

DIAGNOSTIC ACCURACY OF THE MODIFIED PHALEN TEST COMPARED TO OTHER CLINICAL MANEUVERS IN CARPAL TUNNEL SYNDROME: A CROSS-SECTIONAL STUDY

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Submitted 01 June 2025; accepted 14 July 2025

ABSTRACT

Background: Carpal Tunnel Syndrome is one of the most common upper limb compression neuropathies with several tests/signs used for the assessment in clinical diagnosis. This study aimed to assess the effectiveness of the Modified Phalen test in the diagnosis of Carpal Tunnel Syndrome compared to other tests and electrodiagnostic studies.

Methodology: A cross-sectional diagnostic accuracy study was conducted to assess the effectiveness/validity and accuracy of the Modified Phalen test for the diagnosis of Carpal Tunnel Syndrome and compare it to the other available signs/tests. It took 5 months to enroll a total of 100 cases, i.e. hands. The validity, strength of association, and accuracy were assessed using SPSS version 26.

Results: Tinel's sign $P < 0.001$, Durkan test $P = 0.006$, and Modified Phalen Test $P = 0.027$, with very strong and strong correlation; $\Phi = 0.387, 0.275$ and 0.222 , while Phalen test was not significant, $P = 0.086$ and $\Phi = 0.172$. The modified Phalen test showed an accuracy of 78% second to the Durkan test's 81% and had a sensitivity of 85.7% higher than Tinel's sign of 52.4% and the Phalen test's 60.7%, and lower than the Durkan test's 89.3%.

Conclusion: The modified Phalen Test shows moderate diagnostic utility with good sensitivity but poor specificity, suggesting its use may be helpful in screening but not confirmation of Carpal Tunnel Syndrome.

Duhok Med J 2025; 19 (2): 54-63.

Keywords: Carpal Tunnel Syndrome; Modified Phalen Test; Phalen Test; Durkan Test; Tinel's sign.

Carpal Tunnel Syndrome (CTS) is one of the most common upper limb compression neuropathies, accounting for up to 90% of entrapment neuropathies^[1]. According to the duration, the disease can be divided into acute CTS, which is less common and occurs due to a rapid, sustained rise of pressure in the carpal tunnel, as in fractures and dislocations around the wrist, and chronic CTS, which is more common with symptoms lasting for months to years. The exact etiology of increased carpal tunnel pressure remains uncertain, several conditions elevate the risk of CTS, such as Diabetes Mellitus, Obesity, Rheumatoid arthritis, Pregnancy, Hypothyroidism, Acromegaly, Cysts, or

tumors within the tunnel.^[1-6]. The condition is commonly seen in middle-aged individuals and is more commonly among females, with a 3:1 female-to-male ratio^[7]. CTS is a multifactorial condition typically arising from a combination of patient-specific, occupational, social, and environmental factors. The exact pathogenesis of CTS is not clear and several theories describe the condition including; mechanical compression theory which explains the symptoms of CTS as an outcome of median nerve compression in the carpal tunnel; thus the main factors are overuse, exertional strain, hyperfunction, prolonged tool grasping and repeated or prolonged wrist extension, while the theory

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of microvascular insufficiency focuses more on the nutrient and oxygen supply which takes place due to their depletion from lack of blood supply. Finally, the vibration theory explains the symptoms in cases where a long-term effect of vibration tools on the median nerve^[1,8].

Classically, the clinical presentation of CTS includes numbness, pain, and tingling sensations in the distribution of the median nerve, which consists of the thumb, index, middle finger, and radial side of the ring finger, and is aggravated by activities that require wrist flexion and at night. The distribution of these symptoms can vary, ranging from localized discomfort at the wrist, encompassing the entire hand, radiating to the forearm, or extending upward beyond the elbow to the shoulder^[9-12]. In advanced cases, patients might present with hand weakness, reduced grip strength, and might reach a degree of difficulty in performing fine motor tasks^[13-15]. During the physical examination, sensory loss or weakness within the median nerve distribution may become apparent, possibly diminished strength in thumb abduction and opposition, and atrophy of the thenar eminence as well. Various provocative tests exhibit varying degrees of sensitivity and specificity. Several maneuvers are accessible to reproduce CTS symptoms, such as Tinel's sign, Phalen's test, and Durkan's test^[1,16-17]. Nevertheless, the gold standard test for the diagnosis and assessment of severity remains the Nerve Conduction Study (NCS), which also helps to rule out other causes of similar signs and symptoms^[1].

