Original Article

The correlation between modified Phalen's test and electrodiagnostic severity in carpal tunnel syndrome

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Abstract

Objective: To evaluate 1) the diagnostic accuracy of modified Phalen's test compared with the electrodiagnosis in diagnosis of CTS, 2) sensitivity of modified Phalen's test in different electrodiagnostic severity, and 3) the correlation between the duration of positive modified Phalen's test and electrodiagnostic severity.

Design: Retrospective cohort study

Methods: Three hundred and fifty-four patients were referred to do the electrodiagnosis at the Thammasat University hospital from 1 January 2014 to 30 April 2019. Rehabilitation doctor evaluated Modified Phalen's test and electrodiagnosis. The electrodiagnostic protocol and diagnostic criteria for CTS used the recommendations by the American Association of Electrodiagnostic Medicine (AAEM).

Results: One hundred and fifty-three patients with 297 symptomatic hands were analyzed using the modified Phalen's test and electrodiagnosis criteria. The diagnostic accuracy of modified Phalen's test was: sensitivity 54.3%, specificity 76.9%, LR+ 2.4, LR- 0.6, PPV 86.9%, NPV 37.5%, and the area under ROC curve 0.66. Sensitivity in mild, moderate and severe CTS were 47.1%, 55.2% and 63.0%, respectively. The correlation coefficient between the duration of positive modified Phalen's test and the electrodiagnostic severity was -0.2. (P= 0.010)

Conclusions: The diagnostic accuracy of the modified Phalen's test was fair in diagnosis of CTS. The sensitivity of modified Phalen's test increased following the severity of CTS. There was no correlation between the duration of positive modified Phalen's test and the electrodiagnostic severity.

Keywords: modified Phalen's test, electrodiagnostic severity, carpal tunnel syndrome

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Introduction

Carpal tunnel syndrome (CTS) is the most common neuropathy of the upper extremities. It is caused by compression of the median nerve at the carpal tunnel level. In Thailand, the prevalence of computer-worker related CTS was 33.8%.[1] CTS is also common among people 45-60 years old of age and in women. Typical symptoms are numbness or tingling of the hands, wrist pain, and thenar muscle atrophy.[3] Symptoms are usually bilateral.[2] The diagnosis of CTS should be based on the history, provocative tests, and electrodiagnostic studies. There are many provocative tests such as the wrist flexion test (Phalen's test, modified Phalen's test), reverse Phalen's test, Tinel's sign, Durkan/carpal compression test, and wrist flexion with carpal compression test.[4] The modified Phalen's test is highly sensitive and commonly used.[5] Electrodiagnosis is the gold standard test of which the sensitivity and specificity are 49-84% and 95%, respectively.[6, 7] Electrodiagnosis can further categorize the severity of CTS which is useful in selecting a treatment modalities. The patient with mild to moderate CTS can be managed with conservative treatment. However, in severe cases, surgery is the treatment of choice.

The aim of the present study was to evaluate the diagnostic accuracy of modified Phalen's test compared with the electrodiagnostic results in diagnosis of CTS. Other aims were to evaluate the sensitivity of the modified Phalen's test with different electrodiagnostic severities and to correlate the duration of a positive modified Phalen's test with the electrodiagnostic severity.

Method

This retrospective cohort study was approved by Human Research Ethics committee of Thammasat University No.1 (Faculty of Medicine), MTU-EC-RM-0-085/62.

Three hundred and fifty-four patients were diagnosed with CTS by clinical criteria and were referred to perform electrodiagnosis at Thammasat University hospital from 1 January 2014 to 30 April 2019. Data was collected from the electrodiagnostic report. Inclusion criteria were 1) CTS patients meeting clinical diagnostic criteria, 2) electrodiagnosis was performed and 3) modified Phalen's tests and the duration of positive tests were recorded. Electrodiagnostic reports without modified Phalen's test and the duration of positive test were excluded.

For the modified Phalen's test, the patient pushed the dorsal surfaces of both hands together. Both wrists were completely flexed. The patient had to remain in this position for 60 seconds. Numbness or tingling radiating into the thumb, index, middle and ring fingers indicated a positive test.[5]

The electrodiagnostic study was evaluated and interpreted by a rehabilitation doctor. The Synergy & Viking Nicolet EDX was used to evaluate an electrodiagnosis. Nerve conduction study (NCS) of electrodiagnostic study used the recommendations by the American Association of Electrodiagnostic Medicine (AAEM) as below. The studies maintained the hand temperature at 32 °C or greater.[8]

1. Median sensory NCS across the wrist with a conduction distance of 13 cm to 14 cm comparison a sensory NCS of one other adjacent sensory nerve in the symptomatic limb.

