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Short Segment Conduction Study and Localization Features in Ulnar Neuropathy at the Elbow: A Retrospective Study of 57 Patients

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Abstract

Objective: The aim of this study was to investigate the localization properties in electrodiagnostically evaluated patients with a prediagnosis of ulnar neuropathy at the elbow.
Material and Methods: The results of 57 patients who were electrodiagnostically defined as ulnar neuropathy at the elbow, with using short segment conduction study (SSCS), were evaluated retrospectively. The number of extremities determined as having focal conduction block with changes in latency was 30, while focal conduction alone was 27. The locations of nerve entrapment sites were determined as humeroulnar arcade (HUA), retroepicondylar groove (RTC), medial intermuscular septum (MIS).
Results: The entrapment was found in the left upper extremity with a rate of 73%. The frequencies of localizations were determined for RTC (35%), MIS (25%), RTC+MIS (19%), HUA (16%), HUA+RTC (5%).
Conclusion: The entrapments at RTC, MIS and HUA regions could be determined in patients whom 10 cm SCSS technique was used. The localizations of ulnar nerve entrapment at the elbow were RTC, MIS and HUA, in the order of decreasing frequency.
Keywords: Ulnar neuropathy, short segment conduction study, elbow, cubital tunnel syndrome, entrapment neuropathies, electromyography

Introduction

Ulnar neuropathy at the elbow (UNE) is the second most frequently observed entrapment neuropathy in the upper extremity after the median nerve (1). The mean annual incidence is 24.7 per 100.000 people (2).

Developments and innovations recorded with electrodiagnostic techniques are useful for the accurate determination of UNE localization. Sensory nerve conductions recorded from the 5th finger by stimulating from the wrist or motor nerve conductions recorded by stimulating from three points (wrist, below the elbow, and above the elbow) are not sensitive enough to determine UNE localization (3,4). Short segment conduction study (SSCS) is a technique that is used for localizing entrapment through the course of the nerve and is increasingly be-

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coming more common. It has played a role in the increase of diagnostic sensitivity (5,6). Latency differences in short segments and reference values of conduction velocity have been revealed in a study conducted recently (7). A detailed electrophysiological examination including SSCS, in patients with UNE can influence the decision of conservative or surgical treatment and the technique of surgical treatment to be applied (8).

Changes in lifestyle, which lead to recurrent flexion of the elbow and occur with recently improving technology (increasing use of mobile phones, tablet computers and applications, computer games, etc.), have caused an increase in the frequency of UNE (9). It is thought that UNE mostly develops in the humeroulnar arcade (HUA) and/or retroepicondylar groove (RTC) (8,10-12). In addition, to our knowledge, there is no study conducted after these technological developments, in which the frequency of UNE localizations has been investigated.

The aim of this study was to examine the frequency of UNE localizations using the recent reference values that have been revealed retrospectively and the SSCS technique.

Material and Methods

Electrodiagnostic Study

The data of 57 patients (among 92 patients) who were evaluated with the pre-diagnosis of ulnar neuropathy in the electroneuromyography (ENMG) laboratory and who were consistent with UNE were used, and the results were retrospectively examined. The ethics committee approval for the study was received from Kocaeli University.

The study included patients whose differential diagnosis of cervical radiculopathy and/or brachial plexopathy was made based on clinical examinations and whose pre-diagnosis was UNE. The patients who had atrophy and remarkable muscle strength loss in the intrinsic muscles and required a needle electromyography (EMG) study and those who had the electrodiagnostic findings of polyneuropathy were excluded from the study. All electrodiagnostic studies were conducted by the same researcher (P.Y.). Nihon Kohden MEB-9400K (Nihon-Kohden Corp, Tokyo, Japan, 2011) system was used in the study. For motor conduction studies, the filter settings were adjusted between 20 Hz and 10 kHz, stimulation frequency was 1 Hz, and the duration of stimulation was 0.2 msn. For sensory conduction studies, the filter settings were between 20 Hz and 2 kHz, stimulation frequency was 1 Hz, and the duration of stimulation was 0.2 msn. During the procedure, the room temperature was maintained at approximately 25°C, and the skin temperature was maintained between 31 and 34°C.

