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Ulnar Goniometer: a simple device for better neurophysiological evaluation of the Motor Conduction Velocity of the Ulnar Nerve.

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Think green before you print

ABSTRACT

OBJECTIVE

The use of the Ulnar Goniometer standardizes the method of detecting the Motor Conduction Velocity (MCV) of the Ulnar nerve by keeping the elbow flexed at a fixed angle, thus enabling an easier and more precise measurement.

MATERIALS AND METHODS

The stimulations were performed by two independent operators. We evaluated 30 participants of both genders with paresthetic symptoms of the upper limbs and 30 healthy and asymptomatic volunteers. Each operator performed the examination without and with the use of the Ulnar Goniometer, detecting the velocity of motor conduction wrist-below elbow and the speed above-elbow (AE) below-elbow (BE). Agreement between the measurements was assessed with intraclass correlation coefficient (ICC).

RESULTS

The repeatability of the measurements between operators was modest without the use of the support (ICC = 0.152) while a good agreement was found when the operators used the support (ICC = 0.499).

DISCUSSION AND CONCLUSIONS

The most obvious results of the study were the reduction of the difference between operators using the Ulnar goniometer, the increase in the repeatability of the measurements and the specificity of the test.

Keywords: ulnar goniometer, ulnar electroneurography, repeatability.

INTRODUCTION

Electroneuromyography is considered the reference standard for the functional evaluation of the ulnar nerve. This nerve is among the most superficial in the human body and, for this reason, it is particularly vulnerable to acute or repeated trauma to the elbow. Ulnar nerve entrapment neuropathy at the elbow. Ulnar nerve entrapment neuropathy, also referred as Cubital Tunnel Syndrome (CuTS), is the second most frequent acquired condition among "certain" syndromes, only after carpal syndrome [1].

CuTS is a condition associated with the entrapment of the ulnar nerve at the level of a canal present in the inner face of the elbow, the so-called epitrocleo-olecranial shower or cubital tunnel [1]. This consists of a bony fund formed by the medial epicondyle of the humerus, by the olecranon of the ulna and by a ligamentous roof, which is formed by a firm fibrous band stretched between the olecranon and the medial epicondyle. This latter structure may show a thickening known as Osborne band [2]. After passing the cubital tunnel, the ulnar nerve enters a fibrous tunnel formed by a ligament that joins the two muscle heads of the ulnar flexor carpus muscle, which is also anchored to the medial epicondyle of the humerus and the olecranon. This fibrous fascia can also present thickenings, which are capable to result in compressive effects on the ulnar nerve that runs deep inside it [2]. In some cases, the symptoms may also be associated with a phenomenon of dislocation or subluxation of the ulnar nerve outside the epitrocleo-olecranial groove during flexion-extension movements of the elbow. The nerve can also suffer from focal lesions in the wrist and the hand, and even less frequently in the armpit, upper arm, or forearm.

Distinguishing between these different compression sites is not always straightforward. Typical symptoms of CuTS include pain and sensory disturbances on the ulnar side of the hand (the portion of the palm in the last two fingers). Symptoms can occur at night and are typically most pronounced upon awakening. Prolonged flexion of the elbow can make them worse. In most cases, the first electrodiagnostic findings are consistent with a demyelinating trapping neuropathy characterized by a slowing of the nerve conduction velocity in the above elbow (AE) and below the elbow (BE).

For a complete electroneuromyographic examination, the dynamic ultrasound allows the visualization of the nerve along its course, highlighting any volumetric increase (sign of edema) and dislocation of the nerve at the olecranon-epitrochlear shower in combination with the flexion-extension movements of the elbow.

A reduction in motor conduction velocity in the AE-BE tract greater than 10 m/s compared to that evaluated in the underlying elbow-wrist tract is considered pathological [3].

There are several issues related to the electrodiagnostic evaluation of the ulnar nerve, including uncertain tieson the best position of the elbow, the ideal length of the transverse elbow segment, and the value of absolute slowdown in the AE-BE segment as opposed to a relative slowdown in the AE-BE segment, compared to the BE-wrist segment. According to the American Association of Neuromuscular and Electrodiagnostic Medicine (AANEM) guidelines [3] and consistently with the available literature [4], for most accurate detection of the motor conduction velocity (MCV) of the ulnar nerve in the AE- BE, the elbow should be at an angle between 70 and 90 degrees, and the measurement of the above-below-elbow should be approximately 11 cm [3,5].

