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Original Article

Comparative study between physical examination, electroneuromyography and ultrasonography in diagnosing carpal tunnel syndrome☆,☆☆

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ABSTRACT

Objective: To evaluate the sensitivity of electromyography and ultrasonography in diagnosing carpal tunnel syndrome (CTS), in comparison with physical examination, which is considered to be the gold standard.

Methods: In this cross-sectional study, the medical files of 56 patients with 70 hands affected by CTS who were attended between March 2010 and June 2012 were reviewed. The study included patients with a clinical diagnosis of CTS. The sensitivity of the complementary examinations was analyzed and compared with physical examination.

Results: Nocturnal symptoms were found in 96.4%, thenar atrophy in 62.5% and abnormal sense of touch in 50%. The sensitivities found were: ultrasonography, 67.1% (95% CI: 55.7%–78.6%); an association of physical examination tests, 95.7% (95% CI: 90.0%–100%); and electromyography, 98.6% (95% CI: 95.7%–100%). The presence of atrophy, abnormalities of the sense of touch and longer-duration symptoms increased the sensitivity of ultrasonography and physical examination.

Conclusion: The sensitivity of ultrasonography for CTS was lower than that of electromyography and physical examination.

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Estudo comparativo entre o exame físico, a eletroneuromiografia e a ultrassonografia no diagnóstico da síndrome do túnel do carpo

Palavras-chave:
Síndrome do túnel carpal
Ultrassonografia
Eletromiografia

RESUMO

Objetivo: Avaliar a sensibilidade da eletroneuromiografia (ENMG) e da ultrassonografia (USN) no diagnóstico de síndrome do túnel do carpo (STC) comparada com a do exame físico, considerado padrão-ouro.

Métodos: Estudo seccional pela análise de prontuários de 56 pacientes com 70 mãos acometidas com STC entre março de 2010 e junho de 2012. A sensibilidade dos exames complementares foi analisada e comparada com a do exame físico.

Resultados: Constataram-se sintomas noturnos em 96,4%, hipotrofia tenar em 62,5% e alteração do tato em 50%. A sensibilidade da USG foi de 67,1% (95% IC, 55,7%-78,6%); a da associação dos testes do exame físico, de 95,7 (95% IC, 90,0%-100%); e a da ENMG, de 98,6% (95% IC, 95,7%-100%). A presença de hipotrofia, de alterações no tato e o maior tempo dos sintomas aumentaram a sensibilidade da USG e do exame físico.

Conclusão: A sensibilidade da USG para a STC foi inferior à da ENMG e à do exame físico.

Introduction

Carpal tunnel syndrome (CTS) is the commonest neuropathy of the upper extremities.[1] The incidence of the disease is estimated to be between 0.125% and 1% per year and its prevalence ranges from 5% to 15%, depending on the criteria used for diagnosing it.[2,3] More than 80% of the patients are over the age of 40 years and women are more affected than men (5:1). Although bilateral occurrence is common (> 50% of the cases), the dominant hand is usually the first to be affected and is more severely involved.[4]

The following have been described as causal factors: rheumatological and endocrinological diseases; infections; thrombosis of the median artery; inflammatory alterations; bursal fibrotic alterations; bone, muscle and neurovascular abnormalities; trauma; tumoral lesions; and pregnancy. CTS has been correlated with manual activities and there are also cases of idiopathic nature.[5]

The diagnosis is clinical and determined from the history and physical examination,[6] which includes the Tinel, Phalen and Durkan tests. Tinel's sign, which is observed by means of light percussion on the wrist, transmits a feeling of paresthesia in the distribution region of the median nerve. Phalen's test consists of complete flexion of the wrist for 60 s, without applying force. In cases of CTS, the flexed position of the wrist compresses the median nerve even more than it was already compressed in the neutral position, and also transmits a feeling of paresthesia in the region of the median nerve.[7]

Durkan[8] proposed a new test in 1991, in which the examiner uses both thumbs to apply direct pressure to the carpal region for 30 s. This quickly produces the common symptoms of CTS along the path of the median nerve.