In the median motor conduction study, the recording was made from the abductor pollicis brevis. Distal latency, amplitude, and nerve conduction velocity values were calculated. The median and ulnar sensory conductions were antidromically recorded from the 3rd and 5th fingers, respectively. For the ulnar motor response, the recording was made from the abductor digiti minimi muscle, and distal latency, amplitude, and nerve conduction velocity were subsequently calculated by stimulating the wrist and below the wrist.

SSCSs were performed when the shoulder was in abduction and external rotation and the elbow was in 70–90 degrees of flexion. The middle point of the line on the ulnar groove between the olecranon and medial epicondyle was taken as the reference point. In addition, points 4 cm distal and 6 cm proximal to this point were marked with 2 cm intervals. For preventing distal spread and stabilizing stimulation at a specific point, supramaximal stimulation and adequate pressure were applied (4). According to this, five short segments were obtained: first segment: 4 cm distal to the elbow–2 cm distal to the elbow; second segment: 2 cm distal to the elbow–the elbow; third segment: the elbow–2 cm proximal to the elbow; fourth segment: 2 cm proximal to the elbow–4 cm proximal to the elbow; and fifth segment: 4 cm proximal to the elbow–6 cm proximal to the elbow (7).

The compound muscle action potential (CMAP) was recorded from the abductor digiti minimi muscle. Latencies were calculated from the beginning of the stimulation to the beginning of the CMAP, and amplitudes were calculated from the middle line to the negative peak. Latencies and amplitudes were recorded for the five segments mentioned above.

Electrodiagnostic studies of 96 upper extremities of 92 patients were performed with the SSCS technique routinely applied in our electrodiagnosis laboratory and with the technique explained above. In addition, they were retrospectively re-evaluated with reference values that were recently revealed. Based on this evaluation, for latency change, the values above 0.5 msn in the 1st, 4th, and 5th segments; above 0.6 msn in the 2nd segment; and above 0.7 msn in the 3rd segment were accepted to be significant (7). For amplitude change, a decrease over 20% was interpreted in favor of focal conduction block, as recommended by the American Association of Neuromuscular and Electrodiagnostic Medicine (13).

Anatomic Naming

In this study, the entrapments in the medial epicondyle distal were considered as HUA lesions (cubital tunnel syndrome), which was the terminology used by Campbell (14). The entrapments in the immediate proximity of the medial epicondyle were evaluated as RTC, and the ones ≥2 cm proximal were evaluated as the medial intermuscular septum (MIS) entrapment (15).

In the results based on latency and amplitude changes, the classification of entrapments was performed as HUA when abnormal conduction was in the 1st and 2nd segments, as RTC when it was in the 3rd segment, and as MIS when it was in the 4th and 5th segments (14, 15).

Statistical Analysis

For statistical analysis, the Statistical Package for the Social Sciences 15.0 (SPSS, Inc., Chicago, IL, USA) for Windows software was used. Descriptive statistics were presented as number and percentage for categorical variables and as mean, minimum, and maximum values for numerical variables.

Results

Of 96 upper extremities of 92 patients, 57 (the mean age 42±10.9 years) were found to be consistent with UNE. Of these patients, 32 were female and 25 were male. Entrapment was detected in the left upper extremity at the rate of 73%.

Pathological findings obtained from SSCSs and including latency and amplitude changes are given in Table 1 and Table 2. All the electrophysiological findings are presented in Table 3.

Table 1. The values of pathological latency (msn) changes in short segments

	Min.	Max.	M.	SD
HUA - 1 (n=2	0.51	0.74	0.62	0.16
HUA - 2 (n=9)	0.62	1.82	0.85	0.35
RTC (n=29)	0.70	1.88	0.96	0.29
MIS - 1 (n=21)	0.50	1.36	0.71	0.24
MIS - 2 (n=2)	0.72	1.56	1.14	0.59

HUA - 1, humeroulnar arcade - 1: 4 cm distal to the elbow–2 cm distal to the elbow; HUA - 2, humeroulnar arcade - 2: 2 cm distal to the elbow–the elbow; RTC, retroepicondylar groove: the elbow–2 cm proximal to the elbow; MIS - 1, medial intermuscular septum - 1: 2 cm proximal to the elbow–4 cm proximal to the elbow; MIS - 2, medial intermuscular septum - 2: 4 cm proximal to the elbow–6 cm proximal to the elbow; Min: minimum; Max: maximum; M: mean; SD: standard deviation

