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Scientific/Clinical Article

Upper limb neurodynamic test 1 in patients with clinical diagnosis of carpal tunnel syndrome: A diagnostic accuracy study

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ABSTRACT

Study Design: Diagnostic accuracy.
Introduction: Upper limb neurodynamic test 1 (ULNT1) is used to evaluate the mechanical sensitivity especially in the peripheral nerves of the upper limbs. The reproduction of typical symptoms in the affected hand improves the estimation of the probability of carpal tunnel syndrome (CTS). However the test has not been evaluated sufficiently to determine its real usefulness. In the present study the diagnostic accuracy of ULNT1 as a clinical test for CTS was determined.
Methods: We used the ULNT1 as the index test and nerve conduction as the reference standard. 120 subjects, (240 hands), with a medical diagnosis of CTS were evaluated. The study population was a consecutive series of participants. Sensitivity, specificity, positive and negative predictive values, accuracy, and positive likelihood ratio were calculated.
Results: ULNT1 was found to have a sensitivity of 93 % and a specificity of 6.67 %. The positive likelihood ratio was 1.04 and the negative likelihood ratio was 1.00. The positive predictive value was 86.9 % and the negative predictive value was 12.5%.
Discussion: Acute or relatively mild CTS cases may not be accurately identified through nerve conduction tests. The findings of this study coincide with other studies in the finding that ULNT1 has a significant diagnostic and clinical screening value for CTS in people at-risk, or with upper limb symptoms.
Conclusion(s): This research suggests the use of ULNT1 as a screening test for CTS, followed by tests that are more specific.
Level of Evidence: III-2.

Introduction

Carpal tunnel syndrome (CTS) is considered to be the most common nerve entrapment among lesions occurring in the peripheral nerves of the upper limbs.[1] In the United States, it has been estimated that the costs associated with CTS exceed 2 billion dollars a year.[2] In addition, people with physician-diagnosed CTS have substantially more sick leave than the general population.[3] Severe pain and depression have been associated with this condition, along with functional limitations.[4,5]

Prevalence has been estimated between 1.5% and 5.8% in the general population.[6] Occupation has proven to be a very important risk factor for suffering the disorder,[7-9] and high proportions of CTS are observed among construction (8.2%), poultry (8.9%), and dairy workers (16.6%).[10,11] It is associated with work involving repetitive manual tasks, movements of the wrist that require great strength, pressure on the wrist, physical activities with wrist strain, and low job satisfaction.[12,13]

Symptoms of CTS include hand pain and tingling, pain or numbness in the thumb, index finger, middle finger, and radial side of the ring finger, and reduced grip strength and function of the affected hand.[14] The clinical examination consists of history, physical examination, and manual tests.

To date, no diagnostic test research has shown both high sensitivity and high specificity for identifying this disorder.[15]

The average sensitivity of Tinel's sign is about 50%, and the sensitivity of Phalen's test is 68%. The average specificity of Tinel's sign is 77%, with 73% for Phalen's test.[16]

Conflict of interest: All named authors hereby declare that they have no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Phalen's and Tinel's provocative tests have been categorized as highly recommended due to their positive likelihood ratio (LR) above 2.0. The average calculated + LR for Phalen's test in a literature review was found to be 2.68, with 2.95 for Tinel's sign and 2.28 for the modified compression test. A mean negative LR of more than 0.5 resulted from 2 or more studies with high scores (8 of 12) on the MacDermid rating scale.[17]

There is also a documented need to optimize diagnostic criteria for CTS in epidemiologic research.[18]

Upper limb neurodynamic tests (ULNTs) are used to evaluate the mechanical sensitivity of the nervous system, especially in the peripheral nerves of the upper limbs.[19] These tests are considered useful because they determine mechanical function and can even discriminate between normal subjects, patients with shoulder pain secondary to musculoskeletal injuries, and patients with a high probability of neuropathic pain.[20] From this perspective, these tests can contribute greatly to a structural differential diagnosis in CTS cases.

In clinical practice, nerve conduction studies with an 85% sensitivity and 95% specificity are used, along with a physical examination, to determine the degree of nerve involvement in CTS.[21]

Clinical research of the syndrome is continuously exploring new diagnostic techniques. Modified clinical test assessments,[22] symptom questionnaires,[23] ultrasound,[24] and sonoelastography[25] have been developed as aids in diagnosing CTS.

