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The diagnostic role of ultrasound in cubital tunnel syndrome for patients with a previous cubital tunnel surgery

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Abstract *Background:* Ultrasound is widely used in the diagnosis of peripheral nerve compressions. Nevertheless, the role of ultrasound, and in particular the cross-sectional area (CSA) measurements, in the diagnosis of cubital tunnel syndrome (CuTS) is debatable, especially in patients who have had previous surgeries. We evaluated the diagnostic value of ultrasound and CSA measurements in a heterogenous group of CuTS patients suffering from persisting or recurrent CuTS after a previous surgical intervention.
Methods: All patients with persisting or recurrent CuTS after previous surgery, who received a nerve ultrasound with or without CSA measurements in a tertiary referral center between 2015 and 2022, were included. Median CSA was calculated at five locations from the upper arm to the wrist. The sensitivity of ultrasound and electrodiagnostic studies and the correlation between both diagnostic tools were calculated.
Results: Thirty-seven nerves from 35 patients who received nerve ultrasound, of which 21 nerves from 19 patients who received additional CSA measurements, were included. Ultrasound indicated signs of persisting or recurrent compression in 73.0% of patients, and ulnar swelling based on CSA measurements was found in 71.4% of patients. Electrodiagnostic testing was positive in 40.7% of patients. CuTS diagnosis was supported by both electrodiagnostic studies and CSA in only 34.6% of patients.
Conclusions: CSA and electrodiagnostic testing in patients with persistent or recurrent symptoms after previous surgery did not correlate well, and the sensitivity of both tests was lower than in diagnostic accuracy studies. Ultrasound was found to be useful in evaluating ulnar nerves after previous surgery.

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Introduction

Cubital tunnel syndrome (CuTS) is a common disease and the second most prevalent compression neuropathy of the upper extremity.[1] Symptoms include tingling, numbness, and loss of strength distally from the elbow in the ulnar nerve distribution, usually combined with pain.[1]

For the diagnosis of CuTS, the Dutch Institute for Healthcare Improvement's (CBO) guideline recommends to consider ulnar nerve ultrasound in addition to electrodiagnostic studies.[2,3] Both electrodiagnostic studies and ultrasound are widely used in the diagnosis of peripheral nerve compressions. Electrodiagnosis can help localize the site of compression, but on the other hand nerve conduction and electromyography (EMG) are considered to be painful.[4] Ultrasound, on the other hand, is quick, inexpensive, noninvasive, and does not have any contraindications.[5] Ultrasound can also provide additional information about the anatomical location of the entrapment and the appearance of the nerve.[5,6] During a nerve ultrasound, the following findings can point toward a nerve entrapment: a swollen segment proximal of the compression, increased intraneural vascularity, reduced mobility, blurred margins, and loss of the fascicular pattern.[7-10]

Nevertheless, the role of ultrasound in the diagnosis of CuTS is debatable, especially in patients who have had previous surgeries. Studies that evaluate the diagnostic reference values of the cross-sectional area (CSA) and CSA ratio (comparing the CSA to the CSA of the upper arm) of the ulnar nerve are performed in patients who have not had previous surgeries for their ulnar neuropathy.[11-14] In our tertiary referral facility, we mostly see patients with persisting or recurrent ulnar nerve entrapment symptoms. Though recurrence or persistence of symptoms is common, in these patients, the diagnostic algorithm has not defined well.[15]

The aim of this study is to evaluate the diagnostic value of nerve ultrasound, and in particular CSA measurements, in patients suffering from persisting or recurrent CuTS after previous cubital tunnel surgery.

Patients and methods

Patients

All adult patients diagnosed with persistent or recurrent CuTS in 2015 to 2022 after previous ipsilateral cubital tunnel surgery at our hospital were identified. CuTS diagnosis was based on a combination of diagnostic tools, physical examination, and patients' history. Specific signs were pain, tingling, numbness, and decreased motor function of the fourth and fifth fingers. Signs like posturing (clawing of the fourth and fifth fingers) and weakness or atrophy of the atrophy of the intrinsic muscles, hypothenar of first web space were considered signs of advanced disease. The Tinel's sign was considered positive in case of a tingling sensation into the fourth and fifth fingers by tapping along the inside of the elbow, directly over the ulnar nerve.

The results of physical examination, electrodiagnostic testing, and ultrasound were retrospectively retrieved from the electronic patient file, after patients informed consent. Patients with CuTS who had nerve ultrasounds performed were included in the study, after informed consent was obtained. The protocol was approved by the Medical Ethical Committee (MEC-2021–143), and informed consent was obtained from all included participants.

