Original Investigation / Özgün Araştırma

The Usefulness of Ulnar to Median F Wave Latency Difference for the Diagnosis of Ulnar Nerve Entrapment at the Elbow: Is it Really Reliable?

Ulnar ve Median Sinir F Dalga Latans Farkının Dirsekte Ulnar Sinir Tuzak Nöropati Tanısında Kullanılabilirliği: Gerçekten Güvenilir mi?

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ABSTRACT

Objective: Investigators have studied minimum F wave latency difference (FWLD) for the diagnosis of entrapment neuropathies in the past, but there is limited information on the utility of minimum FWLD for the diagnosis of ulnar nerve entrapment at the elbow (UNEE). The aim of this study is to evaluate the utility of ipsilateral ulnar to median nerve FWLD in the diagnosis of UNEE.

Methods: Patients with an electrophysiological diagnosis of unilateral UNEE were included in this retrospective study. Median and ulnar nerves motor and sensory conduction and F wave studies were carried out bilaterally in 52 patients. The minimum FWLD between the ulnar and ipsilateral median nerve was noted for each arm. Data of healthy arms were used as control values.

Results: The ulnar and median nerve minimum F wave latencies were found to be similar in the affected and healthy arms of the subjects. However, the mean ulnar to median nerve minimum FWLD value was higher in the affected arms (0.78 vs. -0.10, p=0.003). Ulnar to median minimum FWLD was found to have a sensitivity of 53.85% and specificity of 80.77% for the diagnosis of UNEE.

Conclusion: Ulnar to median minimum FWLD can be used as a diagnostic marker for UNEE but has low sensitivity. Further studies with larger sample sizes and investigators blinded to the study are required.

Keywords: Ulnar neuropathy, median nerve, F wave, electrodiagnosis, rehabilitation

ÖZET

Amaç: Geçmişte tuzak nöropatilerin tanısında minimum F dalga latans farkı araştırılmıştır. Ancak dirsekte ulnar sinir tuzak nöropati tanısında kullanımı ile ilgili sınırlı bilgi mevcuttur. Bu çalışmanın amacı ipsilateral ulnar ve median sinir F dalga latans farkının dirsekte ulnar sinir tuzak nöropati tanısında kullanılabilirliğini değerlendirmektir.

Yöntemler: Elektrofizyolojik olarak tek taraflı dirsek düzeyinde ulnar sinir tuzak nöropati tanısı alan hastalar retrospektif olarak incelendi. Bilateral median ve ulnar sinir motor ve duyu iletim çalışması yapılmış olan 52 hasta çalışmaya alındı. Ulnar ve ipsilateral median sinir minimum F dalga latans farkı her kol için kaydedildi. Sağlam olan kollara ait veriler kontrol olarak kabul edildi.

Bulgular: Sağlam ve etkilenen koldaki ulnar ve median sinir minimum F dalga latansları benzer olarak bulundu. Ancak, etkilenen kolda ortalama ulnar ve median sinir minimum F dalga latans farkı yüksek bulundu (0.78 vs. -0.10, p=0.003). Ulnar ve median sinir minimum F dalga latans farkının dirsekte ulnar sinir tuzak nöropati tanısındaki sensitivitesi %53.85, spesifitesi %80.77 bulundu.

Sonuçlar: Ulnar ve median sinir minimum F dalga latans farkı dirsekte ulnar sinir tuzak nöropati tanısında kullanılabilir ancak düşük sensitiviteye sahiptir. Daha büyük hasta gruplarıyla ve araştırmacıların çalışmaya kör olduğu ileri çalışmalara ihtiyaç vardır.

Anahtar sözcükler: Ulnar nöropati, median sinir, F dalgası, elektrodiyagnoz, rehabilitasyon

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Introduction

Entrapment of the ulnar nerve at the elbow is the second most common compression neuropathy in the upper extremity after carpal tunnel syndrome (CTS) (1,2). The diagnosis of this neuropathy is based on the clinical symptoms, physical examination, and electrodiagnostic tests. Electrodiagnostic evaluation of ulnar nerve entrapment at the elbow (UNEE) is still a challenging and complex subject. The most reliable finding for UNEE is the slowing of the ulnar nerve across elbow motor conduction velocity.

