DİRSEKTE ULNAR NÖROPATİDE ULTRASONOGRAFİNİN TANISAL DEĞERİ VE UYGULANABİLİRLİĞİ

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ABSTRACT

Objectives: Although ultrasonography is currently used in daily practice in the evaluation of soft tissue problems, its use in diagnosis of ulnar nerve entrapment at the elbow (UNE) is still limited. The purpose of this study is to demonstrate the feasibility of ultrasonograpy in UNE.

Methods: This prospective study included 33 ulnar nerves of 33 consecutive patients (45,2 years, range: 23–69 years, 15 men and 18 women) with the diagnosis of unilateral UNE on clinical and electrodiagnostic studies and 32 ulnar nerves of 16 healthy volunteers (mean age: 35,5 years, range: 26–62 years, 9 men and 7 women) as a control group were examined. The minimum and maximum diameters of the ulnar nerve and the cross sectional areas (CSA) at the level of the medial epicondyle, 4 cm proximal and 4 cm distal to the medial epicondyle.

In statistical analysis, comparisons were made using student t tests. The Mann-Whitney U test was performed for the nonparametric variables, and all tests were considered significant at $p<0.05$ in 95% CIs.

Results: The maximum diameter of the ulnar nerve at medial epicondyle (3,74±0,86 mm; 2,5–6,3 mm), proximal (2,68±0,31 mm; 2,1–3,3 mm) and distal to the medial epicondyle (2,37±0,30 mm; 1,9–2,9 mm) were significantly larger in patients when compared to the same parameters at the same levels in control subjects (2,75±0,37 mm; 2–3,5 mm; 2,16±0,26 mm; 1,6–2,7 mm; 2,16±0,27

mm; 1,7–2,6 mm, respectively, p<0,01). The CSA of the ulnar nerve at medial epicondyle (9,79±4,70 mm; 4-25 mm) and proximal (4,09±0,84 mm; 3-6 mm) to the medial epicondyle were also significantly larger in patients when compared to the same parameters at the same levels in control subjects (5,06±1,19 mm; 3-7 mm; 3,0±0,51 mm; 2-5 mm, respectively (p<0,01). The CSA distal to the medial epicondyle were larger in patients when compared to the CSA at the same level in control subjects, but this difference was not found statistically significant (p>0,05).

Conclusions: Our ultrasonography findings are consistant with electrophysiologic and clinical findings in terms of identifying patients with UNE. Ultrasonography can become a screening imaging modality in patients with UNE.

Keywords: Ulnar Neuropathy; elbow; ultrasonography.

ÖZET

Amaç*:* Ultrasonografinin dirsek düzeyinde ulnar tuzak tanısında kullanımı halen sınırlıdır. Bu çalışmanın amacı dirsekte ulnar tuzak nöropatisinde ultrasonografinin tanı değerini ve uygulanabilirliğini göstermektir.,

Gereç ve Yöntem: Bu prospektif çalışmada klinik ve elektrodiagnostik çalışmalar ile dirsek düzeyinde ulnar nöropati tanısı almış 33 hasta ve kontrol grubu olarak 16 sağlıklı gönüllü dahil edildi.

Ultrasonografi ile medial epikondil düzeyinde, medial epikondilin 4 cm proksimali ve distalinde ulnar sinirin çapı ve kesitsel alanı ölçüldü. İstatistik analizlerde student t ve nonparametrik değişkenler için Mann-Whitney U testi kullanıldı. Bütün testler p<0.05'te, %95 güven aralığıda anlamlı kabul edildi.

Sonuç : Hasta grubunda ulnar sinir çapı medial epikondil düzeyinde (3,74±0,86 mm; 2,5–6,3 mm), proksimalde (2,68±0,31 mm; 2,1–3,3 mm) ve distalde (2,37±0,30 mm; 1,9–2,9 mm), kontrol grubuna göre (2,75±0,37 mm; 2–3,5 mm; 2,16±0,26 mm; 1,6–2,7 mm; 2,16±0,27 mm; 1,7–2,6 mm, sırasıyla, p<0,01) anlamlı düzeyde yüksek bulundu.

Hasta grubunda kesitsel alan ölçümleri de medial epikondil düzeyinde (9,79±4,70 mm; 4-25 mm) ve proksimalde (4,09±0,84 mm; 3-6 mm) kontrol grubuna göre anlamlı derecede yüksek bulundu (5,06±1,19 mm; 3-7 mm; 3,0±0,51 mm; 2-5 mm, sırasıyla, p<0,01). Distalde kesitsel alan hasta grubunda kontrol grubuna göre yüksek olmasına rağmen bu fark istatistiksel olarak anlamlı bulunmadı (p>0,05).