Although the diagnosis is eminently clinical and is based on symptoms and on the distribution of sensory alterations in the hand, it can be made by means of neurophysiological methods for evaluating the conduction velocity of the median nerve.[7,9] Over recent years, in the light of the advent of high-resolution ultrasonography, it has been sought to demonstrate the usefulness of this method as an aid to diagnosing CTS, especially in cases in which compatible symptoms are present together with normal physical and electroneuromyographic examination results.[10,11]

The sensitivity of electrodiagnostic tests on the median nerve ranges from 49% to 84%, while specificities around 95% have been registered.[12] Ultrasonography has been shown to have sensitivity of 77.6% (95% CI: 71.6%–83.6%) and specificity of 86.8% (95% CI: 78.9%–94.8%) for CTS.[13]

Among patients with CTS, anatomical assessment of the carpal tunnel is the most important evaluation for the diagnosis and treatment. Chronic focal compression of the median nerve may lead to morphological alterations and demyelination, caused by mechanical stress that deforms the myelin sheath. Ischemia may the cause of the intermittent paresthesia that generally occurs during the night or with wrist flexion.[14–17]

Imaging techniques have gained great importance over recent decades. Buchberger et al.[18] were the first to report using ultrasonography for diagnosing this syndrome. Their findings confirmed previous magnetic resonance studies.[19,20] The current criteria used for magnetic resonance and ultrasonography are: edema of the median nerve at the entrance to the carpal tunnel and flattening of the median nerve, along with arching of the flexor retinaculum at its exit from the carpal canal.[21]

The aim of this study was to evaluate and compare the sensitivity of physical examination in relation to electroneuromyography (EMG) and ultrasonography (US) examinations for diagnosing CTS among patients with a clinical prediagnosis of this syndrome who were attended at the hand surgery outpatient clinic of a macroregional university referral hospital.

Materials and methods

This was a cross-sectional study on 56 patients with 70 affected wrists who were evaluated between March 2010 and June 2012. The data were obtained by reviewing the medical files.

Individuals with a clinical condition consistent with CTS and with previous EMG and US assessments on the affected wrists were included. Patients were excluded in the following situations: if they had previously undergone surgical treatment for neuropathy; if there were insufficient data in the medical files; if they were lost from the follow-up at the outpatient clinic; and if some of the complementary tests were not done. Complaints of pain or paresthesia on the path of the median nerve, with worsening at night, and presence of at least one positive clinical examination or evidence of atrophy in the thenar region, were considered to be a clinical picture consistent with CTS.

The characteristics of the sample that were evaluated were age, sex, marital status, ethnicity, retired status, length of time working and length of time since the current symptoms first appeared. Clinically, the following were evaluated: presence of hypotrophy; altered sense of touch; loss of thumb opposition; nocturnal symptoms; affected unilaterally or bilaterally; and side affected or with more evident symptoms.

The sensitivities of the EMG, US and physical examinations were evaluated. The physical examination included the Tinel, Durkan and Phalen tests.

The sensitivity of the diagnostic examinations was assessed by correlation with the patients' characteristics. For this purpose, the sample was formed by affected wrists in patients with unilateral alterations and by wrists of the half-body with greater severity of complaints, among the patients with bilateral diagnoses. Following this, all the affected wrists were studied and the sensitivities of the examinations were identified and compared.

The numerical variables were evaluated with regard to their central trend and dispersion measurements (mean ± standard deviation) and the categorical variables were compared with regard to frequency. The numerical variables were compared with the categorical variables by means of the ANOVA and Mann–Whitney tests, after conformation of normal distribution using the Kolmogorov–Smirnov test. The categorical variables were compared with each other by means of the χ^2 and Fisher exact tests. The statistical significance level was taken to be 5%.

For the statistical analysis, the SPSS software version 19.0 was used.

Results

The individuals presented a mean age (± standard deviation) of 49.91 ± 9.44 years (range: 32–67). Higher prevalence of CTS was observed among women (94.6%), married individuals (67.9%) and the white-skinned ethnic group (64.3%). Individuals who were occupationally active accounted for 98.2% of the cases and the mean length of time for which they had been in work was 7.40 ± 10.88 years.