When the ulnar nerve is not positioned at the recommended angle, it is "folded" on itself (fig. 1) leading to a less reliable measurement of the MCV. Accordingly, positioning the limb at the indicated angle [3,5] allows a more accurate assessment of the MCV.

The objective of this study was to standardize the method of detecting the motor conduction velocity of the ulnar nerve, in particular in the AE-BE tract, through the use of an ulnar goniometer (patent number IT201900009912 (A1) - 2020-12 -26) [6] (Fig. 2).

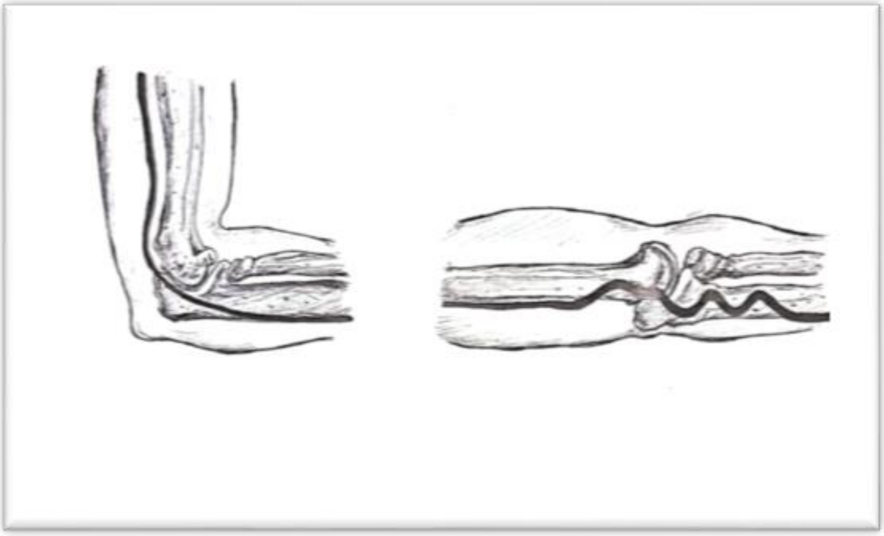

Figure 1. Conformation of the ulnar nerve at the elbow with the limb in flexion (A) and extension (B) – thanks to Antonio Scarafino (MD) for the drawing.

Figure 2. Positioning of the arm on the ulnar goniometer

The use of this device allows to position the arm at a fixed angle (Fig. 2) by partially immobilizing it. Recording is then conducted with surface electrodes from the abductor brevis muscle of the fifth finger and sometimes also from the dorsal interosseous muscle. The obtained measurements are homogeneous with each other (MCV AE-BE and MCV-BE-Wrist are almost equal or vary slightly). The ulnar goniometer is presented as a support consisting of a base and an adjustable arm according to the angle (70 ° or 90 °) that we choose for our measurement, using a "step guide" (Fig. 3).

Figure 3 Ulnar Goniometer

MATERIALS AND METHODS

ULNAR ELECTRONEUROGRAPHY

Ulnar electroneurography (ENG) is the study of the neurophysiological parameters of nerve conduction and measures the ability to transmit nerve impulses along the course of peripheral nerves. During the Stimulation of the ulnar nerve, the recording electrodes are placed on the abductor brevis muscle of the 5th finger in the midpoint of the muscle belly, while the reference electrode on the medial phalanx of the 5th finger. The ground electrode is placed on the medial region of the wrist or on the back of the hand. Stimulation points are at the wrist, approximately 80 mm proximal to the recording electrode, at the sub-elbow (BE), approximately 6-10 mm distal to the medial epicondyle, at the over-elbow (AE), approximately 110 mm from the point under the elbow, armpit and Erb's point [7]. The normal values of MCV at all stimulation sites are higher than 50 m/s (according to the regulatory values of our Laboratory of Miulli Hospital), except for the AE-BE section where the MCV can be reduced to a lesser extent of 10 m/s. Another point of derivation for calculating the MCV of the ulnar nerve is the First Dorsal Interosseus (FDI) muscle, which is more sensitive to speed slowdowns in the AE-BE section [8].

POPULATION AND ANALISYS PARAMETERS

30 partecipants with paresthetic symptoms of the upper limbs and 30 healthy and asymptomatic volunteers were enrolled. The study was approved by the Independent Ethics Committee of the Bari Polyclinic and involved the use of the ulnar goniometer, at a 90 ° angle, for above and below the elbow stimulation of the ulnar nerve. Some subjects gave consent for the exploration of both limbs, others for the single limb.