Koris et al described a diagnostic test combining the sensitivity of the Semmes-Weinstein monofilament measurement and the specificity of the wrist flexion provocative test, which has been evaluated in a group of 21 patients (33 hands) with electrodiagnostically verified carpal tunnel syndrome and 30 asymptomatic hands (controls). This combined test was shown to be more sensitive and specific than the

Phalen test alone. Nevertheless, it was not widely practiced^[18]. Bilkis et al developed a modified Phalen test on 66 hands, which included sensory testing in Phalen's position using the Semmes-Weinstein 2.83-unit monofilament as a screening tool for CTS diagnosis^[17]. The results demonstrate greater accuracy of the modified Phalen test than Phalen's test for predicting CTS^[17].

This study aims to assess the effectiveness of the Modified Phalen test in the diagnosis of Carpal Tunnel Syndrome compared to other tests and nerve conduction studies.

PATIENTS AND METHODOLOGY

This study was conducted as a cross-sectional diagnostic accuracy study assessing the effectiveness/validity of the Modified Phalen test for the diagnosis of Carpal Tunnel Syndrome. The study was conducted during a 5-month interval. Cases were collected from an outpatient Orthopedic clinic/Azadi General Hospital. A total of 100 cases were enrolled conveniently due to the limitation in the number of cases presenting with such complaints. Inclusion criteria included: patients above the age of 18 with clinical signs and symptoms of carpal tunnel syndrome. The exclusion criteria included: patients under the age of 18 years, patients with cervical radiculopathy, and pregnant patients in order to have a pure sample of cases without any confounding factors, as in pregnancy the symptoms can resolve after pregnancy while in cervical radiculopathy the pathology is not in Carpal Tunnel Despite the symptoms.

The permissions were obtained from the necessary authorities, and all patients were assured of the privacy of their information, only the final results of the study will be published.

Each case was initially assessed through a thorough history for symptoms relevant to Carpal Tunnel Syndrome. Once the disease was suspected, each case was examined with specific tests and signs. These tests/signs included Tinel's test, re-

experience of the tingling sensation or discomfort with the examiner tapping lightly over the distal wrist at the site of the median nerve, Phalen test which is done through wrist flexion that causes compression of the median nerve in the tunnel and reproduction of patients symptoms, Durkan Test which is done when the patient forearm is supinated and then the examiner applies direct pressure over the carpal tunnel (median nerve) between the thenar and hypothenar eminence for 30 seconds. Modified Phalen test, which is done through the application of the traditional Phalen test with the application of Semmes-Weinstein 2.83-unit monofilament perpendicularly to the palmar and lateral surface of the distal fingers until it bends to assess the sensation to the fingers with the median nerve distribution, as seen in figure (1)^[1,19]. Later, each case was sent to perform a nerve conduction study (NCS) to confirm the diagnosis. The test performers were blinded to NCS, and only their results were handed to the researcher.



Figure 1: Modified Phalen Test

Data were later input into an Excel worksheet, which was then converted to SPSS version 26. These data were analyzed with the same application to determine the correlation of the Nerve Conduction Study to all four clinical tests, provided with their

Odd ratio, 95% Confidence Interval (CI), and P value. A P value of < 0.05 was regarded as statistically significant. The positive likelihood ratio, negative likelihood ratio, and accuracy test were also assessed. Phi test was used to assess the strength of association; > 0.25 indicated a very strong association, > 0.15 indicated a strong association, > 0.10 indicated a moderate association, > 0.05 indicated a weak association and > 0 indicated no association or very weak association. Using Bivariate correlation, the validity of each of the four clinical tests was assessed; the cut point of the P value was the same. Furthermore, the sensitivity and specificity of each clinical test were calculated compared to the standard Nerve Conduction Study. The accuracy of the tests was assessed compared to the gold standard NCS. The formula used $\{Accuracy = (TP + TN) / (TP + TN + FP + FN)\}$.

RESULTS

In Table (1) the correlation of the Nerve Conduction Study to other clinical tests is shown. Tinel's test is seen to be statistically significantly correlated to the findings on NCS with an Odd ratio (OR) = 0.71 and a 95% Confidence Interval C.I. of 0.6-0.8. As of the Phalen test, the correlation was found non-significant with a P value of 0.086 and a 95% C.I. of 0.86-7.76, while the OR = 2.58. Durkan test showed a statistically significant value at P values of 0.006, while the OR = 5 and 95% C.I. was 1.47-17.03. Finally, the Modified Phalen test is significant with a P value of 0.027, with an OR = 3.6 and a 95% C.I. of 1.10-11.74. The Phi of Tinel's test showed the highest Phi = 0.387 and indicated the strongest association, followed by the Durkan test Phi = 0.28 which also indicates a very strong association, and then the Modified Phalen test Phi = 0.22 which indicated a strong association. In addition, the Phalen test was not significant, it showed the lowest Phi = 0.17 which also indicated a strong association.