The reproduction of typical symptoms in the affected hand during ULNT1 improves the estimation of the probability of CTS. This aids the early and differential diagnosis of median nerve compression at the carpal tunnel level. For this test, Vanti et al[26] estimated sensitivity at 91.67%, specificity at 15%, positive LR at 1.0784, negative LR at 0.5556, and the post-test probability for negative tests at 40%. However, ULNT1 has not been tested sufficiently to determine its real usefulness.[17]

In the present study, the diagnostic accuracy of ULNT1 as a clinical test for CTS was determined, thus defining its diagnostic value as a screening test to be implemented in the health surveillance examinations and monitoring of people under hazardous conditions, or who present upper limb neurologic symptoms compatible with CTS.

Methods

Study design

A diagnostic accuracy study. Data collection was planned previously. We used ULNT1 as the index test and nerve conduction as the reference standard. This study lasted 18 months, from January 2013 to August 2014.

Participants

Study population

About 118 subjects (230 hands), with a medical diagnosis of CTS and no specification of unilateral or bilateral involvement, were evaluated between the months of August 2013 and February 2014, at a health services institution.

The inclusion criteria were female and male patients aged 18-86 years, referred with a clinical diagnosis of CTS. Exclusion criteria were pathologies of the upper limbs and cervical spine that might limit the range of motion of the left or right upper extremities[27]; patients with a history of rheumatoid arthritis, anterior shoulder dislocation, complex regional pain syndrome, Raynaud's syndrome, breast cancer, or rotator cuff injuries; and patients with cervical spinal stenosis, or cognitive deficits.

Recruitment

The study population was a consecutive series of participants defined by the selection criteria, with a clinical diagnosis of CTS, attending the health institution for a nerve conduction test.

This study was previously approved by the ethics committee of the Universidad del Rosario's School of Medicine and Health Sciences. All subjects were informed about the research and were asked to sign an informed consent form. Nerve conduction study results were blinded to both the examiner and the patient. Because ULNT1 is testing the mechanosensitivity of the nerve, the performance of electrodiagnostic tests could have increased this sensitivity before ULNT1. To prevent this increased sensitivity, ULNT1 was applied 20 minutes after the nerve conduction test.

Test methods

The evaluation team was made up of 2 physiotherapists who took the patient's history and performed the clinical tests, including ULNT1, and a physiatrist who performed the nerve conduction studies.

To determine the diagnostic accuracy of ULNT1, an evaluation form that included the following components was used:

1. History: Demographics, biomechanical demands, and occupation.
2. Because the primary symptoms reported by the CTS population could be similar to those of cervical radiculopathy (upper extremity pain, numbness, and weakness),[28] the physical examination included Spurling's test and the distraction test to exclude participants who might have had cervical radiculopathy.
3. Reference standard method: A physiatrist used the technique and recommendations outlined by the American Association of Electrodiagnostic Medicine[29] for the study of motor and sensory nerve conduction.
   The classification recommended by the Association of Electrodiagnostic Medicine and used in this study was normal (grade 0); very mild (grade 1), CTS demonstrable only with the most sensitive tests; mild (grade 2), sensory nerve conduction velocity slow on finger or wrist measurement, normal terminal motor latency; moderate (grade 3), sensory potential preserved with motor slowing, distal motor latency to abductor pollicis brevis (APB) <6.5 milliseconds; severe (grade 4), sensory potentials absent but motor response preserved, distal motor latency to APB <6.5 milliseconds; very severe (grade 5), terminal latency to APB >6.5 milliseconds; and extremely severe (grade 6), sensory and motor potentials effectively unrecordable (surface motor potential from APB <0.2 mV amplitude).
4. Index test: ULNT1 for median nerve was graded according to Wainner's criteria,[22] and symptoms were located as proposed by Lohkamp and Small.[30] The decrease in range of motion was measured with a goniometer.

Each patient initially underwent nerve conduction study. Twenty minutes later, 2 physiotherapists specializing in manual therapy, with 12 years of experience, took the patient's history and performed Spurling's test and the distraction test. One of the physiotherapists performed all ULNT1 tests.

The procedure used for measuring range of motion was as follows[31]: the ulnar styloid process, medial epicondyle of the humerus, and anterior aspect of the acromion process were marked to use as reference points for the elbow joint angle measurements. One physiotherapist performed the test, whereas another registered the measurements to avoid bias. The axis was placed on the medial epicondyle with the stationary arm pointing to the acromion and the moveable arm to the ulnar styloid process.