Recordings were performed by two operators, each one performing the exam without and with the use of the Ulnar Goniometer for the detection of the MCV BE-wrist and the MCV AE-BE. In the sessions in which the Goniometer was not used, patients were asked to keep the arm in flexion at about 90 °, but due to stimulation and lack of cooperation, the position varied during the examination. In subjects in whom there was evidence of slowing of the MCV, the ulnar nerve was explored by recording from the First Dorsal Interosseus (FDI) muscle [7].

STATISTICAL ANALISYS

Data are shown as the mean value ± standard deviation, and categorical variables are given as frequencies or percentages. Patients and controls were compared by using Student's t-test (continuous variables) and by chi-square test (categorical data) while repeated measures in the same subject were evaluated by paired-sample Student's t-test. Equality of variances was tested to compare the variability of measurements with and without the use of the ulnar goniometer. Bland-Altman analysis was used to assess the agreement between the measurements by plotting the differences of values with and without support against the averages of the two techniques. A horizontal line was drawn at the mean difference, and at the limits of agreement, which are defined as the mean difference plus and minus 1.96 times the standard deviation of the differences. To quantify agreement between measurements we calculated the Intraclass Correlation Coefficient (ICC), which ranges from 0 (poor reliability) to 1 (perfect agreement between measurements). A $p < 0.05$ was considered for statistical significance. All analyses were conducted using STATA software, version 16 (Stata-Corp LP, College Station, Tex).

RESULTS

The demographics of the 30 patients and 30 controls are shown in Table 1. No significant differences were found between groups for distribution by gender and age. Tables 2 and 3 describe the measurements performed by the two operators in the entire sample. Part of the patients and controls had one measurement only because they consented only to a single arm stimulation.

	Controls	Patients	
	n = 30	n = 30	p
Gender			0,19
Female	15 (50%)	20 (67%)	
Male	15 (50%)	10 (33%)	
Age	46 ± 11	51 ± 15	0,16

Table 1: demographics of the 30 patients and the 30 controls

Measurements (m/s)	all	Controls	Patients	
Operator 1	n=76	n=35	n=41	p
MCV BE-Wrist Without Goniometer	63.5±8.9	62.9±5.2	64.1±11.1	0,56
MCV AE-BE Without Goniometer	59.5±10.1	57.6±8.6	61.0±11.1	0,15
Difference MCV WithoutGoniometer	4.1±14.1	5.2±9.7	3.1±17.0	0,5
MCV BE-Wrist with Goniometer	61.9±5.0*	61.7±4.1*	62.2±5.6*	0,65
MCV AE-BE with Goniometer	59.2±6.5*	59.0±4.7*	59.3±7.7*	0,82
Difference MCV with Goniometer	2.8±4.7*	2.7±3.4*	2.9±6.4*	0,88

*Table 2. * p <0.05 for comparison of standard deviations with and without Goniometer*

Measurements (m/s)	All	Controls	Patients	
Operator 2	n=76	n=35	n=41	p
MCV BE-Wrist Without Goniometer	63.6±6.8	63.7±7.4	63.5±6.3	0,89
MCV AE-BE Without Goniometer	61.1±11.5	62.2±10.9	60.2±11.9	0,46
Difference MCV Without Goniometer	2.5±13.9	1.6±14.5	3.3±13.4	0,59
MCV BE-Wrist with Goniometer	61.2±5.1*	61.0±5.2*	61.4±5.0*	0,68
MCV AE-BE with Goniometer	57.6±6.0*	57.6±5.4*	57.6±6.6*	0,99
Difference MCV with Goniometer	3.6±4.7*	3.4±2.8*	3.9±5.8*	0,64

*Table 3. * p <0.05 for comparison of standard deviations with and without Goniometer.*

No significant differences were found between groups for both operator 1 and operator 2. In the recordings without support, we found a significantly increased variability (standard deviation) compared to the same measurements when the evaluation was carried out with the support.

Figures 4 and 5 show the Bland-Altman graph for the evaluations performed by the two operators to measure the difference between MCV BE-wrist and AE-BE without using the ulnar goniometer (standard measurement) and with the use of the support. The difference in the measurements made with and without support by the two operators has an average close to zero with a fair dispersion of the values and a positive trend of the difference between measurements as the estimated value increases without support. The Bland-Altman analysis suggests a tendency to overestimate measurements without the support compared to the evaluation with ulnar goniometer, for both groups and for the two operators. The overestimation is related to the average of the measurements (the difference between measurements increases as the estimated value increases without support).