Sonuç :Ultrasonografi bulgularımız, dirsekte ulnar nöropati tanısında klinik ve elektrodiagnostik bulgular ile uyumlu bulunmuştur. Ultrasonografinin dirsekte ulnar nöropatide tanısal tarama metodu olarak kullanılabileceğini düşünmekteyiz.

Anahtar kelimeler: *Ulnar Nöropati; dirsek; ultrasonografi.*

INTRODUCTION

Ulnar nerve entrapment at the elbow (UNE) is the second most common entrapment neuropathy of the upper extremity (1). Repetitive elbow flexion and chronic external pressure applied to the elbow are claimed in the pathogenesis of UNE. Clinical symptoms are paresthesia in the fourth and fifth digits, weakness in hand grip force and neuropathic pain. Clawing of fingers and atrophy of intrinsic hand muscles may be seen in severe cases. In routine clinical practice diagnosis of UNE is achieved by the combination of clinical and electrophysiological findings. Electrophysiological studies are performed for confirmation of diagnosis, for the differential diagnosis of other conditions leading to similar symptoms and for the assessment of severity of the lesion. Routine nerve conduction studies are diagnostic in severe cases but may be

normal in mild cases despite clinical symptoms. Recently ultrasonography is being widely used in the diagnosis and follow-up of various musculoskeletal diseases. Clinical use of ultrasonography is increasing because it provides a noninvasive, inexpensive, high resolution and dynamic imaging. Although ultrasonography is currently used in daily practice in the evaluation of soft tissue problems its use in diagnosis of UNE is limited. This study is designed to evaluate the ultrasonography findings of UNE.

MATERIALS AND METHODS

Patient Population

This prospective study was approved by the institutional ethical board. Written informed consent was obtained from all participants. Between October 2013 and December 2013, 33 ulnar nerves of 33 consecutive patients (with unilateral UNE; mean age: 45,2 years, range: 23–69 years, 15 men and 18 women) were evaluated. As a control group, 32 ulnar nerves of 16 healthy volunteers (bilaterally ulnar nerves examined; mean age: 35,5 years, range: 26–62 years, 9 men and 7 women), were evaluated. These volunteers had no signs or symptoms of UNE or had systemic diseases associated with polyneuropathy.

Clinical Assessment

The patients referring to the physical medicine and rehabilitattion outpatient clinic with the symptoms of suspected UNE were evaluated. Patients having sensory and motor symptoms suggestive of UNE were assessed with neurological examination, electrophysiological and other indicated diagnostic studies for differential diagnosis. Inclusion criteria for the study required the presence of UNE based on clinical examination and EMG findings and an age of 18–70 years. Exclusion criteria were polyneuropathy, cervical radiculopathy, brachial plexopathy, ulnar neuropathy at a site distant from the elbow. Patients with history of ulnar nerve surgery, therapeutic steroid injection to the elbow and traumatic origin of UNE were also excluded from the study. Physical examination included Tinel sign, motor function of ulnar innervated hand muscles and sensory function of the ulnar nerve.

Electrodiagnostic Studies

Nerve conduction studies were performed with a Nihon Kohden Neuropack S1 (MEB-9400K) device. Sensory nerve action potentials (SNAP) were recorded using ring electrodes placed over the fifth digit with stimulation at 11 cm proximal to the active recording electrode on the proximal interphalangeal joint. The onset latency was measured at the initial deflection of SNAP with a sensitivity of 10 μV per division, amplitude of the SNAP was measured from peak to peak and averaged at least ten times. Motor nerve conduction studies of ulnar nerve were performed with the compound muscle action potential (CMAP) recorded at the abductor digiti minimi muscle using bipolar bar electrodes. Short segment conduction study (SSCS) was performed when the patient was in the supine position, with the shoulder at 45° abduction and external rotation, the elbow at 90° flexion and the forearm in supination. A line was drawn from the medial epicondyle to the olecranon and the midpoint of the ulnar groove was marked. A 10 cm segment between 4 cm distal and 6 cm proksimal to this point was marked with 2 cm intervals. The latencies were measured from the stimulus to the initial deflection of the CMAP and the amplitudes were measured from peak to peak with a sensitivity of 5 mV per division. Latency and CMAP amplitude changes over each 2 cm segments were recorded.