F wave latencies elicited by distal stimulation represent the motor conduction time to and from the spinal cord along the entire motor nerve axon (3). The F wave has found a wide application in the assessment of peripheral nerve lesions, and has been used to evaluate proximal motor nerve conduction and excitability of the motor neuron pool. Analysis of F waves is very useful in neurophysiology and may help affirm or disprove a compression neuropathy (4). Sander et al. (5) first described the usefulness of F wave latencies in entrapment neuropathies and found that median to ulnar nerve minimum F wave latency difference (FWLD) could be useful in the diagnosis of CTS. Others reported similar results regarding the usefulness of FWLD in the diagnosis of CTS (6-8). Recently Alemdar (9) examined ulnar to median FWLD in the diagnosis of UNEE for the first time. A total of 17 patients with UNEE were included in the study and it was found that UNEE could be confirmed easily and with a high sensitivity and specificity with F wave latency difference studies. To the best of our knowledge, there is no other study on the value of ulnar to median FWLD in the diagnosis of UNEE. The aim of this study was to conduct further analysis of ulnar to median FWLD in the diagnosis of UNEE.

Material and Methods

Study Population

The medical records of patients referred to our electroneuromyography laboratory with a clinical suspicion of unilateral UNEE between January 2008 and December 2013 were retrospectively evaluated. Patients with an electrophysiological diagnosis of UNEE together with normal contralateral upper extremity nerve conduction study results were included in the study.

Patients were excluded if they had a history of previous elbow surgery or trauma, or clinical or electrophysiological signs of pathological conditions such as radiculopathy, brachial plexopathy, thoracic outlet syndrome, myelopathy, other mononeuropathy or ulnar neuropathy at the wrist, Martin-Gruber anastomosis, polyneuropathy, diabetes mellitus or other medical disease associated with polyneuropathy or a lack of ulnar nerve F response. A total of 104 arms (52 patients) were included. The study was approved by the local ethics committee.

Electroneuromyographic Studies

All patients were evaluated with the Medelec® Synergy multimedia electromyograph instrument (Oxford Instruments, Surrey, England). Examinations were conducted at temperatures above 25°C. The extremity distal skin temperature was measured with a thermistor probe plugged into the amplifier (Medelec, Oxford Instruments) from the hand dorsum for each participant and maintained above 32°C. The electrodiagnostic study included motor and sensory nerve conduction and F wave study of the median and ulnar nerves, and sensory conduction studies of the radial nerve on both sides by the conventional method. UNEE was diagnosed according to the criteria of the American Association of Electrodiagnostic Medicine (10). Filter settings were 3 Hz-10 kHz for motor conduction studies and 20 Hz-2 kHz for sensory conduction studies. The same type and size of electrodes were used for all patients. The compound muscle action potentials (CMAPs) were recorded using a 9 mm diameter disc surface cup (Ag/AgCl) electrode (TECA Accessories, Medelec, Oxford Instruments, Old Woking, UK) placed over the motor point of the abductor digiti minimi (ADM) muscle for the ulnar nerve and over the abductor pollicis brevis (APB) muscle for the median nerve. In motor conduction studies, the ulnar nerve was stimulated 8 cm proximal to the active electrode (wrist), about 3-4 cm distal to the medial epicondyle (below the elbow), and 10-12 cm proximal to the below elbow site (above the elbow). The elbow was flexed to 90 degrees and the wrist kept in the neutral position (11). Ulnar nerve distal motor latencies (DML), CMAP amplitudes and motor conduction velocities (MCV) at the forearm and below elbow-above elbow (BE-AE) segments were calculated. The median nerve was stimulated at a distance of 8 cm from the active electrode, between the tendons of the flexor carpi radialis and palmaris longus muscles at the wrist and at the antecubital fossa. Median nerve DML, forearm MCV, and CMAP amplitudes were recorded. DML was measured from the negative take-off, and CMAP amplitude was defined as the height from the baseline to the first negative peak of the action potential.

Sensory nerve conduction studies were performed antidromically. The ulnar nerve was stimulated at the wrist 12 cm from the active electrode, about 3-4 cm distal to the medial epicondyle (below the elbow), and then 10-12 cm proximal to that site (above the elbow).