Figures 6 and 7 show Bland-Altman chart for the assessments performed without the use of the ulnar goniometer (standard measurement) and with the use of the support to quantify the difference between motor conduction velocity (MCV) under the elbow-wrist and over-under-elbow made by the two operators. The difference in the measurements made by the two operators has an average close to zero with a large dispersion of the values measured by the two operators without support and with a reduction in the differences observed between operators when the measurement was performed with the ulnar goniometer.

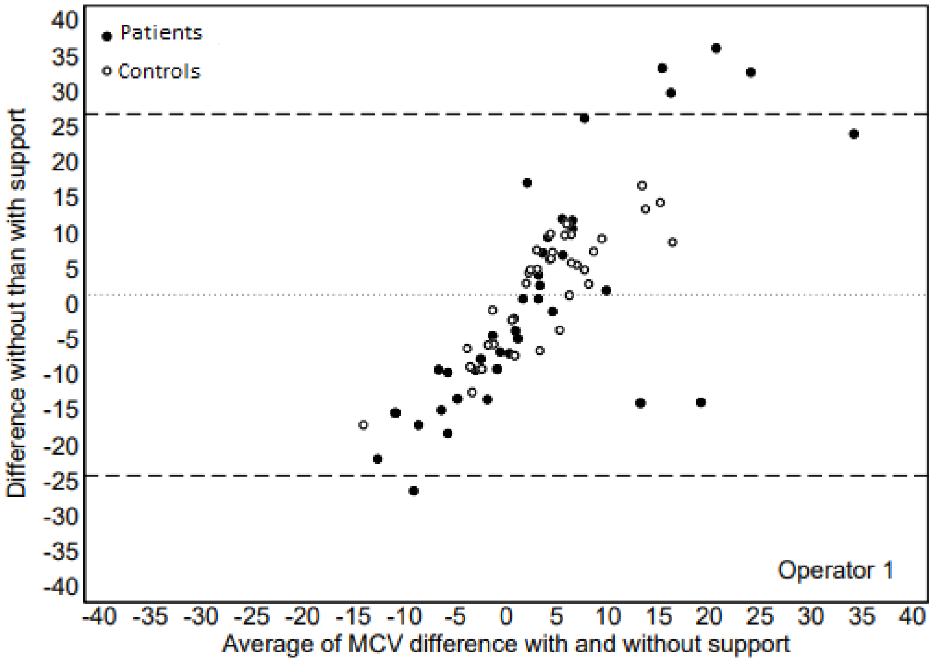

Figure 4: The dashed line represents the average of the difference between unsupported measurement compared to the measurement made using the ulnar goniometer. The dotted lines represent the range of ± 1.96 of the standard deviation of the differences

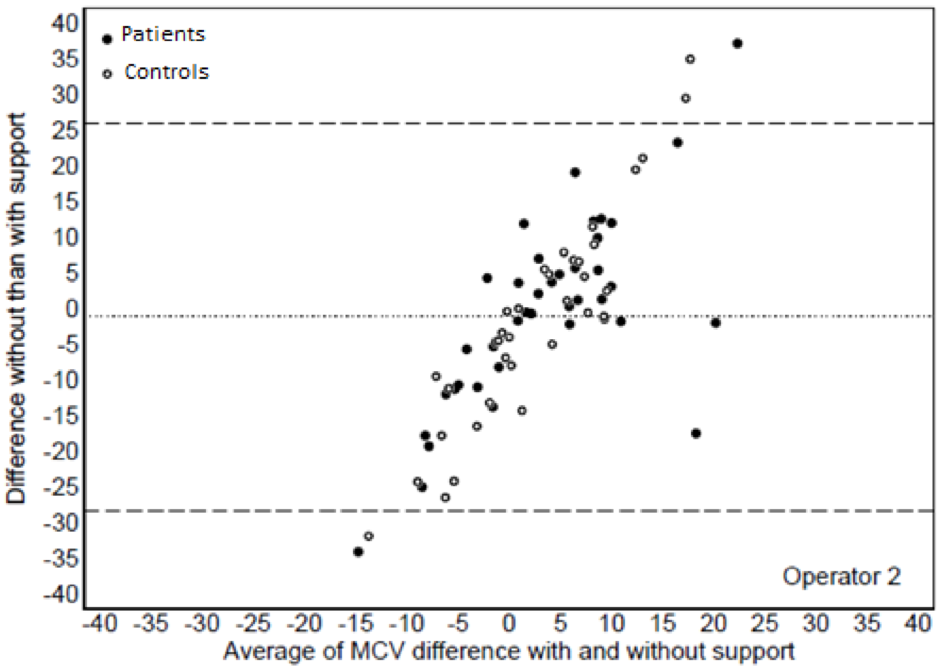

Figure 5: The dashed line represents the average of the difference between unsupported measurement compared to the measurement made using the ulnar goniometer. The dotted lines represent the range of ± 1.96 of the standard deviation of the differences