Ultrasonography Techniques and Image Acquisition

All ultrasonography examinations were performed in high-resolution ultrasonography scanner (Acuson Antares,

Siemens, Erlangen, Germany) with a multifrequency 5-13 MHz linear array transducer. All ultrasonography examinations were prospectively performed by the same radiologist (A, 4-year experience with musculoskeletal ultrasonography) who were blinded to the symptoms, clinical and electrodiagnostic findings of the patients. Elbow sonograms were obtained within one week of the electrodiagnostic studies.

Ultrasonography examinations were performed while the subjects were lying in a supine position with the examined elbow flexed to 135°. Ulnar nerve were examined in axial and longitudinal planes for demonstration of the internal architecture and echogenicity. The minimum and maximum diameters of the ulnar nerve and the cross sectional areas (CSA) were measured at the level of medial epicondyle using automatic tracing programme of the ultrasound scanner. The same measurements (the mimimum and maximum diameters of the ulnar nerve and the CSA) were taken from the 4 cm proximal and 4 cm distal to medial epicondyle. The main diagnostic criteria used by the radiologists to determine the presence of UNE on ultrasonography were the loss of normal fascicular pattern of the ulnar nerve, decrease in echogenicity or abrupt size change of the nerve [2,3]. Same measurement protocol were performed for the control subjects.

Statistical Analysis

Statistical analysis were performed with NCSS (Number Cruncher Statistical System) 2007&PASS (Power Analysis and Sample Size) 2008 Statistical Software (Utah, USA). Comparisons were made using student t tests. The Mann-Whitney U test was performed for the nonparametric variables. Pearson and Spearman correlations were performed to assess the correlation between the parameters (maximum diameter and CSA of the ulnar nerve at the level of medial epycondyle, 4 cm proximal and 4 cm distal to the medial epycondyle). All tests were considered significant at $p<0.05$ in 95% CIs. We used a receiver operating characteristic (ROC) curve analysis to evaluate the accuracy in using ultrasonography to detect UNE. For this analysis, the side of ulnar nerve was used as the unit of analysis. The area under the ROC curve (AUC) and the corresponding confidence intervals were estimated.

RESULTS

Clinical and Electrodiagnostic Studies

Thirty-three ulnar nerves of 33 patients with the diagnosis of unilateral UNE on clinical and electrodiagnostic studies and 32 ulnar nerves of 16 volunteers as control group were examined. In patients with UNE, 5 had right-sided lesions (15,2 %) and 28 had left-sided lesions (84,8 %).

Ultrasonography Imaging Findings

In all control subjects ulnar nerve had the normal echogenicity and internal architecture in ultrasonography (**Fig. 1**).

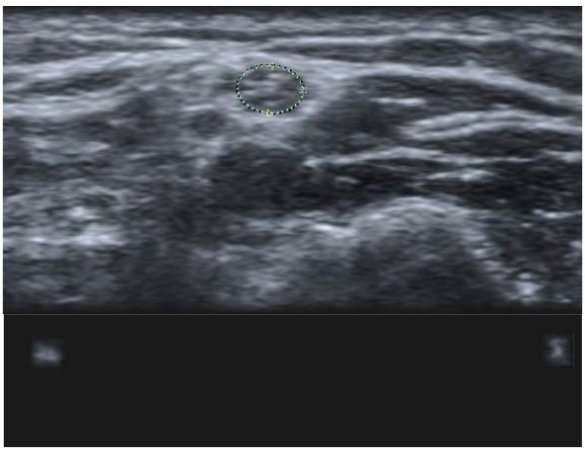


Figure. 1 *Axial US image of ulnar nerve at the elbow in a 35 year-old healthy woman. The nerve is composed of multiple rounded hypoechoic round areas in hyperechoic background. The diameter and CSA of the ulnar nerve were in the normal limits.*

All patients with the diagnosis of UNE had the decrease in echogenicity and/or loss of architecture at the level of medial epycondyle in ultrasonography (**Fig. 2**).