Ulnar nerve distal sensory latencies, sensory nerve action potentials (SNAP) amplitudes (measured from peak to peak), and sensory conduction velocities of the forearm and BE-AE segments were recorded from the fifth digit using ring electrodes. Radial nerve sensory conduction studies were performed to exclude polyneuropathies. For the radial sensory nerve, the active surface electrode was placed over the extansor pollicis longus tendon, and the reference electrode was placed on the lateral side of the head of the second metacarpal. The superficial radial nerve was stimulated along the lateral border of the radius, 12 cm proximal to the active electrode.

For recording of the F wave response, cathodal electrical pulses of 0.1 ms duration were applied at the distal stimulation sites of the median and ulnar nerves with the surface electrode recording from the APB and ADM muscles, respectively. After at last 16 supramaximal stimulation, minimum F wave latencies were recorded for each nerve while the muscle examined remained relaxed. F wave latency was measured automatically by the software on each trace followed by visual inspection. When necessary, manual editing assured correct cursor position. The FWLD between the ulnar and ipsilateral median nerve was noted for each arm.

Latencies were expressed in milliseconds (ms), CMAP amplitudes as millivolts (mV), and SNAP amplitudes in microvolts (μV). Nerve conduction velocities were calculated as m/s.

Needle electromyography (EMG) was performed to exclude a root lesion. The presence of any denervation potential in the ADM muscle was recorded.

Statistical Analysis

Data were analyzed using SPSS version 20 for Windows (IBM SPSS Inc, Chicago, IL). Normal distribution of the data was examined with the Kolmogorov-Smirnov test. Numeric variables that show normal distribution variables were presented as mean±standard deviation and others as median (minimum–maximum). Categorical variables were cited as the number of cases and percentages (%). The comparisons between normal and affected arms were calculated using Student's t-test for values with a parametric distribution or the Mann-Whitney U test for values with an nonparametric distribution. A p-value < 0.05 was deemed to indicate statistical significance for statistical analysis with 95% confidence interval and 5% margin of error. The diagnostic efficiency of ulnar and median F wave latencies and ulnar to median FWLD levels were analyzed by receiver operating characteristic (ROC) curves and Youden index. Determination of the cut-off value at which Youden index is maximum.

Results

A total of 295 patients were diagnosed as UNEE. A total of 52 patients (22 women and 30 men) met the study criteria, and had received a clinical and electrophysiological diagnosis of unilateral UNEE with normal contralateral upper extremity nerve conduction study values. The mean age of the patients was 47.94±14.6 years. The demographic characteristics of the study population are presented in Table 1.

An ulnar nerve motor conduction block was found with above elbow stimulation in 3 patients (5.8%). An increase in the ulnar nerve minimum F wave latency was present in 7 patients (13.4%). ADM muscle denervation potential was found in 3 patients (5.8%) on needle EMG.

Mean of ulnar nerve minimum F wave latencies (26.27±1.9 vs. 25.65±1.7, p=0.096 respectively) and median nerve minimum F wave latencies (25.35±2.0 vs. 25.72±1.8, p=0.310 respectively) were found to be similar in the affected and healthy arms. However, the mean ulnar to median nerve FWLD was higher in the affected arm (0.78 vs -0.10, p=0.003). Table 2 presents the nerve conduction study results in the affected and healthy arms.

The ulnar to median nerve FWLD was found to have a sensitivity of 53.85% and specificity of 80.77% for the diagnosis of ulnar nerve entrapment at the elbow (Table 3). The evaluation with ROC analysis showed that ulnar to median nerve FWLD has diagnostic value in predicting the presence of UNEE (Area under curve =0.67, % confidence interval=0.57-0.76, P=0.019). The cut off value of the F-wave latency difference has been recommended as 0.6 (Figure 1).

Discussion

The goals of electrodiagnostic study of the ulnar nerve are localising ulnar nerve dysfunction and determining the severity. Various electrodiagnostic techniques have been suggested for ulnar neuropathy at the elbow (12-

Table 1. Demographic data of the subjects.

Variables	n=52
Age (years)	47.94±14.6
Gender Males (%) Females (%)	 30 (57.7) 22 (42.3)
Height (m)	165.98±8.34
Weight (kg)	70.19±12.5
Body mass index	25.5±4.0

16). The most reliable finding for UNEE is slowing of the ulnar nerve across elbow motor conduction velocity to less than 50 m/sec while recording from the ADM muscle. Alternative techniques such as relative ulnar slowing in different ulnar nerve segments, use of alternative muscles, and sensory and mixed nerve techniques provide complementary information but are highly operator-dependent like all nerve conduction studies and should be used on a case by case basis. The elbow position and temperature of the skin should be carefully considered to avoid false negative and positive results when performing the study (13,16,17).