Table 2. The values of pathological amplitude difference (%) in short segments

	Min.	Max.	M.	SD
HUA - 1 (n=1)	21.2	21.2	21.2	-
HUA - 2 (n=4)	25.1	47.7	32.3	10.3
RTC (n=15)	20.1	41.7	28.6	6.1
MIS - 1 (n=9)	22.6	78.2	37.3	18.7
MIS - 2 (n=2)	21.6	22.3	21.9	0.5

HUA - 1, humeroulnar arcade - 1: 4 cm distal to the elbow–2 cm distal to the elbow; HUA - 2, humeroulnar arcade - 2: 2 cm distal to the elbow–the elbow; RTC, retroepicondylar groove: the elbow–2 cm proximal to the elbow; MIS - 1, medial intermuscular septum - 1: 2 cm proximal to the elbow–4 cm proximal to the elbow; MIS - 2, medial intermuscular septum - 2: 4 cm proximal to the elbow–6 cm proximal to the elbow; Min: minimum; Max: maximum; M: mean; SD: standard deviation

Table 4. Distributions of UNE with latency change accompanied by focal conduction block and with only latency change

	Latency change and focal conduction block	Latency change
Number of extremities	30	27
Age (m, min-max)	39 (21-64)	44 (23-70)
Gender (F, % / M, %)	17 (57) / 13 (43)	15 (55) / 12 (45)
Right / Left (n, %)	8 (27) / 18 (73)	7 (26) / 23 (74)
HUA (n, %)	4 (15)	5 (18)
RTC (n, %)	8 (30)	12 (44)
MİS (n, %)	8 (30)	6 (23)
HUA+RTC (n, %)	1 (3)	2 (7)
RTC+MIS (n, %)	6 (22)	5 (18)

UNE: ulnar neuropathy at the elbow; HUA: humeroulnar arcade; RTC: retroepicondylar groove; MIS: medial intermuscular septum; HUA+RTC: entrapment in humeroulnar arcade and retroepicondylar groove together; RTC+MIS: entrapment in retroepicondylar groove and medial intermuscular septum together; F: female; M: male

Table 5. Localization features of UNE

	Female		Male		Total
	Right n=8	Left n=24	Right n=6	Left n=19	n=57
HUA (n, %)	0 (0)	5 (21)	2 (33)	2 (10)	9 (16)
RTC (n, %)	4 (50)	10 (42)	2 (33)	4 (21)	20 (35)
MIS (n, %)	4 (50)	4 (16)	1 (17)	5 (26)	14 (25)
HUA+RTC (n, %)	0 (0)	0 (0)	0 (0)	3 (19)	3 (5)
RTC+MIS (n, %)	0 (0)	5 (21)	1 (17)	5 (26)	11 (19)

UNE: ulnar neuropathy at the elbow; HUA: humeroulnar arcade; RTC: retroepicondylar groove; MIS: medial intermuscular septum; HUA+RTC: entrapment in humeroulnar arcade and retroepicondylar groove together; RTC+MIS: entrapment in retroepicondylar groove and medial intermuscular septum together

Table 3. All latency (msn) changes and amplitude (mV) difference values in short segments (n=57)

	Latency				Amplitude			
	Min.	Max.	M.	SD	Min.	Max.	M.	SD
HUA - 1	0.04	0.74	0.33	0.13	-4.83	2.02	-.6791	1.53108
HUA - 2	0.08	1.82	0.41	0.31	-1.29	5.00	.1596	1.08857
RTC	0.10	1.88	0.66	0.37	-3.50	3.90	.8808	1.79317
MIS - 1	0.14	1.36	0.51	0.27	-2.90	3.99	.8273	1.81266
MIS - 2	0.02	1.56	0.28	0.25	-1.10	1.50	-0.1250	0.28963

HUA - 1, humeroulnar arcade - 1: 4 cm distal to the elbow–2 cm distal to the elbow; HUA - 2, humeroulnar arcade - 2: 2 cm distal to the elbow–the elbow; RTC, retroepicondylar groove: the elbow–2 cm proximal to the elbow; MIS - 1, medial intermuscular septum - 1: 2 cm proximal to the elbow–4 cm proximal to the elbow; MIS - 2, medial intermuscular septum - 2: 4 cm proximal to the elbow–6 cm proximal to the elbow; Min: minimum; Max: maximum; M: mean; SD: standard deviation

Although the number of extremities in which latency change with focal conduction block was detected was 30, the number of extremities in which only conduction block was found was 27 (Table 4). In the evaluation of localization frequencies, RTC, MIS, RTC+MIS, HUA, and HUA+RTC were found as 35%, 25%, 19%, 16%, and 5%, respectively (Table 5).