Table (1). The correlation of Nerve Conduction Study test to other clinical tests.

			Nerve Conduction Study		Phi	Pearson Correlation	Odd Ratio	95% Confidence Interval	P value
			Negative	Positive					
Tinel's test	Negative	Count	16	40	0.387	14.966	0.714	0.6-0.8	< 0.001
		% within NCS	100.0%	47.6%					
	Positive	Count	0	44	0.172	2.955	2.576	0.86-7.76	0.086
		% within NCS	0.0%	52.4%					
Phalen test	Negative	Count	10	33	0.275	7.56	5	1.47-17.03	0.006
		% within NCS	62.5%	39.3%					
	Positive	Count	6	51	0.222	4.91	3.6	1.10-11.74	0.027
		% within NCS	37.5%	60.7%					
Durkan test	Negative	Count	6	9	0.222	4.91	3.6	1.10-11.74	0.027
		% within NCS	37.5%	10.7%					
	Positive	Count	10	75	0.222	4.91	3.6	1.10-11.74	0.027
		% within NCS	62.5%	89.3%					
Modified Phalen test	Negative	Count	6	12	0.222	4.91	3.6	1.10-11.74	0.027
		% within NCS	37.5%	14.3%					
	Positive	Count	10	72	0.222	4.91	3.6	1.10-11.74	0.027
		% within NCS	62.5%	85.7%					

Figure 2. Demonstrates the sensitivity and specificity of different Clinical tests for Carpal Tunnel Syndrome compared to the gold standard NCS. The most sensitive test was the Durkan test 89.3% followed by the modified Phalen test 85.7%. The least

sensitive tests were Phalen and Tinel's test, 60.7% and 54%, respectively. While as regards specificity, the most specific test was Tinel's at 100% followed by the Phalen test at 62.5%. Durkan and Modified Phalen tests showed a specificity of 37.5% each.

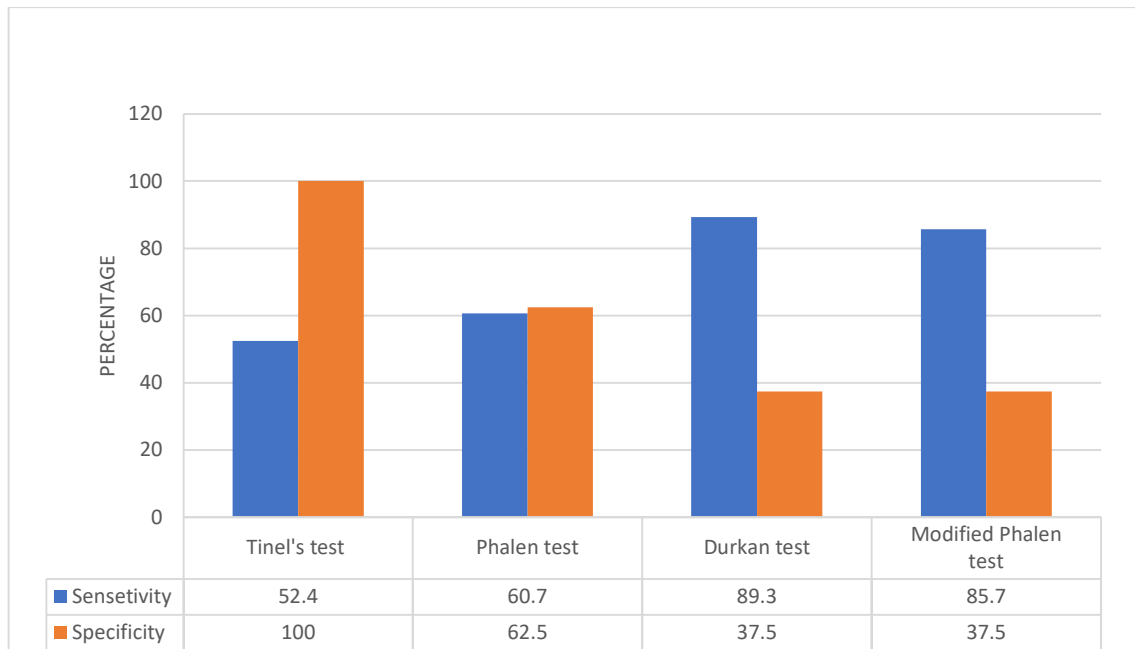


Figure 2. Demonstrates the sensitivity and specificity of different Clinical tests for Carpal Tunnel Syndrome compared to the gold standard NCS

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Table (2). Sensitivity and Specificity of different clinical tests.