The recording of F waves is a simple and non-invasive technique that is used commonly in nerve conduction studies. Most electrodiagnosticians agree that F wave latencies are valuable markers of the conduction properties of motor axons that may even be superior to

Table 2. Conduction parameters of affected and healthy arms of the subjects.

Variables	Affected arm n=52	Healthy arm n=52	P value
Median nerve			
DML	3,23±0,39	3,27±0,38	0,630
MCV (forearm)	58,13±4,38	59,10±3,96	0,238
Ulnar nerve			
DML	2,66±0,28	2,68±0,33	0,837
MCV (forearm)	65,81±7,5	65,51±7,5	0,226
MCV (across-elbow)	50,05±8,0	60,13±6,46	0,001*
CMAP	9,03±2,4	9,26±2,46	0,638
DSL	2,87±0,24	2,86±0,25	0,741
SNAP	37,26 (3-116)	30,9 (1,5-116,8)	0,686
Ulnar nerve MFL	26.27±1.9	25.65±1.7	0.096
Median nerve MFL	25.35±2.0	25.72±1.8	0.310
Ulnar to median nerve FWLD	0.78 [(-2.15)-(7.10)]	-0.10 [(-2.10)-(3.20)]	0.003*

**p<0.05*

DML (ms): *Distal motor latency,* ***CMAP (mV):*** *Compaund muscle action potential,* ***MCV (m/s):*** *Motor conduction velocity,* ***DSL (ms):*** *Distal sensory latency,* ***SNAP (μV):*** *Sensory nerve action potential,* ***MFL (ms):*** *Minimum F latency,* ***FWLD:*** *Minimum F wave latency difference*

Table 3. Diagnostic values of nerve conduction parameters and cut-off levels.

Variables	Ulnar minimum F latency	Median minimum F latency	Ulnar to median FWLD
Sensitivity % (95% CI)	46.15 (32.2-60.5)	23.08 (12.5-36.8)	53.85 (39.5-67.8)
Specificity % (95% CI)	71.15 (56.9-82.9)	96.15 (86.8-99.5)	80.77 (67.5-90.4)
Positive predictive value (95% CI)	61.5 (44.4 - 76.8)	85.7 (55.8 - 98.4)	73.7 (56.9-86.6)
Negative predictive value (95% CI)	56.9 (44.0 - 69.2)	55.6 (44.7 - 66.0)	63.6 (50.9-75.1)
Positive probability rate	1.6 (1.1 - 2.2)	6.0 (3.6 - 9.9)	2.8 (2.1 - 3.7)
Negative probability rate	0.76 (0.5 - 1.2)	0.80 (0.2 - 3.1)	0.57 (0.3 - 1.1)
Youden index	0,170	0,192	0,346
ROC curve			
AUC	0,578	0,568	0,669
Standard error	0,0564	0,0568	0,0543
95% confidence interval	0,478-0,675	0,468-0,665	0,570-0,758
p value	0,164	0,228	0,0019
Cut-off value	26.2	≤23.4	0.6

AUC: *Area under curve,* ***FWLD:*** *Minimum F wave latency difference,* ***ROC:*** *Receiver operating characteristic,* ***CI:*** *Confidence interval*

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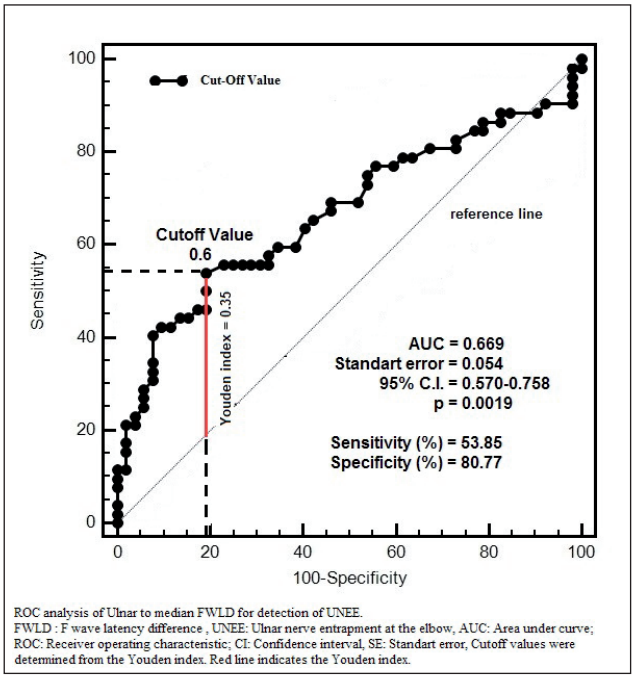