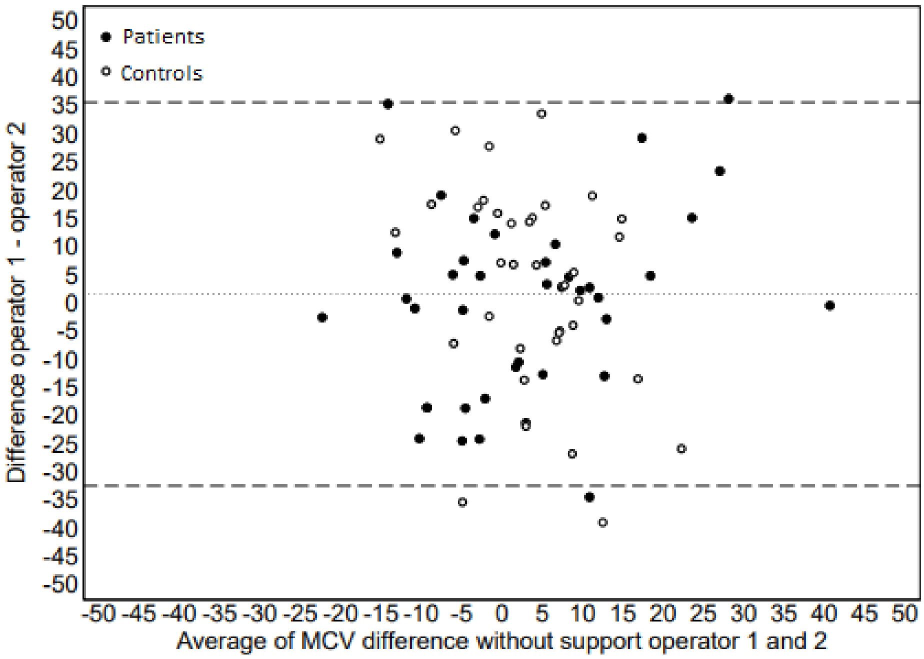

Figure 6: The dashed line represents the average of the difference between measurement made by the first operator compared to the measurement made by the second operator. The dotted lines represent the range of ± 1.96 of the standard deviation of the differences (compared to the mean).

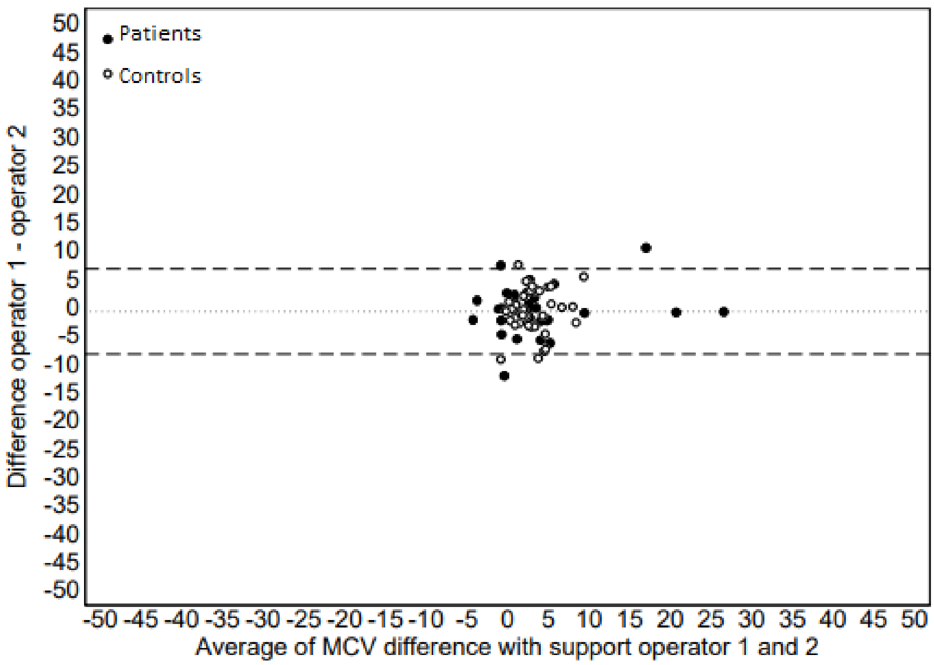

Figure 7: the dashed line represents the average of the difference between measurement made by the first operator compared to the measurement made by the second operator. The dotted lines represent the range of ± 1.96 of the standard deviation of the differences (compared to the mean).