Some type of pain was reported by 74% of the patients and 50% reported paresthesia. Unilateral symptoms occurred in 75% and, among these, the left wrist was affected in 54.8%. Among the patients with bilateral complaints, the left side presented more evident complaints in 57.1%.

Nocturnal symptoms were present in 96.4% and muscle hypotrophy in 62.5%. The mean time from the start of symptoms until access to a consultation was 1.99 ± 1.22 years. Altered sense of touch was observed in 50% of the cases and there were no cases of loss of thumb opposition.

Presence of thenar hypotrophy was associated with greater sensitivity of the physical examinations. Altered sense of touch was associated with greater sensitivity in Phalen's test. Presence of hypertrophy, altered sense of touch and greater duration of symptoms were also associated with greater sensitivity of US (Table 1).

The results from the Tinel, Phalen and Durkan tests correlated with each other and with the result from US. No association among the results from these three tests and the result from EMG was observed (Table 2).

The sensitivity of EMG was significantly greater than the sensitivity of US, in comparison with the physical examination tests (Table 3).

Discussion

The sensitivity of the Tinel and Phalen tests and of US among the sample studied was concordant with the literature.[1,13] However, the sensitivity of EMG (95% CI: 95.7%–100%) was higher than that in the literature, in which values between 85% and 90% had been established.[22]

The sensitivity of EMG for diagnosing CTS was significantly greater than the sensitivity of both US and the three physical tests (Tinel, Phalen and Durkan) when assessed separately. Tinel's test alone had the lowest sensitivity of all of the tests.

In the study conducted by Durkan[8] (1991) on 31 patients seen between 1987 and 1990, 46 hands with a confirmed EMG diagnosis of CTS were evaluated. This author's test was positive in 40 hands out of the 46 evaluated (87%). In applying Phalen's test, 32 (70%) of the 46 hands presented the sign, while Tinel's sign was present in 26 hands (56%).

In the same study, the sensitivity of Phalen's test was 70% and its specificity was 84%, with a false-positive rate of 16%. On the other hand, Tinel's test was less sensitive: 56% of the patients in whom CTS had been confirmed by means of electrophysiological examinations were positive in this test, with specificity of 80% for the hands, and 20% showed false positive results. In Durkan's test, the sensitivity was 87% and the specificity was 90%, with a false positive rate of 10%. In view of the high sensitivity and specificity of this test, it can be used among some patients with signs and symptoms typical of CTS to identify candidates for surgical treatment, thereby avoiding expenditure on complementary examinations.[8]

The presence of hypotrophy was associated with greater sensitivity of the physical examinations. Altered sense of touch was associated with increased sensitivity of Phalen's test, which in turn contributed toward increased sensitivity of the association of physical examination tests. Presence of hypotrophy was also associated with altered

Table 1 – Comparison of sensitivities and mean sensitivities of the examinations performed on 56 patients with CTS, according to the characteristics of the sample. For the patients with a bilateral diagnosis, the body half with the greater complaint was evaluated.