Variable	Nerve Conduction Study				
	Sensitivity %, C.I.	Specificity %, C.I.	Accuracy%, C.I.	Positive Likelihood ratio	Negative Likelihood ratio
Modified Phalen	85.7 (76.4 – 92.4)	37.5 (15.2 – 64.6)	78% (68.6 – 85.7)	1.37	0.38
Tinel's test	52.4 (41.2 - 63.4)	100 (79.4 -100.0)	60 % (49.7 - 69.7)	0	0.48
Phalen test	60.7 (49.5-71.2)	62.5 (35.4 – 84.8)	61 % (50.7 – 70.6)	1.62	0.63
Durkan test	89.3 (80.6 – 95.0)	37.5 (15.2 – 64.6)	81% (71.9 – 88.2)	1.43	0.29

As seen in table (2). The specificity and sensitivity of all four clinical tests were assessed based on the gold standard Nerve Conduction Study. The Durkan test was the most sensitive with 89.3% (C.I. 80.6% - 95.0%) followed by the Modified Phalen test with 85.7% (C.I. 76.4% - 92.4%).

Phalen test and Tinel's test were least sensitive, 60.7% (C.I. 49.5% -71.2%) and 54% (41.2% - 63.4%), respectively. The accuracy test was used to identify the accuracy of each test compared to the gold standard.

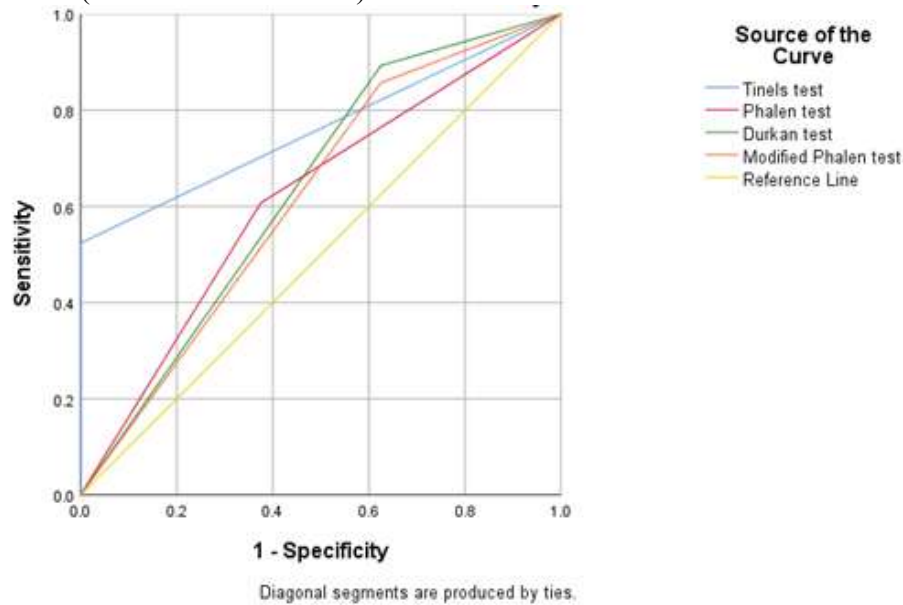


Figure (3). ROC Curve analysis comparing the clinical tests of Carpal Tunnel Syndrome to the Gold Standard Nerve Conduction Study

Figure 3 demonstrates the ROC curve analysis of the clinical signs. The modified Phalen test showed a non-significant result with a p-value of 0.142. Additionally, the Area Under the Curve (AUC) of MPT was 0.616 indicating a poor value. Tinel's test shows a significant result with a fair AUC of 0.762 and its standard error is 0.049. Nevertheless, the other two tests, Phalen

and Durkan both showed non-significant P values, 0.142 and 0.091, and their AUC was also poor, 0.616 and 0.634, respectively.

