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# Which ultrasonographic measure has the upper hand in ulnar neuropathy at the elbow?

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HIGHLIGHTS

- This study, designed according to the STARD initiative criteria, explored the usefulness of several types of ultrasonographic ulnar nerve size measurements in the diagnosis of ulnar neuropathy at the elbow.
- The diagnostic accuracy of ultrasonography in ulnar neuropathy at the elbow was lower than previously reported.
- Ultrasonographic ulnar nerve diameter, cross-sectional area and swelling ratio measurements are equally useful in diagnosing ulnar neuropathy at the elbow.

ABSTRACT

*Objective:* To compare the diagnostic accuracy of ultrasonographic ulnar nerve diameter, cross-sectional area (CSA) and swelling ratio measurement in ulnar neuropathy at the elbow (UNE).
*Methods:* Ultrasonographic diameter, CSA, and swelling ratio measurements were compared with a reference standard including clinical examination, electrophysiological studies, and follow-up in a prospective cohort of patients. All patients in whom a diagnosis of UNE was considered were eligible for the study. Reference values for ultrasonography were obtained in 73 healthy volunteers.
*Results:* Of 191 patients, 137 had UNE or probable UNE, while 54 had another condition and these were analysed as patient controls. Patients with UNE had a larger ulnar nerve diameter, CSA and swelling ratio than healthy controls and patient controls ($p < 0.01$). The diagnostic accuracies of these different measurements were comparable with a specificity of 78–87%, a positive predictive value of 87–90%, a sensitivity of 42–61% and negative predictive value of 37–44%. ROC-analysis for these measurements showed an area under the curve of 0.75–0.77.
*Conclusion:* Ultrasonographic measurements of ulnar nerve diameter, CSA and swelling ratio have comparable diagnostic value, which was lower than reported previously.
*Significance:* Ultrasonographic ulnar nerve diameter, CSA and swelling ratio measurements are equally useful in diagnosing UNE.


## 1. Introduction

The diagnosis of ulnar neuropathy at the elbow (UNE) may seem straightforward in most of the cases. However, clinical examination is often non-localizing, the role of provocative tests only marginal, while electrophysiological tests may be normal or non-localizing with sensitivities ranging from 37% to 86% (AAEM, 1999; Beekman et al., 2009; Stewart, 1987). High-resolution ultrasonography has been advocated as an accurate additional test by demonstrating ulnar nerve thickening at the elbow, but the best way of measurement is not clear and its definite role is not yet firmly established (Beekman et al., 2011).

It has been suggested that two-dimensional measurements of the ulnar nerve cross-sectional area (CSA) on transverse scans are more accurate than one-dimensional diameter measurements on longitudinal scans (Wiesler et al., 2006). Furthermore, several authors have found that nerve thickness may be confounded by

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age, sex, weight, and body mass index and it is therefore hypothesised that a swelling ratio comparing ulnar nerve thickness around the elbow with ulnar nerve thickness at a more proximal or distal site may be more reliable, using the patient as his own control (Thoirs et al., 2008; Yoon et al., 2008).

Several studies have shown that measurements of CSA and swelling ratio can differentiate patients with UNE from healthy controls (Bayrak et al., 2010; Gruber et al., 2010; Mondelli et al., 2008; Thoirs et al., 2008; Volpe et al., 2009; Wiesler et al., 2006; Yoon et al., 2008). However, the actual diagnostic accuracy of these two tests remains unknown because patient controls were never studied (Beekman et al., 2011). In our study, designed according to the STARD initiative criteria (Bossuyt et al., 2003), we therefore sought to determine whether the diagnostic accuracy of ultrasonographic measurements of ulnar nerve CSA and swelling ratio are superior to diameter measurements.

## 2. Methods

### 2.1. Patients

Between August 2009 and September 2010, we prospectively studied the diagnostic value of ultrasonographic measurements of the ulnar nerve in patients referred to the outpatient department of neurology of our center, a large general teaching hospital. Patients were eligible for the study if UNE was considered in the differential diagnosis after clinical examination. Exclusion criteria were acute traumatic origin, previous elbow surgery, history of a polyneuropathy or genetically proven hereditary neuropathy with liability to pressure palsies, and findings of a polyneuropathy at clinical examination. The study was approved by the local medical ethical committee.