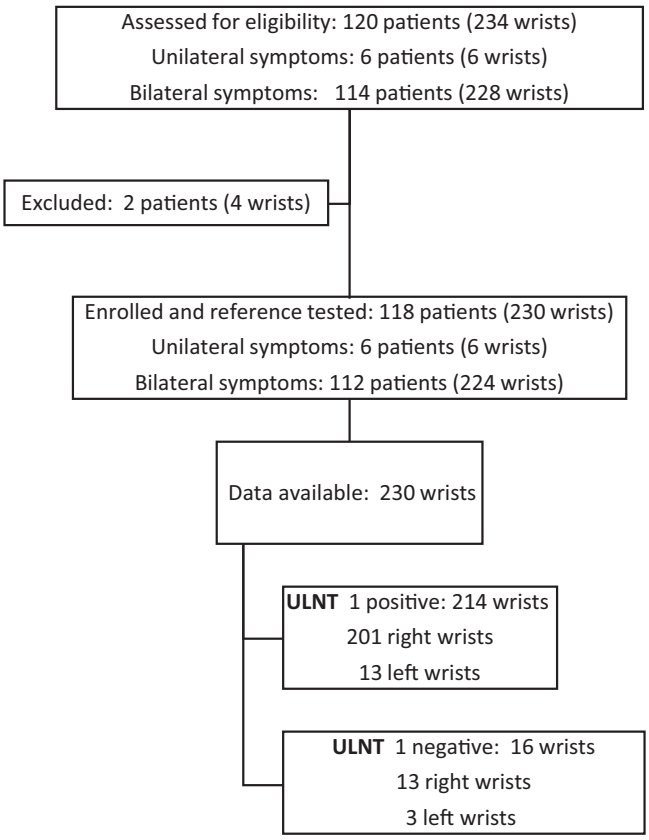

Fig. 1. Patients enrolled and tested. ULNT = upper limb neurodynamic test.

For all tests, participants lay supine without a pillow, arms along the body, and legs straight. Tests were carried out slowly, and participants were instructed to indicate the point at which it was too uncomfortable to continue with the movement (point of pain tolerance). Angle measurements were then taken at this point. The total time for each test was always under 1 minute, but there was no standardization of the movement time. Once the test was ended, the location and nature of the sensory response was marked on a body chart. Participants were asked an open question about the nature of the sensory response, but if they had difficulty finding a descriptor, they were prompted with the following: stretch, pain, tingling, pins and needles, numbness, and burning. Multiple responses were allowed in both area and nature of sensation.

The starting position for ULNT1 was 90° abduction and 90° external rotation of the shoulder, 90° elbow flexion, forearm supination, maximum extension of wrist and fingers, and abduction of the thumb. One of the physiotherapist's hands was placed on the scapula to prevent elevation; the other hand maintained finger abduction. The elbow was then slowly extended until the point of pain tolerance, and the elbow angle was measured.

Table 1
Demographic characteristics of the study population ($N = 118$)

Characteristic	Total ($n = 118$)	
Age	Range	Mean
	18-86	50.51
	N	%
Female	98	83.05
Right handed	105	88.98
Smokers	95	80.5
Occupation with repetitive hand movements	94	79.6

Table 2
Duration of wrist/hand symptoms ($N = 115$)

Months	*N*[a]	%
<1 mo	2	17
1-3	14	12.2
>3 mo	99	86.1

[a] Missed: 3.

The analysis was conducted using Wainner's criteria, and ULNT1 was considered positive if the patient had at least 1 of the following items: (1) reproduction of the patient's symptoms, (2) range of motion limited 10° or more in elbow extension, and (3) symptomatic limb side: contralateral neck side-bending increased symptoms, or ipsilateral side-bending decreased symptoms.

Data analysis

Data were analyzed using SPSS, version 20.0 (SPSS, Inc, Chicago, IL).

For demographic data (age, sex, dominance, and tobacco use), and reported symptom's evolution time, ranges and absolute and relative frequencies were calculated.

Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy, and positive LR (LR = sensitivity/1 − specificity) were calculated using a 2 × 2 table, with 95% confidence intervals (95% CIs). In all analyses, $P < .05$ was considered statistically significant.

Sensitivity was estimated as the proportion of true positives that were correctly identified by ULNT1, and specificity as the proportion of true negatives that were correctly identified by this test.

To know the probability of ULNT1 giving us the correct diagnosis, we calculated the PPV and NPV of the test. PPV was estimated as the proportion of patients with positive test results who were correctly identified, and the NPV was calculated as the proportion of patients with negative test results who were correctly identified.

Results

The population consisted of 120 patients (234 hands) with a clinical diagnosis of CTS who attended a health services institution between the months of August 2013 and February 2014 for a study of motor and sensory nerve conduction. Two participants were excluded because of exclusion criteria; therefore, 118 patients and 230 hands were enrolled and tested (Fig. 1).