For both groups, the assessments performed by the two operators were highly variable without the use of the support device. When the measurement was performed with the ulnar goniometer, the repeatability between operators increased significantly. Table 4 shows ICC results for the measurements performed by the two operators in the entire population. The repeatability of the measurements between operators was modest without the use of the support (ICC = 0.152). Stronger repeatability (ICC = 0.499) was found when the operators used the support.

Figure 8 shows percentage of measurements with difference between motor conduction speed (MCV) under the elbow-wrist and over-under-elbow greater than 10 units for the assessments performed by the two operators without the use of the ulnar goniometer (standard measurement) and with the use of the support. The difference between under-elbow-wrist and over-under-elbow MCV was greater than 10 units in 29% of measurements performed without support by the first operator and in 24% by the second operator with no difference between patients and controls (29% in both groups for the first operator with 24% of the patients and 23% of the controls for the second operator). The difference between under-elbow-wrist and over-under-elbow MCV with ulnar goniometer was greater than 10 units in 5% of the measurements performed by the first operator and in 4% by the second operator without differences between patients and controls (3% of patients and 1% controls for the first operator with 3% of patients and no controls for the second operator).

	ICC between operators	p
Difference MCV without Goniometer	0.152	0.031
Difference MCV with Goniometer	0.499	<0.001

Table 4: ICC results for the measurements performed by the two operators in the entire population

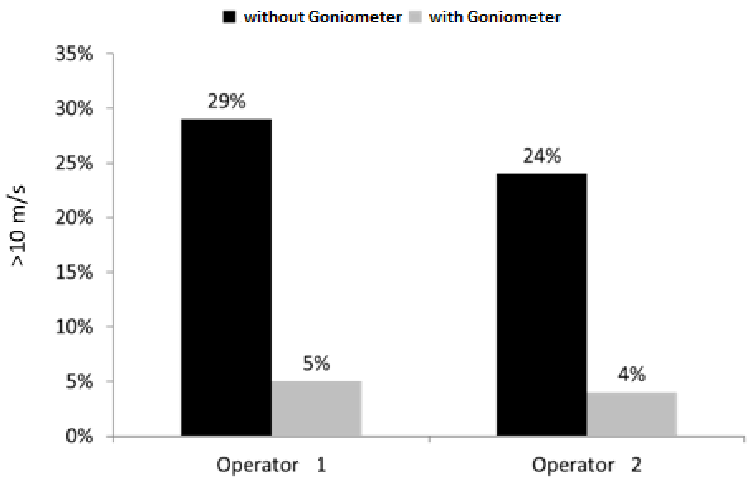

Figure 8: percentage difference between MCV under the elbow-wrist and over-under-elbow

DISCUSSION AND CONCLUSIONS

When left untreated, the cubital tunnel syndrome can lead to motor disturbances affecting the small muscles of the hand with reduced strength and difficulties in making fine movements.

Our investigations of the MCV of the AE-BE and the BE-wrist showed a reduction of the variability of the measurements and a greater agreement between operators by using the Ulnar Goniometer. Overall, our results suggest that this device may enable more precise and reproducible measurements. Furthermore, performing the measurements with the Ulnar Goniometer led to a reduced percentage of false positives (greater specificity of the method). This would likely result in a smaller percentage of patients undergoing further examinations, and/or receiving unnecessary treatment, ultimately translating into a saving of resources of the health-care system.

In this study major focus was given to the variability between methods and between operators, as the patients included did not present symptoms purely typical of CuTS. In future work, we aim to evaluate patients with probable or confirmed SCC or other neuropathies associated with morphological alterations of the elbow [9] to assess the diagnostic capability of measurements with and without device, including analysis of sensitivity (ability to identify the patient) and specificity (ability to discriminate between healthy subjects and patients). Lastly, we aim to provide the results obtained with ultrasound images of the ulnar nerve at the elbow, evaluating the cross-sectional area also with dynamic tests.

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