Area Under the Curve

Test Result Variable(s)	Area	Std. Error	Asymptotic Significance	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Tinel's test	0.762	0.049	0.001	0.665	0.859
Phalen test	0.616	0.077	0.142	0.466	0.766
Durkan test	0.634	0.084	0.091	0.470	0.798
Modified Phalen test	0.616	0.083	0.142	0.454	0.779

DISCUSSION

CTS is one of the commonest upper limb compression neuropathies a multifactorial interaction typically arising from a combination of patient-specific, occupational, social, and environmental factors^[1,5]. The gold standard test for the diagnosis is NCS^[1], however, the suspicion of the cases requires signs and symptoms from the history and clinical tests. For this purpose, several maneuvers/tests/signs are used by clinicians to increase the suspicion of the disease; Tinel's sign, Phalen's test, Durkan test, and Modified Phalen test^[1,12-13,17]. The aim of this study was to compare the effectiveness of the Modified Phalen test in the diagnosis of Carpal Tunnel Syndrome compared to other tests and nerve conduction studies.

Most of the literature describes the sensitivity and specificity of the Phalen test and Tinel's sign^[1,16-17,20]. In this study, the validity of all four clinical tests was compared to the gold standard nerve conduction study. To determine the efficacy of the Modified Phalen Test and compare it to other clinical tests. MPT was seen as a moderately valid test for the diagnosis of Carpal Tunnel Syndrome. Additionally, MPT is more accurate compared to Tinel's sign and less accurate compared to the Durkan test. The findings in this study indicate MPT is more sensitive than the traditional Phalen test and Tinel's sign; 85.7% vs 60.7% vs 52.4%; it has improved the sensitivity by 25% and 33.3%, respectively. Thus, it can be seen as a useful diagnostic test, with fewer false negative results compared to the previous two tests/signs. This study is consistent with Koris et al^[18] and Bilkis et al^[17].

Furthermore, in this study, Durkan showed the highest sensitivity with 89.3%, slightly higher than MPT. Additionally, the test was found to have an accuracy of 78%, higher than both the traditional Phalen test and Tinel's sign, 61% and 60%, respectively. Indicating that MPT has only moderate diagnostic value for CTS with poor AUC and low specificity. While it can be a useful tool for assessing Carpal Tunnel Syndrome, it must be used in combination with other clinical and bedside tests for a more accurate diagnosis.

Strengths and Limitations

The uniqueness of this article remains relies on the set of describing the sensitivity and screening usefulness of the Modified Phalen test compared to the gold standard and other three maneuvers, and it is one of the very few, and probably the sole, articles that provide such description. Furthermore, the accuracy of the test was assessed and compared to the other provocative tests of CTS taking into consideration the Nerve Conduction Study as the gold standard. The Limitation of the study is mainly in the low number of cases.

CONCLUSION

The modified Phalen Test is a moderately useful screening tool for the initial assessment of Carpal Tunnel Syndrome with an accuracy of more than ¾ and an acceptable sensitivity compared to Tinel's sign and traditional Phalen test. Yet, the Durkan test showed the highest accuracy and sensitivity. Hence, the Modified Phalen Test shows moderate diagnostic utility with good sensitivity but poor specificity, suggesting its use may be helpful in screening but not confirmation. All four

tests show strong association and validity to the gold standard Nerve Conduction Study. Further studies are required to determine the sensitivity and accuracy of the test.

Funding

None.

Conflict of Interest

There is nothing to declare.

Clinical Trail

Not applicable

Ethical Approval

The ethical approval was obtained from the university college.

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پوخته

ووردببیا پشکینی بو راپرسینا فالینا راسته‌کری به‌راورد دگهل لئینین نه‌خوشی بین دی دنه‌خوشیا تونیا دهستی: فه‌کولینه‌کا به‌شه‌کی

پیشه‌کی و نارمانج: نه‌خوشی کارپهل ته‌نیل (Carpal Tunnel Syndrome) به‌کیکه له زورترین نیروپاتیبه‌کانی فشاری به‌سهر لیری سهره‌وه، که به چند تاقیکردنه‌وه و نیشانه جیگیر ده‌کریت بو ناساندنی ناوخوا. ئەم توئیزینه‌وهیه ئامانجی هه‌یه کارامه‌یی تاقیکردنه‌وهی "فه‌لمنی گوراو" (Modified Phalen Test) بو ناساندنی ئەم نه‌خوشییه به‌راورد به تاقیکردنه‌وه و نیشانه‌کانی تر و ئەو توئیزینه‌وهیه ئەلیکترۆنیرۆلوژیکیه‌کان.