Ultrasonography

Ultrasonography was performed using a Philips iU22 (Philips Medical Instruments, Bothell, WA) with a 5–17 MHz linear array transducer. Patients were placed in a supine position, with the shoulder in 90° abduction and the elbow 90° flexion. The ulnar nerve was examined from midupper arm to midforearm. The appearance of the nerve (i.e., thickening, echogenicity, and edema), luxation and angulation of the nerve, adhesions, and possible anatomical abnormalities were all noted. Intraneural vascularity was not measured in standard practice. Using a standardized protocol, the CSA of the nerve was determined at the following 5 locations: Guyon's canal, proximal 1/3th of the forearm, distal of the cubital sulcus, medial epicondyle, proximal of the cubital sulcus, and distal 1/3th of the upper arm. The reference value for a swollen nerve is set at $\geq$10mm^2, according to a meta-analysis of Chang et al.[11] CSA measurements on the contralateral asymptomatic side were not performed.

Electrodiagnostic studies

Sensory and motor nerve conduction studies of the ulnar nerve were taken. Electrodiagnostic testing was performed with the elbow flexed in 90° during the examination with a standardized distance of 8–10 cm between the segments. Motor response was recorded from the abductor digiti minimi muscle (ADM) and the first dorsal interosseous muscle (FDI). Compound muscle action potential (CMAP) and sensory nerve action potentials (SNAP) were registered. In case of a severely decreased CMAP, a motor study of the FCU muscle with inching was considered to determine focal conduction slowing or partial conduction block.

Statistical analyses

Ultrasound measurements and observations were analyzed using descriptive statistics using median with interquartile range (IQR) or absolute numbers with percentages. Missing data were not imputed. Statistical analysis was performed using SPSS version 27.0.

Results

A total of 37 ulnar nerves were studied from 35 patients diagnosed with persistent or recurrent CuTS after previous ipsilateral cubital tunnel surgery who received a nerve ultrasound, of which 21 ulnar nerves from 19 patients receiving additional CSA measurements of the ulnar nerve. Since patients were seen in a tertiary center, 90% of the patients were referred from other hospitals for a second opinion after persistence or recurrence of symptoms after the previous surgery. A total of 18 patients had advanced

Table 1 Characteristics of patient groups.

	Patients with nerve ultrasound	Patients with CSA measurement
Patients, N	35 (20 male, 15 female)	19 (9 male, 10 female)
Elbows, N	37 (22 male, 15 female)	21 (11 male, 10 female)
Age in years, median (IQR)	57 (43 - 68)	56 (41 - 71)
BMI, median (IQR)	27.5 (24.17 - 30.0)	26.2 (24.2 - 30.0)
Symptoms, N (%)		
Pain	34 (91.9)	19 (90.5)
Tingling	27 (73.0)	18 (85.7)
Numbness	20 (54.1)	13 (61.9)
Posturing	5 (13.5)	2 (9.5)
Weakness	15 (40.5)	10 (23.8)
Months between last surgery and ultrasound, median (IQR)	16 (11 - 39)	16 (10 - 39)
Operations before ultrasound, N (%)		
1	8 (21.6)	5 (23.8)
2	13 (35.1)	8 (38.1)
3	9 (24.3)	5 (23.8)
4	4 (10.3)	3 (14.3)
5	3 (7.7)	0 (0)
Type of surgery before ultrasound, N (%)		
Open decompression	5 (13.5)	4 (19.0)
Endoscopic decompression	3 (8.1)	1 (4.8)
Submuscular transposition	19 (51.4)	11 (52.4)
Free muscle transfer	10 (27.0)	5 (23.8)

BMI = body mass index; IQR = interquartile range.

Table 2 Nerve ultrasound outcomes.

	N of nerves (%)
Signs of nerve compression	27 (73.0)
Nerve thickening	26 (70.3)
Other echostructure	9 (24.3)
Edema	1 (2.7)
Luxation of the nerve	7 (18.9)
Angulation of the nerve	3 (8.1)
Adhesions	5 (13.5)

Ultrasound was performed in a total of 37 nerves.

disease based on reported symptoms. The Tinel's sign was performed in 29 of 35 patients and was described to be positive in 24 patients. Table 1 shows the patient characteristics including symptoms and the number and type of operations of all the included patients.