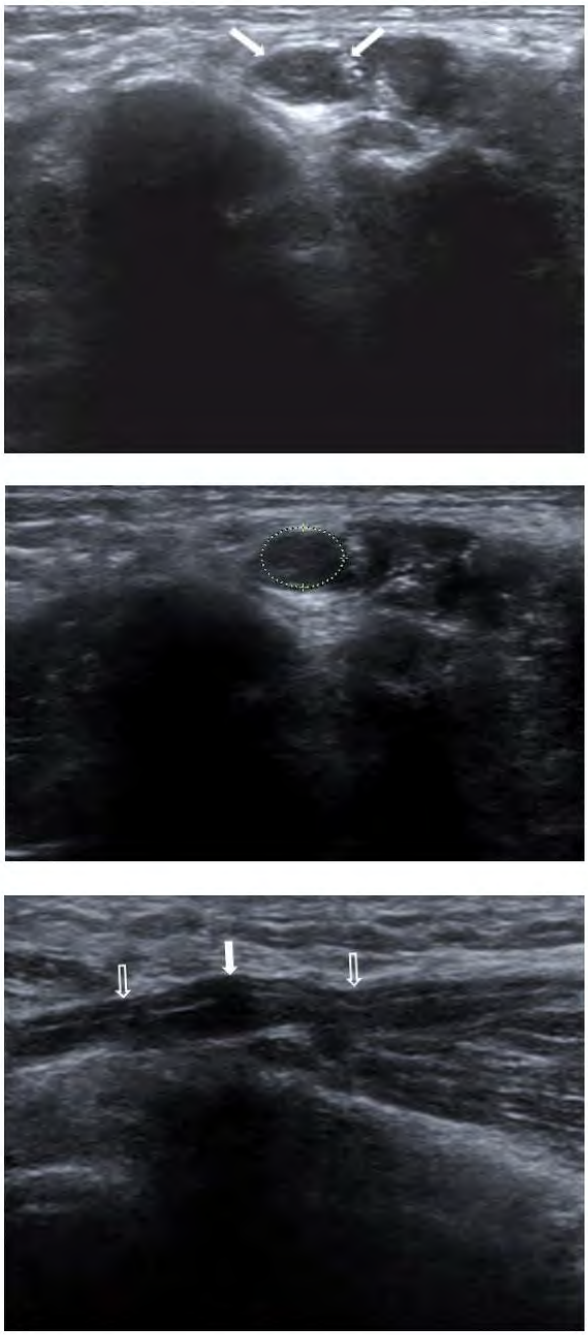


Figure.2 *UNE in a 47 year-old man. a Axial US image and b CSA measurement at the same level show a decrease in echogenicity and loss of architecture along with an enlargement in the ulnar nerve c US image in longitudinal plane shows the extention of the defined findings in a and b (open arrows), the nerve is more enlarged at the level of medial epicondyle (arrow).*

Table 1 summarizes the maximum diameter and CSA of the ulnar nerve at the level of medial epicondyle, proximal and distal to the medial epicondyle in patients and control subjects. The mean values for the maximum diameter of the ulnar nerve at medial epicondyle (3,74±0,86 mm; 2,5–6,3 mm), proximal (2,68±0,31 mm; 2,1–3,3 mm) and distal to the medial epicondyle (2,37±0,30 mm; 1,9–2,9 mm) were significantly larger in patients when compared to the same parameters at the same levels in control subjects (2,75±0,37 mm; 2–3,5 mm; 2,16±0,26 mm; 1,6–2,7 mm; 2,16±0,27 mm; 1,7–2,6 mm, respectively, p<0,01).

Table 1

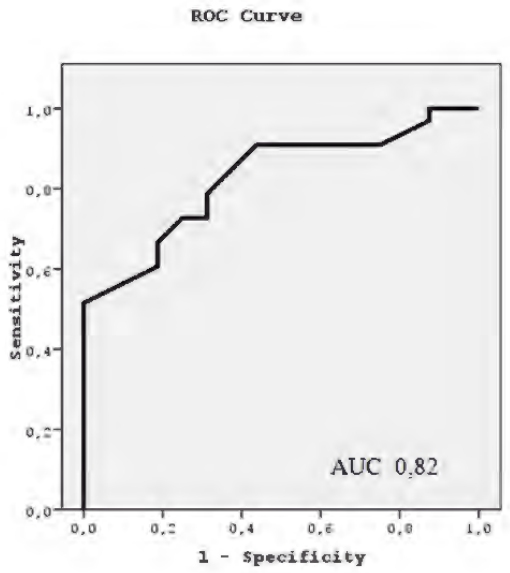
Table 1: *The maximum diameter and CSA values of the ulnar nerve in patients and control subjects* **.**