رئوشوین: توئیزینه‌وهیه‌کی راده‌ی ته‌واو و دروستبوونی ناساندن به‌ه‌ویج کرا بو هه‌لسه‌نگاندنی دروستبوون و کارامه‌یی تاقیکردنه‌وهی فه‌لمنی گوراو، و به‌راوردی پیکرا له‌گه‌ل نیشانه و تاقیکردنه‌وه‌کانی تر. بو ئەم توئیزینه‌وهیه ۱۰۰ که‌یس (دهست) به‌شیه‌وه‌یه‌کی پیاپی کزکراونه‌وه له‌ماوه‌ی ۵ مانگدا. به‌کاره‌ینانی به‌نامه‌ی SPSS و‌شانی ۲۶، به‌رزبوونه‌وه‌ی گه‌وره‌ی په‌یوه‌ندیدار بوون، راستی و دروستبوونی هه‌ژمارکرا.

نه‌نامه‌کان: نیشانی Tinel ($P < 0.001$)، تاقی Durkan ($P = 0.006$)، و تاقی فه‌لمنی گوراو ($P = 0.027$) هه‌موویان په‌یوه‌ندییه‌کی به‌هه‌یز و گرنگیان په‌یدا کرد، به Phi به‌ریژه‌ی 0.387، 0.275 و 0.222. تاقی فه‌لمن به‌شیه‌وه‌یه‌کی گرنگ نه‌ده‌رکه‌وت ($P = 0.086$ ، $\text{Phi} = 0.172$). فه‌لمنی گوراو راستیه‌که‌ی ۷۸٪ بو که له‌دوای تاقی Durkan دایه به ۸۱٪، به‌حساسیه‌تی ۸۵.۷٪، که به‌رزتره له‌نیشانی Tinel (۵۲.۴٪) و تاقی فه‌لمن (۶۰.۷٪)، به‌لام که‌متره له‌تاقی Durkan (۸۹.۳٪).

کو‌تایی: تاقی فه‌لمنی گوراو نیشانی ئەوه‌یه که به‌هه‌یز نیه له‌ریگه‌ی دروستبوونی ناساندن، به‌لام حساسیه‌تی باشی هه‌یه، و‌هک تاقیکردنه‌وه‌یه‌کی پیشه‌کی به‌سووده بو سکرین کردنی نه‌خوشی کارپهل ته‌نیل، به‌لام نه بو دلنیاکردنه‌وه

الخلاصة

دقة التشخيص لاختبار فالين المعدل مقارنة بالمناورات السريرية الأخرى في متلازمة النفق الرسغي: دراسة مقطعية

الخلفية والأهداف: تعد متلازمة النفق الرسغي من أكثر اعتلالات الأعصاب الانضغاطية شيوعاً في الأطراف العلوية، وتستخدم العديد من الاختبارات/العلامات لتقييم التشخيص السريري. هدفت هذه الدراسة إلى تقييم فعالية اختبار فالين المعدل في تشخيص متلازمة النفق الرسغي مقارنة بالاختبارات الأخرى ودراسات التشخيص الكهربائي.

طرق البحث: أجريت دراسة مقطعية لدقة التشخيص لتقييم فعالية/صلاحية ودقة اختبار فالين المعدل لتشخيص متلازمة النفق الرسغي ومقارنته بالعلامات/الاختبارات الأخرى المتاحة. استغرقت الدراسة 5 أشهر لتسجيل ما مجموعه 100 حالة، أي من اليدين. تم تقييم الصلاحية وقوة الارتباط والدقة باستخدام برنامج SPSS الإصدار 26.

النتائج: كانت قيمة P لعلامة تينيل > 0.001 ، وقيمة P لاختبار دوركان = 0.006، وقيمة P لاختبار فالين المعدل = 0.027، مع ارتباط قوي جداً؛ فاي = 0.387، 0.275، و0.222، بينما لم يكن اختبار فالين ذا دلالة إحصائية، حيث بلغت قيمة $P = 0.086$ وقيمة $P = 0.172$. أظهر اختبار فالين المعدل دقة بنسبة 78%، أي أقل من دقة اختبار دوركان البالغة 81%، وحساسية أعلى بنسبة 85.7% من دقة علامة تينيل البالغة 52.4% واختبار فالين البالغة 60.7%، وأقل من دقة اختبار دوركان البالغة 89.3%.

الاستنتاجات: أظهر اختبار فالين المعدل فائدة تشخيصية متوسطة، مع حساسية جيدة وخصوصية ضعيفة، مما يشير إلى أن استخدامه قد يكون مفيداً في فحص متلازمة النفق الرسغي، ولكنه ليس مفيداً في تأكيدها.