Discussion

In this study, the most common entrapment region of the ulnar nerve at the elbow was firstly RTC and then MIS. The least common region was HUA. It was observed that the number of patients diagnosed with focal conduction block that accompanied latency change was higher than the number of patients diagnosed only with latency change. In our study, it was detected that left dominance was available in patients with the diagnosis of UNE.

Electrodiagnostic tests can be restricted to the investigation of the accuracy of the pre-diagnosis established by a clinician or surgeon. Because the diagnostic value of routine motor conduction studies is lower, avoiding from standardized studies will keep patients away from unnecessary and disturbing procedures. The sensitivity of SSCS in the determination of UNE is similar to that of nerve conduction studies that are routinely performed, but its specificity is higher (3,5,6). Therefore, in our study, nerve conduction studies performed with stimulation below and above the elbow were not preferred, and SSCS was applied instead of them. The results were re-evaluated retrospectively using new reference values detected in a large population.

The general view based on a few studies conducted on this issue is that the ulnar nerve is mostly entrapped in RTC and/or HUA (8,10-12). Two studies are often reported as a basis for this information. In the study of Kanakamedala et al. (16), which was conducted on 13 patients, the rates of entrapment in RTC and HUA were reported as 62% and 28%, respectively. In the study conducted by Campbell et al. (17), in which they used intraoperative electroneurography by saying that "it was good, but not perfect", the results were consistent with this study, and the entrapment rates of RTC and HUA were reported as 69% and 23%, respectively. We assume that results different from those in our study may have resulted from the low number of patients in the first study and not using the SSCS technique, which has a high sensitivity and specificity in the detection of UNE, in both studies.

In the study of Kim et al. (18), which was published in 2003, they retrospectively examined the surgical exploration results of a large population (n=654), and they revealed that the most frequent region of lesion was the medial epicondyle proximal. The results of this study are similar to ours. However, it does not give a true opinion on the frequency of entrapment regions because it included ulnar nerve injuries such as gunshot injuries and lacerations to a large extent.

The entrapment of the ulnar nerve in the retroepicondylar groove and proximal was called as "tardy ulnar palsy", which is a terminology that is not often used currently. With the term "tardy", entrapments developing after a fracture or injury at the elbow was implied (19). From our point of view, rarity of this kind of etiologies caused a relatively high frequency of HUA entrapments. The term of entrapment also covers traction and friction that develop in the nerve as well as nerve dysfunction occurring because of the increased compression of the surrounding anatomical structures on the nerve. Compression, traction, and friction mechanisms lead to pathology in the formation of ulnar neuropathy (12). The products that have come into our lives with developing technology and that are becoming more common with long-term use require the elbow to be used with prolonged increased flexion. In a study conducted by Gelberman et al. (20), it was demonstrated that elbow flexion over 130 degrees increased intraneural pressure with traction mechanism. We assume that an increased frequency of entrapment in the MIS region occurs with the traction and stretching mechanisms in this region of the nerve. Although the extension in the proximity of the medial epicondyle can reach to 10 mm with the elbow flexion, the extension to the region distal to the medial epicondyle (in HUA) can be 3–6 mm (21,22). Therefore, a more apparent extension that develops in the MIS region of the ulnar nerve with an increased elbow flexion causes this segment to remain relatively ischemic and the capacity to be stimulated is blocked. The reason for the increase in the frequency of neuropathy in the MIS region can be explained by this. On the other hand, RTC is the elbow region in which exposure to acute and chronic external compression is easier; therefore, the frequency rate of compression is higher. Moreover, recurrent subluxation of the ulnar nerve is one of the factors increasing UNE frequency in this region.

In the study of Visser et al. (5), which was conducted using SSCS in 2005 (n=60), entrapment was detected in the region distal to the medial epicondyle in 40% of patients and in the retroepicondylar groove in 35% of patients. SSCS was also used in this study, but it was applied with 8 cm technique instead of 10 cm technique. However, some of the MIS entrapments occur 4–6 cm proximal to the medial epicondyle and in the 5th segment as in our study. Different results can be explained with this technical difference and also with that this study was conducted with a population in which technological applications requiring elbow flexion were not so common and not used in those years.