Participants ranged from 18 to 86 years, with a mean of 50.51 years and a standard deviation of 11.1. About 83.05% were women (Table 1). About 97.4% had health insurance; 18.3% were unemployed, 50.4% were employed, and 31.3% worked independently. About 45.7% were enrolled in the worker's compensation system. None of these groups was homogeneous.

About 76.5% of subjects in this study were workers engaged in activities, such as cleaning, washing, and ironing clothes. About 79.6% performed repetitive movements during their jobs,

Table 3
ULNT1 crosstabulation results compared with nerve conduction test

Test	Nerve conduction test			
		Positive	Negative	Total
ULNT1	Positive	186	28	214
	Negative	14	2	16
	Total	200	30	230

ULNT1 = upper limb neurodynamic test 1.

Table 4
Diagnostic accuracy of ULNT1

Test	Sensitivity, % (95% CI)	Specificity, % (95% CI)	Prevalence, % (95% CI)	PPV	NPV	Positive LR	Negative LR
ULNT1 right	93.33 (88.09-9.58)	10 (0.0-33.6)	91.3 (85.72-96.89)	91.59	12.50	1.04	0.67
ULNT1 left	93.62 (88.14-99.09)	9.52 (0.0-24.5)	81.74 (74.24-89.24)	82.24	25	1.03	0.67
ULNT1 bilateral	93.00 (88.21-96.79)	6.67 (0.0-33.59)	86.96 (82.39-91.53)	86.92	12.50	1.00	1.05

ULNT1 = upper limb neurodynamic test 1; 95% CI = 95% confidence interval; PPV = positive predictive value; NPV = negative predictive value; LR = likelihood ratio.

and 73.9% used tools, such as scissors, grinders, hammers, strikers, tweezers, needles, blades, spatulas, and brushes, among others.

Symptoms

The most frequently reported symptoms were numbness in 57.4%, electric shock sensation in 42.6%, and tingling in 84.3%. About 82.6% reported loss of strength, and 57.4% reported trouble with fumbling or dropping objects from the affected hand. Other symptoms such as pins and needles and burning pain were described in 21% of cases.

The duration of the symptoms in most of the patients was over 3 months (Table 2).

About 73% mentioned that the symptoms were triggered with work, and 76.5% said symptoms were exacerbated by activities at home, such as making beds, twisting a mop, and washing dishes.

Test results

ULNT1 was administered 20 minutes after the nerve conduction test. About 93.9% of participants had CTS, according to Wainner's criteria. About 80% had decreased range of motion in the elbow, 80% reported reproduction of symptoms, and 67% reported a change in symptoms when performing bending movements of the cervical spine, or releasing wrist extension during the test.

During ULNT1 of the left upper limb, 78.3% had reproduction of symptoms during the test, 82.6% showed decreased range of motion in the elbow, and 68.7% had a change in symptoms during the test. About 67.8% had a positive ULNT1 as graded by Wainner's criteria. ULNT1 was compared with the upper limb tension test, part A.

The nerve conduction test for the diagnosis of CTS was positive in 92.2% of right limbs and 81.7% of left upper limbs.

When ULNT1 was compared with the gold standard for diagnosis of CTS, 186 true positive cases where found.

The estimated test sensitivity was 93.0% (95% CI, 88.09-98.58), and the specificity was 6%, with a PPV of 86.9% and an NPV of 12.5%. About 14 cases were false negatives, and 28 cases were false positives (Table 3).

Analysis of the right and left ULNT1 showed a 93% sensitivity (95% CI, 88.21-96.79), with a PPV of 86.92% (95% CI, 82.2-91.7). We found an estimated positive LR of 1.00, with a 95% CI between 0.90 and 1.10, and a negative LR of 1.05, with a 95% CI from 0.25 to 4.89 (Table 4).

The Wainner's criteria with the highest sensitivity were symptom reproduction and reduction in the range of motion. On the other hand, the change in symptoms with changes in the position of the wrist or the position of the neck showed the highest specificity and a lower sensitivity. The specificity of the other criteria was below 30%. The PPV of all the criteria showed values above 80%. The positive LR for symptom change in right upper limbs was very high, indicating that the diagnostic strength of the test is also high for CTS. This could be explained by the fact that changes in symptoms with stretching of the median nerve when changing wrist position are highly related to the nerve entrapment area in CTS (Table 5).