### 2.2. Study procedures

After clinical examination, patients were referred for electrophysiologic and ultrasonographic studies. The protocol for electrophysiologic and ultrasonographic studies is described below, a description of the clinical examination can be found elsewhere (Beekman et al., 2004). Electrophysiologic and ultrasonographic studies were performed without knowledge of the clinical information or disease status of the patient. The electrophysiological examiner was masked for the ultrasonographic test result and vice versa. Additional electrophysiological and imaging studies could be ordered if the differential diagnosis included a possible radiculopathy, plexopathy, or other neuropathy. The final diagnosis was made without knowledge of the result of ultrasonography. Patients in whom a diagnosis other than UNE was made were analysed as patient controls. If patients reported bilateral complaints, only the most severely affected side according to the patient was used for analysis.

### 2.3. Healthy controls

A control group of healthy volunteers was recruited among hospital personnel and inpatients to determine reference values of the ultrasonographic measurements. Volunteers were only considered if they had no symptoms of a neuropathy. One arm of each individual was randomized. Informed written consent was obtained in all healthy controls. For all measurements upper limits of normality (ULN) were defined as the mean plus two standard deviations (SD).

### 2.4. Electrophysiological studies

Ulnar sensory and motor nerve conduction studies were performed with the elbow flexed at 90°. If necessary, skin temperature was raised to >32 °C using hot water baths. Surface stimulation was performed with the cathode placed at the proximal wrist crease, 4 cm distal to the medial epicondyle, and 4–6 cm above the elbow (range of the across-elbow distance was 8–10 cm). Compound muscle action potentials (CMAP) were recorded from the ADM and FDI muscles using surface electrodes in a belly-tendon montage. Sensory nerve action potentials (SNAP) were obtained antidromically using ring electrodes placed over the fifth digit. With use of concentric needle myography, the ulnar muscles were studied for fibrillations, positive waves, motor unit potential configuration, and recruitment pattern.

In accordance with guidelines of the Dutch Neurophysiological Society and AAEM, we only localized the ulnar neuropathy at the elbow when one or more of the following abnormalities were found (reference values derived from our previous studies, mean ± 2 SD): CMAP reduction from the below- to the above-elbow site of >16% (block); motor nerve conduction velocity (MNCV) across the elbow of <46 m/s (slowing); MNCV at the across-elbow segment >15 m/s slower than at the forearm segment (differential slowing); abnormal needle myography of the FCU or FDP muscles. Other abnormalities, such as low or absent distal action potentials, or abnormal needle myography of the ADM or FDI muscles, could suggest an ulnar neuropathy but did not localize it at the elbow. Cut-off values for an abnormally low action potential were as follows: <5.5 mV for the ADM CMAP; <7.0 mV for the FDI CMAP; <6.5 μV for the digit V ulnar SNAP (Beekman et al., 2004).

### 2.5. Index test – ultrasonography

Using a 5- to 16-MHz linear-array transducer experienced neurophysiological personnel performed ultrasonographic examination of the affected ulnar nerve using standardized settings of the ultrasound machine. All participants were in a supine position with their elbow 90° flexed. On longitudinal scans, the diameter of the ulnar nerve was determined within the echogenic rim surrounding the ulnar nerve, accurate to 0.1 mm (Fig. 1). On transverse scans, the CSA of the ulnar nerve was determined using the automatic ellipse tool of the ultrasound machine, accurate to 1 $mm^2$ (Fig. 2). Nerves in which the shape on transverse images was not well suited to CSA measurements by fitting an ellipse were measured by direct tracing. The ulnar nerve was scanned from the middle of the upper arm to the middle of the forearm. Nerve size was measured at the level of the medial epicondyle, 2 cm proximal and distal to this level but also at the site of maximum thickness around the elbow, and in the middle of the upper arm and forearm. Ulnar nerve upper arm and forearm swelling ratios were calculated by dividing the maximum ulnar nerve CSA at the elbow to the ulnar nerve CSA at the middle of the upper arm or forearm respectively.

Ultrasonography was considered positive for UNE when: (a) the maximum diameter or CSA of the ulnar nerve around the elbow was larger than the ULN for maximum diameter or CSA in the healthy control group, (b) the diameter or CSA at one or more of

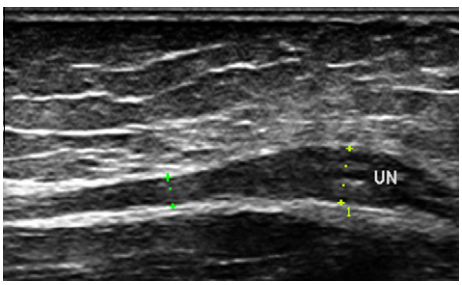


**Fig. 1.** Ultrasound picture of an enlarged ulnar nerve just proximal to the medial epicondyl on a longitudinal section (diameter measured by calipers increases from 2.2 to 4.1 mm).