2. If the initial median sensory NCS is normal, one of the following additional studies is recommended: a. comparison of median sensory or mixed nerve conduction across the wrist over a short (7 cm to 8 cm) conduction distance with ulnar sensory nerve conduction across the wrist over the same short (7 cm to 8 cm) conduction distance, b. comparison of median sensory conduction across the wrist with radial or ulnar sensory conduction across the wrist in the same limb, c. comparison of median sensory or mixed nerve conduction through the carpal tunnel to

sensory or mixed NCSs of proximal (forearm) or distal (digit) segments of the median nerve in the same limb.

3. Motor NCS of the median nerve recording from the thenar muscle and of one other nerve in the symptomatic limb to include measurement of distal latency.

4. Supplementary NCS: Comparison of the median motor nerve distal latency (second lumbrical) to the ulnar motor nerve distal latency (second interossei), median motor terminal latency index, median motor nerve conduction between wrist and palm, median motor nerve compound muscle action potential (CMAP) wrist to palm amplitude ratio to detect conduction block, median sensory nerve action potential (SNAP) wrist to palm amplitude ratio to detect conduction block, short segment (1 cm) incremental median sensory nerve conduction across the carpal tunnel (Option).

5. Needle electromyography of a sample of muscles innervated by the C5 to T1 spinal roots, including a thenar muscle innervated by the median nerve of the symptomatic limb (Option).

Patients with bilateral CTS were separately analyzed. The symptomatic hands were divided into 2 groups following the electrodiagnostic study. CTS group was abnormal NCS. Non-CTS group was normal NCS. CTS group was divided into 3 subgroups (mild, moderate, severe) following the severity of NCS by AAEM criteria.[9]

• Mild CTS: Prolonged sensory (> 3.5 millisecond) or mixed NAP distal latency (> 0.5 millisecond) ± SNAP amplitude below the lower limit of normal (peak to peak amplitude < 20 μV)

• Moderate CTS: Abnormal median sensory latencies as above, and prolongation of median motor distal latency (> 4.2 millisecond)

• Severe CTS: Prolonged median motor and sensory distal latencies, with either an absent SNAP or mixed NAP, or low amplitude or absent thenar CMAP (baseline to peak amplitude <5 μV), Needle examination often reveals fibrillations, reduced recruitment, and motor unit potential changes.

The data was analyzed via STATA version 15.1. Categorical data was presented as frequency and percentages. Continuous data was presented as mean, median, standard deviation and minimal-maximal values depend on nature of data. The sensitivity, specificity, likelihood ratio of a positive test and a negative test, positive and negative predictive values, and the area under ROC curve were calculated by 2*2 table. Subgroup analysis for a duration of positive modified Phalen's test used ANOVA or Kruskal Wallis test. Spearman's rank correlation was used between the duration of positive modified Phalen's test and the electrodiagnostic severity.

Results

One hundred and fifty-three patients that consisted of 297 hands were divided into CTS group (hand = 219) and non-CTS group (hand = 78) by electrodiagnosis. The average ages were 53.1 years. Female and male were 82.3% and 17.7%. The median duration of symptoms was 8 months. (Table 1)

Table 1 Demographic data of patients

Variable	Frequency (%)
Electrodiagnostic results (hand)	
CTS	219 (73.7)
Non -CTS	78 (26.3)
Age (year) (mean ± SD)	53.1 ± 12.3
Gender	
Female	126 (82.3)
Male	27 (17.7)
Duration of symptoms (month)	
mean ± SD	7.6 ± 4.1
median (min-max)	8 (1-18)

Sensitivity and specificity of modified Phalen's test was 54.3% (95% CI: 47.5 - 61.1) and 76.9% (95% CI: 66.0 - 85.7). Likelihood ratio of a positive test and a negative test (LR +, LR-) was 2.4 (95% CI: 1.5 - 3.6) and 0.6 (95% CI: 0.5 - 0.7). Positive and negative predictive values (PPV, NPV) were 86.9% (95% CI: 80 - 92) and 37.5% (95% CI: 30.0 - 45.5) at prevalence 73.7%. Area under the ROC curve was 0.66 (95% CI: 0.60 - 0.71). (Table 2, 3 and Figure 1)

Table 2 Modified Phalen's test and Electrodiagnosis

Modified Phalen's test	Electrodiagnosis		Total
	CTS	Non-CTS	
Positive	119	18	137
Negative	100	60	160
Total	219	78	297