Discussion

The main conclusion of this study is that ULNT1 has a significant value in the diagnosis and clinical screening for CTS of people at risk or with symptoms of this disorder. It has been demonstrated that electrodiagnostic studies do not identify CTS in all cases.[32,33] Acute or relatively mild CTS cases may not be accurately identified through nerve conduction tests, although these are still considered to be the reference standard for the diagnosis of the disease.[34] This finding is useful for hand rehabilitation processes in CTS because the therapist can treat the syndrome early, intervene in risk exposure, and prevent chronicity and its sequelae.

According to the results of this study, ULNT1 has a rate of false negatives around 7%, whereas the rate of false negatives with electrodiagnostic studies can be as high as 20%.[35]

In this study, we found that ULNT1 has a sensitivity of 91% and a specificity of 6.67%. This finding coincides with the studies of Wainner and Vanti, where a sensitivity of 75% and 91% and a specificity of 13% and 15% were found, respectively.

ULNT1 has been used for the assessment of several pathologies, such as cervical radiculopathy,[36] brachial plexus lesions,[37] and chronic nonspecific neck pain.[38]

Research regarding the value of CTS provocative tests recommends the use of Tinel's, Phalen's, and the carpal tunnel compression tests because their positive LR is >2.0, or their mean negative LR is <0.5.[17] For ULNT1, we found an estimated positive LR of 1.00 with a CI between 0.90 and 1.10 and a negative LR of 1.05 with a CI from 0.25 to 4.89.

Table 5
Diagnostic accuracy of ULNT1—Wainner's criteria

Test	Sensitivity, % (95% CI)	Specificity, % (95% CI)	PPV, %	NPV, %	LR+, %	LR−, %
Reduction in range of motion RUL	81.90 (74.06-89.74)	33.33 (0.0-69.7)	93.48	13.64	1.23	0.54
Reduction in range of motion LUL	77.66 (68.71-86.61)	25.00 (3.5-46.5)	82.95	19.23	1.04	0.89
Symptoms change with change in RUL	14.29 (7.2-21.46)	100 (94.4-100)	100	9.09	—	0.86
Symptoms change with change in LUL	8.60 (2.37-14.84)	90.4 (75.5-100)	80.00	18.27	0.90	1.01
Symptoms reproduction RUL	79.25 (71.05-87.44)	11.11 (0.0-37.2)	91.30	4.35	0.89	1.87
Symptoms reproduction LUL	84.04 (76.11-91.98)	19.05 (0.0-38.2)	82.29	21.05	1.04	0.84

ULNT1 = upper limb neurodynamic test 1; 95% CI = 95% confidence interval; PPV = positive predictive value; NPV = negative predictive value; LR = likelihood ratio; RUL = right upper limb; LUL = left upper limb.

ULNT1 has a significant diagnostic and clinical screening value for CTS in people at risk or with upper limb symptoms. The test helps to determine the location of the neural mechanical disorder at proximal or distal levels, through changes in wrist position or changes in cervical spine position. Due to its low specificity, the Tinel, Phalen, and compression tests are performed afterward. The syndrome is confirmed through electrodiagnostic studies and ultrasonography. However, we should consider that the test predicts or identifies those with CTS before electrodiagnostic studies do because these are sensitive in advanced disease.

Only subjects with a clinical diagnosis of CTS participated in this study. We suggest that future research include healthy subjects to obtain estimates that can be generalized to the overall population. Likewise, it would be advisable to complement the diagnostic accuracy studies of ULNT1 with other provocative tests and confirmatory examinations such as ultrasonography and electromyography. In addition, we suggest new studies to assess the predictive value of c for CTS to act on the disease in an early phase.

Conclusion

This research suggests that ULNT1 constitutes a complementary procedure to the history and physical examination for early identification of people with CTS and adds knowledge regarding new approaches to the analysis of Wainner's criteria in CTS.

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#1. The authors describe the study as
   a. RCTs
   b. qualitative
   c. a diagnostic accuracy study
   d. a random cohort investigation

#2. Approximately _____ % of subjects with positive electrical diagnostic tests tested positive on the ULNT1
   a. 95
   b. 75
   c. 55
   d. 5

#3. The ULNT1 was shown to have
   a. low specificity
   b. high sensitivity
   c. positive predictive value
   d. all of the above

#4. The authors suggest using the ULNT1 clinically
   a. only if nerve conduction times are slowed on electrical testing
   b. only if the examiner has successfully completed an Elvey certification process
   c. as a screening test
   d. if the patient is suspected of having bilateral CTS

#5. The authors conclude that the ULNT1 test is the definitive test in evaluating patients for possible CTS
   a. true
   b. false

When submitting to the HTCC for re-certification, please batch your JHT RFC certificates in groups of 3 or more to get full credit.