Sample characteristics	*n* (%)	*n* (sensitivity %) or mean								
		Physical examination							US	EMG
		Tinel	Phalen	Durkan	Ti + Ph	Ti + D	Ph + D	Ti + Ph + D		
Sex		$p = 0.636$	$p = 0.764$	$p = 0.732$	$p = 0.795$	$p = 0.795$	$p = 0.861$	$p = 0.895$	$p = 0.614$	$p = 0.964$
Male	2 (3.6)	1 (50.0)	2 (100)	2 (100)	2 (100)	2 (100)	2 (100)	2 (100)	1 (50.0)	2 (100)
Female	54 (96.4)	33 (61.1)	47 (87.0)	46 (85.2)	48 (88.9)	48 (88.9)	50 (92.6)	51 (94.4)	34 (63.0)	53 (98.1)
Marital status		$p = 0.834$	$p = 0.422$	$p = 0.813$	$p = 0.290$	$p = 0.508$	$p = 0.844$	$p = 0.854$	$p = 0.864$	$p = 0.789$
Single	14 (25.0)	8 (57.1)	11 (78.6)	12 (85.7)	11 (78.6)	12 (85.7)	13 (92.9)	13 (92.9)	9 (64.3)	14 (100)
Married	38 (67.9)	24 (63.2)	34 (89.5)	33 (86.8)	35 (92.1)	35 (92.1)	35 (92.1)	36 (94.7)	24 (63.2)	37 (97.4)
Widowed	4 (7.1)	2 (50.0)	4 (100)	3 (75.0)	4 (100)	3 (75.0)	4 (100)	4 (100)	2 (50.0)	4 (100)
Ethnicity		$p = 0.293$	$p = 0.836$	$p = 0.478$	$p = 0.894$	$p = 0.163$	$p = 0.711$	$p = 0.425$	$p = 0.344$	$p = 0.754$
Black	7 (12.5)	3 (42.9)	6 (85.7)	5 (71.4)	6 (85.7)	5 (71.4)	6 (85.7)	6 (85.7)	5 (71.4)	7 (100)
Mixed	13 (23.2)	10 (76.9)	12 (92.3)	11 (84.6)	12 (92.3)	11 (84.6)	12 (92.3)	12 (92.3)	10 (76.9)	13 (100)
White	36 (64.3)	21 (58.3)	31 (86.1)	32 (88.9)	32 (88.9)	34 (94.4)	34 (94.4)	35 (97.2)	20 (55.6)	35 (97.2)
Retired status		$p = 0.607$	$p = 0.875$	$p = 0.857$	$p = 0.893$	$p = 0.893$	$p = 0.929$	$p = 0.946$	$p = 0.375$	$p = 0.982$
Yes	1 (1.8)	1 (100)	1 (100)	1 (100)	1 (100)	1 (100)	1 (100)	1 (100)	0 (0)	1 (100)
No	55 (98.2)	33 (60.0)	48 (87.3)	47 (85.5)	49 (89.1)	49 (89.1)	51 (92.7)	52 (94.5)	35 (63.6)	54 (98.2)
Nocturnal symptoms		$p = 0.150$	$p = 0.236$	$p = 0.018$[a]	$p = 0.205$	$p = 0.010$[a]	$p = 0.139$	$p = 0.105$	$p = 0.136$	$p = 0.964$
Present	54 (96.4)	34 (63.0)	48 (88.9)	48 (88.9)	49 (90.7)	50 (92.6)	51 (94.4)	52 (96.3)	35 (64.8)	53 (98.1)
Absent	2 (3.6)	0 (0)	1 (50.0)	0 (0)	1 (50.0)	0 (0)	1 (50.0)	1 (50.0)	0 (0)	2 (100)
Hypotrophy		$p = 0.033$[a]	$p = 0.009$[a]	$p = 0.119$	$p = 0.024$[a]	$p = 0.133$	$p = 0.016$[a]	$p = 0.048$[a]	$p = 0.001$[a]	$p = 0.625$