Focal conduction block is associated with the shorter duration of symptoms and younger age of patients (5). One of the potential weaknesses of our study is that the duration of symptoms was not investigated previously because of it being a retrospective study. UNE is a neuropathy that generally develops as acute (23). In acute compression neuropathies, the physiological response occurs as focal conduction block (24). In consistency with this situation, it was observed in our study that the number of patients determined with focal conduction block was higher than the number of patients diagnosed only with latency change.

In our study, UNE was detected in the left upper extremity at the rate of 75%. Although this seems irrational considering that the dominant hand of most people is the right hand, other studies also confirmed this result. In fact, when the dominant hand is actively used, the non-dominant hand and elbow remain in the flexion position for holding objects or for leaning on a fixed surface. Also, in the studies of Todnem et al. (12) and Visser et al. (5), the rates of the left upper extremities with UNE were 79% and 65%, respectively.

Electrophysiological examination in association with the accurate detection of localization with SSCS is important for the elimination of other diagnoses, confirmation of pre-diagnosis, and choice of surgical treatment technique (8). In our study, anatomical naming of the area corresponding to the localization region that was determined with SSCS was used. In the previous studies conducted with the SSCS technique, the localization of entrapment in a 10 cm region proximal and distal to the elbow had been reported, but an exact anatomical definition had not been made.

UNE is a subject that has not reached a consensus with respect to its terminology. As is known, some researchers accept all UNE cases as "cubital tunnel syndrome" (25). On the other hand, for preventing confusion, some other researchers use the term "HUA" for the region that is anatomically corresponding to the "cubital tunnel" region, as in our study (8). Apart from that, there is no consensus on the entrapment regions. Campbell described four entrapment regions for the ulnar nerve at the elbow: MIS, RTC, HUA, and the exit point from the flexor carpi ulnaris (FCU) (18). On the other hand, according to Posner, there are five potential compression regions with the addition of the arcade of Struthers to the abovementioned regions (26). RTC is the region between the medial epicondyle and olecranon, HUA is approximately 3–25 mm distal to the medial epicondyle, and MIS starts from approximately 2 cm proximal to the medial epicondyle and extends on the upper arm (15,18,26). The arcade of Struthers is a fibrous structure located 6–10 cm proximal to the medial epicondyle, and its existence was revealed in 70% of people (27). Entrapments in this region are quite rare. The exit point from FCU is another rare entrapment region, and it occurs 4–7 cm below the medial epicondyle (28). Because SSCS was applied in a 10 cm area in our study, the exit point from FCU and the arcade of Struthers were not evaluated. The entrapments 0–4 cm distal to the medial epicondyle were accepted as HUA, the entrapments 0–2 cm proximal to the medial epicondyle were accepted as RTC, and the ones 2–6 cm proximal were evaluated as MIS entrapments. Nevertheless, because all these anatomical regions are extremely close to each other, the distance should be specified in cm according to a reference point (medial epicondyle, etc.), and the term "approximately" should be used in the reports to avoid possible anatomical variations among people.

The retrospective feature of our study and relatively low number of patients are the limitations of our study. On the other hand, the use of new reference values for patients evaluated electrodiagnostically with SSCS has strengthened the results of our study.

Conclusion

The entrapment regions of the ulnar nerve at the elbow were RTC, MIS, and HUA according to the order of their frequency rates. The accurate detection of UNE localization can affect the treatment plan. The presence of focal conduction block that is revealed with SSCS and the effect of findings such as a localization region on the clinical symptoms can be determined with further prospective studies. Our study is important for the physician who diagnoses and the physician who plans the treatment to speak the same language in UNE for which different names are available for the same regions. Localization in UNE is clarified with electrodiagnostic evaluations and it should be clearly mentioned.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Kocaeli University.

Informed Consent: Due to the retrospective design of the study, informed consent was not taken.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - P.Y.; Design - P.Y.; Supervision - H.G.; Resource - P.Y., T.O.M., G.E.; Materials - P.Y., A.Y.; Data Collection and/or Processing - P.Y., A.Y., T.O.M., G.E.; Analiz ve/veya yorum / Analysis and/or Interpretation - P.Y., A.Y.; Literature Review - P.Y., T.O.M., G.E.; Writer - P.Y., H.G.; Critical Review - H.G.

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