Ultrasound

Nerve ultrasound was positive for ulnar nerve compression in 27 (73.0%) patients. All findings are shown in Table 2. In one patient, data on nerve thickening were missing. Although not measured in all patients, increased intraneural vascularity was recorded in one patient. Other findings were a lipoma, a subcutaneous lymph node, and swelling of an unknown origin in the elbow, all without pressure on the ulnar nerve. An epitrochlear muscle was not described to compress the ulnar nerve.

Table 3 Median CSA.

	CSA, median (IQR)	Min	Max
Guyon's canal	5.3 (4.5-6.1)	4.0	7.5
1/3th of the lower arm	6.0 (5.4-6.6)	5.0	9.2
Distal sulcus	8.1 (7.0-8.5)	4.9	11.1
Medial epicondyle	12.1 (9.3-14.5)	5.9	17.0
Proximal sulcus	8.3 (6.8-10.5)	5.8	15.5
1/3th of the upper arm	6.5 (5.6-7.6)	3.8	8.8
Maximum CSA	12.0 (9.0-14.4)	7.4	17.0

CSA measurements were assessed using standard protocol in 21 nerves in total. Median values with IQR and range and minimum and maximum values are shown for all measurement points. CSA = cross-sectional area; IQR = interquartile range.

CSA measurements

Ulnar swelling (CSA $>10mm^2$) was found in 15 (71.4%) patients. The maximum CSA was located at the medial epicondyle, the proximal, and the distal sulcus in 14 (66.7%), 4 (19.0%), and 3 (14.3%) patients, respectively. In 7 patients (33.3%), swelling of the ulnar nerve was found not only focally but also along a trajectory of the nerve covering the medial epicondyle and the trajectory proximal and/or distal to the medial epicondyle. Median CSA measurements for all five locations are shown in Table 3.

Electrodiagnostic studies

Electrodiagnostic studies were performed in 27 nerves from 26 patients. In 13 nerves, no abnormalities were seen. The

Table 4 Correlation between nerve ultrasound and electrodiagnostic studies.

		Reported nerve thickening ($N = 26$)		Absolute CSA measurements ($N = 21$)	
		No ($N = 7$)	Yes ($N = 19$)	<10 mm2 ($N = 5$)	≥10 mm2 ($N = 11$)
Electrodiagnostic studies	CuTS	2 (11.5)	6 (23.1)	1 (4.8)	3 (14.3)
	Mild CuTS	0 (0)	3 (11.5)	0 (0)	3 (14.3)
	Neuropathy but no compression	0 (0)	3 (11.5)	1 (4.8)	2 (9.5)
	No abnormality	5 (19.2)	7 (26.9)	3 (14.3)	3 (14.3)

Nerve thickening was assessed using two methods: 1) descriptive outcomes of ultrasound in which nerve thickening in and around the sulcus was reported and 2) absolute CSA measurements at specific locations of the ulnar nerve, following the described protocol. Percentages given are based on the total of nerves assessed. CuTS = cubital tunnel syndrome.

signs of CuTS were found in 11 nerves (40.7%), of which four had only mild focal slowing. Three nerves showed signs of neuropathy without nerve compression.

Correlation between CSA measurements and electrodiagnostic studies

In 26 nerves, outcomes on electrodiagnostic and nerve thickening were available. In 34.6% of these patients both diagnostic tools supported a CuTS diagnosis. Outcomes did not correlate in 12 patients (46.2%). In 5 patients (19.2%), both CSA measurements and electrodiagnostic studies did not support CuTS diagnosis. However, CuTS diagnosis was made based on clinical symptoms, and patients were treated accordingly. Table 4 shows the correlation between nerve thickening (based on reported thickening and absolute CSA measurements) and outcomes of electrodiagnostic studies.

Discussion

In this study, we described the CSA measurements of patients with clinically diagnosed persistent or recurrent CuTS after previous ipsilateral cubital tunnel surgery. Hereby, we are able to give insight in the outcomes of ultrasound, including CSA measurements and electrodiagnostic studies in a heterogenous group that is poorly described in the literature. Besides two small studies, most studies exclude patients with a previous cubital tunnel surgery from their database.[16,17]