	Patients (n=33)	Control Subjects(n=32)	p
	Mean±SD	Mean±SD	
Maximum diameter at medial epicondyle	3,74±0,86 (2,5-6,3)	2,75±0,37 (2-3,5)	[a]*0,001***
Proximal Diameter	2,68±0,31(2,1-3,3)	2,16±0,26 (1,6-2,7)	[a]*0,001***
Distal Diameter	2,37±0,30 (1,9-2,9)	2,16±0,27 (1,7-2,6)	[a]*0,006***
CSA at medial epicondyle	9,79±4,70 (9,0) (4-25)	5,06±1,19 (5,0) (3-7)	[b]*0,001***
Proximal CSA	4,09±0,84 (3-6)	3,0±0,51 (2-5)	[a]*0,001***
Distal CSA	3,48±0,71 (2-5)	3,19±0,82 (2-5)	[a]*0,123*

[a]*Student-t Test* [b]*Mann-Whitney U Test* ***p<0,01*

The CSA of the ulnar nerve at medial epicondyle (9,79±4,70 mm; 4-25 mm) and proximal (4,09±0,84 mm; 3-6 mm) to the medial epicondyle were also significantly larger in patients when compared to the same parameters at the same levels in control subjects (5,06±1,19 mm; 3-7 mm; 3,0±0,51 mm; 2-5 mm, respectively (p<0,01). The CSA distal to the medial epycondyle were larger in patients when compared to the CSA at the same level in control subjects, but this difference was not found statistically significant (p>0,05).

ROC curve (**Fig 3a**)

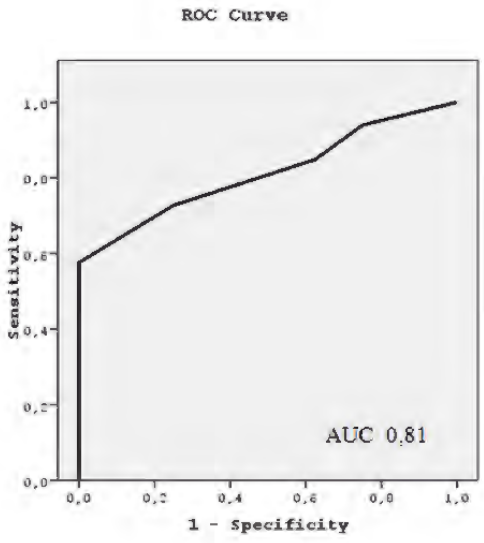


for the detection of UNE regarding the maximum diameter of the ulnar nerve at medial epicondyle showed the AUC of 0,82 (95% confidence interval: 0.71, 0.94). Four cutoff points (3; 3,10; 3,20 and 3,30 mm) were explored to assess the sensitivity and specificity, positive predictive, negative predictive value and accuracy of ultrasonography in demonstrating UNE. The maximum diameter at medial epicondyle of 3,20 mm to define the UNE yielded sensitivity, specificity, positive predictive, negative predictive value and accuracy of 72,7%, 75%, 85,7%, 57,1% and 73,4%, respectively) (**Table 2**).

Cutoff value for the maximum diameter at medial epicondyle (mm)	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Accuracy
>3,00	78,79	68,75	83,87	61,11	75,51
>3,10	72,73	68,75	82,76	55,00	71,43
>3,20	72,73	75,00	85,71	57,14	73,47
>3,30	66,67	81,25	88,00	54,17	71,43

Table 2: *ROC analysis of the maximum diameter of the ulnar nerve at medial epicondyle measurements.*

ROC curve (**Fig 3b**)



for the detection of UNE regarding the CSA of the ulnar nerve at medial epicondyle showed the AUC of 0,81 (95% confidence interval: 0.69, 0.92). Four cutoff points (5,6,7 and 8 mm2) were also explored in order to assess the sensitivity and specificity, positive predictive, negative predictive value and accuracy of

ultrasonography in demonstrating UNE. The CSA at medial epicondyle of 7 mm^2 to define the UNE yielded sensitivity, specificity, positive predictive, negative predictive value and accuracy of 57,5%, 100%, 100%, 53,3% and 71,4%, respectively)

(**Table 3**).