Present	35 (62.5)	25 (71.4)	34 (97.1)	32 (91.4)	34 (97.1)	33 (94.3)	35 (100)	35 (100)	28 (80.0)	34 (97.1)
Absent	21 (37.5)	9 (42.9)	15 (71.4)	16 (76.2)	16 (76.2)	17 (81.0)	17 (81.0)	18 (85.7)	7 (33.3)	21 (100)
Sense of touch (order)		$p = 0.085$	$p = 0.005$[a]	$p = 0.352$	$p = 0.012$[a]	$p = 0.665$	$p = 0.056$[b]	$p = 0.118$	$p < 0.001$[a]	$p = 0.500$
Normal	28 (50.0)	14 (50.0)	21 (75.0)	23 (82.1)	22 (78.6)	25 (89.3)	24 (85.7)	25 (89.3)	11 (39.3)	27 (96.4)
Altered	28 (50.0)	20 (71.4)	28 (100)	25 (89.3)	28 (100)	25 (89.3)	28 (100)	28 (100)	24 (85.7)	28 (100)
Symptoms		$p = 0.267$	$p = 0.433$	$p = 0.651$	$p = 0.528$	$p = 0.528$	$p = 0.305$	$p = 0.414$	$p = 0.132$	$p = 0.750$
Unilateral	42 (75.0)	24 (57.1)	36 (85.7)	36 (85.7)	37 (88.1)	37 (88.1)	38 (90.5)	39 (92.9)	24 (57.1)	41 (97.6)
Bilateral	14 (25.0)	10 (71.4)	13 (92.9)	12 (85.7)	13 (92.9)	13 (92.9)	14 (100)	14 (100)	11 (78.6)	14 (100)
Side		$p = 0.569$	$p = 0.091$	$p = 0.207$	$p = 0.023$[a]	$p = 0.154$	$p = 0.392$	$p = 0.162$	$p = 0.529$	$p = 0.446$
Right	25 (44.6)	15 (60.0)	24 (96.0)	23 (92.0)	25 (100)	24 (96.0)	24 (96.0)	25 (100)	16 (64.0)	24 (96.0)
Left	31 (55.4)	19 (61.3)	25 (80.6)	25 (80.6)	25 (80.6)	26 (83.9)	28 (90.3)	28 (90.3)	19 (61.3)	31 (100)
Age (years)		$p = 0.690$	$p = 0.359$	$p = 0.914$	$p = 0.179$	$p = 0.376$	$p = 0.985$	$p = 0.608$	$p = 0.843$	$p = 0.112$
Mean for positive tests		49.5	49.47	49.85	49.32	49.52	49.9	49.75	49.71	50.18
Mean for negative tests		50.55	53	50.25	54.83	53.17	50	52.67	50.24	35
Length of time working (years)		$p = 0.162$	$p = 0.870$	$p = 0.888$	$p = 0.850$	$p = 0.375$	$p = 0.311$	$p = 0.510$	$p = 0.738$	$p = 0.262$
Mean for positive tests		6.31	7.42	7.49	7.27	7.15	7.82	7.67	7.16	7.26
Mean for negative tests		9.09	7.29	7.13	8.5	9.5	2	2.67	7.81	15
Duration of symptoms (years)		$p = 0.424$	$p = 0.568$	$p = 0.259$	$p = 0.849$	$p = 0.892$	$p = 0.336$	$p = 0.601$	$p = 0.029$[a]	$p = 0.680$
Mean for positive tests		2.04	1.99	2.07	1.97	1.97	2.04	2.02	2.21	1.99
Mean for negative tests		1.91	2	1.5	2.16	2.17	1.38	1.5	1.62	2
TOTAL	56 (100)	34 (60.7)	49 (87.5)	48 (85.7)	50 (89.3)	50 (89.3)	52 (92.9)	53 (94.6)	36 (64.3)	55 (98.2)