We found ulnar swelling in the majority of patients. Our reported sensitivity of 71.4% in patients with persisting or recurring symptoms after previous surgery is lower than the previously reported sensitivity in patients diagnosed with CuTS without previous surgery, being 85% (95% CI 78% - 90%).[11-13] This is possibly the result of our heterogenous patient group in a tertiary center (due to referral bias), a wide variety of underlying causes for recurrent or persisting symptoms, and the different types of surgery (simple decompression or submuscular transposition). Median CSA values in our cohort (12.1 mm2 at the medial epicondyle and 8.1 mm2 and 8.3 mm3 at the distal and proximal sulcus) are comparable, but a bit lower compared to mean values reported by Gruber et al. (11.49 mm2 distal to the upper fascial passage and 10.84 mm2 proximal to the lower fascial passage) and lower than reported by Kowalska (18.0 mm2).[16,17]

In line with previous studies, nerve swelling was present not only at the medial epicondyle but also at the distal and proximal sulcus.[17,18] A recent meta-analyses reported that over half of previously performed diagnostic accuracy studies only measured CSA at the medial epicondyle,[11] which may therefore have underestimated nerve swelling. Based on our findings, we advise to not only measure at the medial epicondyle but also to measure the CSA at multiple locations along the ulnar nerve trajectory around the elbow joint.

Nerve swelling after previous surgery can have several reasons. Firstly, it may be the result of recurrent compression due to ineffective surgery, scar tissue, or adhesions. Secondly, swelling may be residual after initial compression, and CSA does not normalize independent of symptoms. Thirdly, nerve swelling may occur or worsen postoperatively. Two studies found that CSA measurements to significantly decrease after surgery, although in one study, CSA measurements remained high and stayed above the diagnostic cutoff value.[19,20] Unfortunately, studies could not correlate the CSA decrease with clinical findings. Kowalska noted that in patients who experienced several years of symptoms, despite clinical improvement after release, the regression of pathological echo structure was not always observed.[16]

We had repeated CSA measurements of only two patients with persistent complaints, in which both patients had persistent nerve thickening. One patient had two preoperative CSA measurements, eight months apart (11.7 mm^2 and 13.4 mm^2), and showed persistent nerve thickening seven months after surgery (15.7 mm^2) with additional nerve angulation at the sulcus. Another patient had two post-operative CSA measurements, one for recurrent complaints 39 months after initial surgery (14.9 mm^2) and the other for persisting complaints two months after revision surgery (12.2 mm^2), respectively. Unfortunately, preoperative measurements are missing. The latter nerve ultrasound also showed additional adhesions. Electrodiagnostic studies were performed in the first patient only and were positive for CuTS before and after surgery.

The sensitivity of electrodiagnostic testing was 40.7% in patients with previous surgery. Consequently, the percentage of patients for whom both electrodiagnostic testing and ultrasound support CuTS diagnosis is low (34.6%). This is lower than reported by Kowalska, where electrodiagnostic testing confirmed the clinical and ultrasound diagnosis in 60% of patients.[16] These numbers suggest that in our clinical practice, we base our diagnosis on clinical symptoms rather than only on diagnostic tools, mostly because the majority of patients have been referred for a second opinion and have had previous surgery. Electrodiagnostic findings were reported to be 'mild' in three patients, in which all had ulnar swelling. As more patients had positive ultrasound findings than electrodiagnostic findings, CSA measurements seem to be more representative of clinical outcomes than electrodiagnostic testing in our cohort. However, nerve thickening may persist after surgery, regardless of persistent or recurring symptoms.

The present study is limited by a relatively small number of patients, a single center design, and a retrospective design. Because of the retrospective design and the fact that patients are referred to our center from other hospitals for a second opinion, data on preoperative diagnostics, duration of symptoms, and intraoperative findings are not available in all patients. Larger prospective studies should further investigate the sensitivity of both diagnostic tools in patients with recurrent or persisting CuTS symptoms after previous surgery and their correlation to clinical findings.

Conclusion

Our study indicates that the sensitivity of both CSA and electrodiagnostic testing is lower than in diagnostic accuracy studies, when conducted in patients with persistent or recurrent symptoms after previous surgery. Although ultrasound may be very useful to assess postoperative anatomy, adhesions, location and stability of the nerves, both CSA and electrodiagnostic outcomes should be critically appraised, and CuTS diagnosis should be primarily based on clinical findings and the exclusion of other possible pathologies. If CSA measures are performed, it should include measurements of the entire elbow region and not only the medial epicondyle.

Declaration of Competing Interest

None.

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None

Ethical approval

The protocol was approved by the Ethical Medical Committee (MEC-2021-143), and informed consent was obtained from all included participants.

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