Cutoff value for the CSA at medial epicondyle (mm^2)	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Accuracy
>5	93,94	25,00	72,09	66,67	71,43
>6	84,85	37,50	73,68	54,55	69,39
>7	57,58	100,00	100,00	53,33	71,43
>8	54,55	100,00	100,00	51,61	69,39

ROC: receiver operating characteristic; CSA: cross-sectional area

Table 3**:** *ROC analysis of CSA of the ulnar nerve at medial epicondyle measurements.*

There were no statistically significant correlation regarding maximum diameter (**Table 4**) and CSA (**Table 5**) of the ulnar nerve at the levels of medial epicondyle, proximal and distal to the medial epicondyle in patients with UNE.

Patient Group (n=33)	Diameter in medial epicondyle	
	r	p
Proximal diameter	0,323	*0,066*
Distal diameter	-0,013	*0,942*

r=Pearson correlation coefficient

Patient Group (n=33)	CSA at medial epicondyle	
	r	p
Proximal CSA	0,283	*0,111*
Distal CSA	0,190	*0,288*

r=Spearman correlation coefficent

Table 4: *The correlation between the maximum diameter of the ulnar nerve at medial epicondyle and proximal and distal to the medial epycondyle in patients with UNE.*

Table 5**:** *The correlation between the CSA of the ulnar nerve at medial epicondyle and proximal and distal to the medial epicondyle in patients with ulnar neuropathy.*

DISCUSSION

Studies concerning the diagnostic value of ultrasonography have demonstrated promising results in the detection of ulnar neuropathy (4–9). Although these studies have employed various measurement techniques, they suggested the ulnar nerve was enlarged in those with entrapment when compared with controls (9–11). In a study investigating the diagnostic value of ultrasonography in patients with UNE showed the median CSA of the ulnar nerve at four studied levels (4 cm proximal and the distal to the medial epicondyle, at the level of the medial epicondyle and maximum CSA between these points) was significantly greater in UNE patients than in controls ($p < 0.001$) (4). Yoon et al (12), reported that the nerve CSA at the point of maximal enlargement in UNE, as well as studies of other focal neuropathies (13,14), is the most appropriate measurement in evaluating entrapment neuropathy.

Our results showed that ultrasonography is a sensitive method for demonstration of internal architecture and echogenicity in patients with UNE. All patients had the ultrasonography findings of UNE (the loss of normal fascicular pattern of ulnar nerve, decrease in echogenicity or abrupt size change of the

nerve). In control group the echogenicity and internal architecture of the ulnar nerve were normal. The maximum diameter of the ulnar nerve at medial epicondyle, 4 cm proximal and 4 cm distal to the medial epicondyle were significantly larger in patients with UNE than the maximum diameter of ulnar nerve evaluated with the same parameters in control subjects. The CSA were also significantly larger at medial epicondyle and 4 cm proximal to the medial epycondyle in UNE patients when compared to the control subjects.

ROC curves for the detection of UNE regarding the maximum diameter and CSA of the ulnar nerve at medial epicondyle showed high AUC values of 0,82 and 0,81 respectively. The maximum diameter at medial epicondyle of 3,20 mm to define the UNE yielded sensitivity, and specificity of 72,7% and 75%, respectively. In the present study, we found that the cut-off value of 7 mm2 for CSA at medial epicondyle had sensitivity of 57,5% and specificity of 100% in UNE diagnosis. Ayramlou et al (4) reported an AUC of 0,83, sensitivity of 82% and specificity of 65% at cutoff value of 5 for the CSA at medial epicondyle, Other studies analysing the CSA maximum yielded the cut-off value of >8 had sensitivity of 46–100% and specificity of 65–98% in UNE diagnosis (5–7, 9,15).

Our results are consistant with the literature as showing high resolution ultrasonography is a sensitive method to show ulnar nerve changes in patients with ulnar UNE. The CSA of the ulnar nerve at the medial epicondyle and proximal to the medial epicondyle was significantly larger than in normal subjects. In addition this study showed the maximum diameter of the ulnar nerve in all studied levels was also significantly higher than the maximum diameter in normal subjects.

Relatively a small number of patients in our the study is one of our limitations. Also, intraobserver or interobserver agreement were not performed in the study. Another limitation is the underlying abnormalities and anatomical variations were not investigated in patients with UNE. Furthermore this study did not focused on investigating the precise localization of UNE by ultrasonography. Since we intended to demonstrate that ultrasonography is a practical method in the detection of UNE which could be more commonly used in the daily practice in UNE.

In conclusion, the ulnar nerve at the elbow may easily be imaged using

ultrasonography. Ultrasonography findings are consistant with electrophysiologic and clinical findings in terms of identifying patients with UNE. Ultrasonography may become a screening imaging modality in patients with UNE.

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