Ti, Tinel; Ph, Phalen; D, Durkan; EMG, electroneuromyography; US, ultrasonography; +, association between tests.

[a] Statistical significance.

[b] Close to statistical significance.

sense of touch and increased sensitivity of US. Positive results from US were correlated with greater duration of symptoms, which suggests progression of the lesion.

The presence of nocturnal symptoms influenced Durkan's test and increased its sensitivity. However, the number of cases without nocturnal symptoms was too small to validate this observation. There was no significant difference in the sensitivity of EMG regarding the characteristics of the sample.

The association between the results from the physical examination tests and the results from US suggests that this complementary examination positively identified damage that had been clinically perceived in the physical examination. On the other hand, EMG seemed to be capable of showing subclinical damage, given the absence of evidence of an association between the other tests and the high sensitivity encountered.

Pain presented high frequency of occurrence in the general population and is considered to be the commonest symptoms present in clinical practice.[23] This was corroborated in the present study, given that 74% of the patients affirmed that they had some type of pain.

Table 2 – Evaluation of the associations between the diagnostic examinations on 70 hands affected with CTS in 56 patients attended at a university hospital.

Physical test	Physical test							US	EMG
	Tinel	Phalen	Durkan	Ti + Ph	Ti + D	Ph + D	Ti + Ph + D		
	Positive result in both tests in relation to the total (%)								
Tinel	–	61.400	58.6	62.9	62.9	61.4	62.9	52.9	61.4
Phalen	0.003[a]	–	80	88.6	82.9	88.6	88.6	65.7	87.1
Durkan	0.026[a]	0.012[a]	–	80.0	85.7	85.7	85.7	61.4	84.3
Ti + Ph	0.001[a]	0.000[a]	0.055[b]	–	84.3	88.6	90.0	65.7	88.6
Ti + D	0.001[a]	0.028[a]	0.000[a]	0.019[a]	–	88.6	90.0	64.3	88.6
Ph + D	0.141	0.000[a]	0.000[a]	0.002[a]	0.002[a]	–	94.3	65.7	92.9
Ti + Ph + D	0.047[a]	0.001[a]	0.002[a]	0.001[a]	0.001[a]	0.0[a]	–	65.7	94.3
USG	0.000[a]	0.001[a]	0.057[b]	0.004[a]	0.035[a]	0.1	0.25	–	67.1
EMG	0.629	0.886	0.857	0.900	0.9	0.943	0.957	0.329	–
	Significance of the correlation (*p*-value)								

Ti, Tinel; Ph, Phalen; D, Durkan; US, ultrasonography; EMG, electroneuromyography; +, association between tests.
[a] Statistical significance.
[b] Tendency toward significance.

Table 3 – Sensitivity of the tests in relation to the 70 hands affected.

	Physical test							US	EMG
	Tinel	Phalen	Durkan	Ti + Ph	Ti + D	Ph + D	Ti + Ph + D		
s (%)	62.9	88.6	85.7	90	90	94.3	95.7	67.1	98.6
95% CI	50.0–74.3	80.0–95.7	77.1–92.9	81.5–97.1	82.9–95.7	88.6–98.6	90.0–100	55.7–78.6	95.7–100

Ti, Tinel; Ph, Phalen; D, Durkan; US, ultrasonography EMG, electroneuromyography; s, sensitivity; +, association between tests.

The false negative rate for EMG (95% CI: 0%–4.3%) for the sample studied here was significantly lower than in the literature. Werner and Andary[22] reported that false negative rates for EMG of 10–15% were possible in diagnosing CTS (sensitivity of 85–90%). This can be explained by the fact that there are patients with intermittent symptoms in whom demyelinating or axonal lesions do not occur. Dhong et al.[24] and Pádua et al.[25] pointed out that there were false negative results in their studies and stated that given the patients' symptoms and the results from the electrophysiological examinations, the latter should be considered to be the reference and the diagnosis should be confirmed through the typical symptoms.

Nonetheless, the significantly higher sensitivity of EMG that was observed (95% CI: 95.7%–100%) can partly be explained by the long period with symptoms that the patients experienced before gaining access to the healthcare system.

Because US is an observer-dependent examination, it may give rise to conflicting results and opinions.[26] Researchers warn that information bias may exist, given that US images that are evaluated were produced by different professionals on different equipment. Moreover, the possibility that labor-law or social-security interests might influence the results cannot be dismissed.

On the other hand, US provides the possibility of diagnostic evaluation both of associated diseases and of neural anatomical variations. In addition, it can be done quickly and dynamically, at a relatively low cost in relation to EMG.[26]

Conclusion

The sensitivity of EMG for diagnosing CTS was significantly greater than the sensitivities of US and the three physical examination tests (Tinel, Phalen and Durkan), when evaluated separately. When used together, the three clinical tests presented sensitivity that was greater than that of US. In addition, the results from the physical examination tests (evaluated both separately and together) and from USD did not show any correlation with the results from EMG.

EMG was shown to be a valuable complementary examination in the cases studied. It was not influenced by the variables considered and showed sensitivity greater than that of US. Prospective studies with larger samples that evaluate the specificity and predictive value of complementary examinations and clinical tests should be envisaged so that definitive conclusions can be reached.

Conflicts of interest

The authors declare no conflicts of interest.

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