ROC analysis of Ulnar to median FWLD for detection of UNEE.
FWLD : F wave latency difference , UNEE: Ulnar nerve entrapment at the elbow, AUC: Area under curve; ROC: Receiver operating characteristic; CI: Confidence interval, SE: Standart error, Cutoff values were determined from the Youden index. Red line indicates the Youden index.

Figure 1. Receiver operating characteristic curve analysis of ulnar to median F wave latency difference.

distal motor conduction studies in detecting mild or early generalized abnormalities (18). The latencies of F waves are characteristically prolonged in neuropathies and may be abnormal even when peripheral motor conduction studies are normal. F wave latency prolongation has also long been described in patients with a focal proximal nerve lesion (19,20). A very sensitive criterion of abnormality is a latency difference between the two sides, or between two nerves in the same limb in a unilateral disorder affecting a single nerve (14). The ulnar nerve F wave over the ADM muscle and the median nerve F wave over the APB muscle share a common pathway at the level of the brachial plexus and medulla spinalis as both motor fibers that innervate these muscles originates from the same roots (C8 and T1).

Investigators have studied the median to ulnar nerve FWLD for the diagnosis of entrapment neuropathies. Sander et al (5) conducted a study on the 79 hands of 50 CTS patients and reported that median to ulnar FWLD could be useful in the diagnosis of CTS . Some investigators have also found results to the Sander et al study, with the exception of Joshi et al (6,7). Joshi et al (21) studied 125 CTS patients and found that the difference between distal sensory latencies of the median and ulnar nerves, the median sensory nerve conduction velocity and the difference between DML of the median and ulnar nerves had the highest sensitivity and specificity while difference between median nerve F wave latency and the median to ulnar nerve FWLD had the lowest sensitivity and specificity for the diagnosis of CTS. Using FWLD for the diagnosis of CTS has therefore remained a challenging and complex issue.

Alemdar (9) was the first to examine ulnar to median FWLD in the diagnosis of UNEE. They examined 34 arms of 17 UNEE patients and found that UNE could be confirmed easily and with a high sensitivity and specificity using F wave latency difference studies . To the best of our knowledge, the only other study on the value of ulnar to median FWLD in the diagnosis of UNEE is Alemdar's study. They found a sensitivity value of 94.1% and specificity value of 94.1% for ulnar to median FWLD in the diagnosis of UNEE and suggested it as a strong confirmatory method. They have also noted their small sample size. We had a larger sample size (52 UNEE patients) in our study. The ulnar to median nerve FWLD value was higher in the affected arm ($p<0.05$) in our study. This difference in latency was significant and could be explained on the basis of either demyelination or axonal loss in the elbow segment of the ulnar nerve. When sensivity and specificity studies were performed, we found that ulnar to median FWLD had a sensitivity of 53.85% and a specificity of 80.77% for the diagnosis of ulnar nerve entrapment at the elbow. This result is inconsistent with Alemdar's study. Several factors can contribute these results. First of all, our sample size was larger than in Alemdar's study but further studies are still required with high-power calculated samples. Secondly, the severity of UNEE can affect F wave values and lead to false negative or positive results. Studies stratified for the severity of UNEE are therefore needed. Thirdly the examiner placing F wave markers must be blinded to the diagnosis to eliminate bias. F wave marker placement is sometimes subject to examiner's choice, and this point is also a limitation of the study.

In conclusion, the ulnar to median FWLD is helpful as an adjunct to the clinical electrodiagnosis of UNEE. According to result although the sensitivity was low, specificity was found to be 80.77%. We therefore suggest that the FWLD be used in a confirmatory manner in diagnosing UNEE. An abnormality of the ulnar to median FWLD should be associated with an additional test abnormality that is localizing to the elbow segment of the ulnar nerve. Additional testing should be considered in the event that an abnormal FWLD is the sole electrodiagnostic abnormality.

Disclosure of conflict of interest

No conflict of interest

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