Table 3 The diagnostic accuracy of modified Phalen's test

Sensitivity% (95% CI)	Specificity% (95% CI)	LR+ (95% CI)	LR- (95% CI)	PPV% (95% CI)	NPV% (95% CI)	AuROC (95% CI)
54.3 (47.5 - 61.1)	76.9 (66.0 - 85.7)	2.4 (1.5 - 3.6)	0.6 (0.5 - 0.7)	86.9 (80 - 92)	37.5 (30 - 45.5)	0.66 (0.60 - 0.71)

At prevalence 73.7%

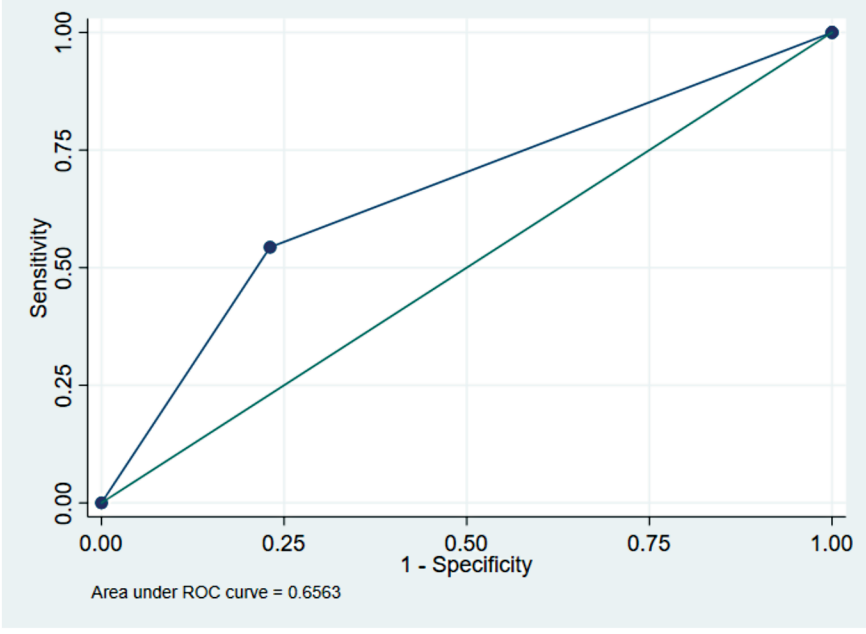

Figure 1 Area under the ROC curve

297 hands were divided into a normal group (hand =78), mild CTS group (hand =68), moderate CTS group (hand =105) and severe CTS group (hand =46) by electrodiagnosis. Sensitivity in mild, moderate and severe CTS groups were 47.1% (95% CI: 34.8-59.6), 55.2% (95% CI: 45.2 - 65.0) and 63.0% (95% CI: 47.5 - 76.8), respectively. (Table 4)

Table 4 Sensitivity following electrodiagnostic severity

	Electrodiagnostic Severity			
	Normal (hand =78)	Mild (hand =68)	Moderate (hand =105)	Severe (hand =46)
Modified Phalen test (n, %)				
Positive	18 (23.1)	32 (47.1)	58 (55.2)	29 (63.0)
Negative	60 (76.9)	36 (52.9)	47 (44.8)	17 (37.0)
Sensitivity% (95% CI)	-	47.1 (34.8 - 59.6)	55.2 (45.2 - 65.0)	63.0 (47.5 - 76.8)

The mean duration of positive modified Phalen's test was 36.9 ± 14.1 seconds in the normal group, 35.2 ± 15.6 seconds in the mild CTS group, 30.3 ± 14.2 seconds in the moderate CTS group and 27.8 ± 14.4 seconds in the severe CTS group. The median duration of positive modified Phalen's test was 30 seconds in all groups. There was no statistically significant difference between groups. (p = 0.087) (Table 5) The correlation coefficient between a duration of positive modified Phalen's test and electrodiagnostic severity was -0.2. (p = 0.010)

Table 5 Duration of positive modified Phalen's test

Duration (second)	Electrodiagnostic Severity				P - value
	Normal (hand = 78)	Mild (hand = 68)	Moderate (hand = 105)	Severe (hand = 46)	
Mean ± SD	36.9 ± 14.1	35.2 ± 15.6	30.3 ± 14.2	27.8 ± 14.4	0.087
Median (min-max)	30 (20 - 60)	30 (10 - 60)	30 (5 - 60)	30 (10 - 60)	

Discussion and Conclusion

The present study showed sensitivity, specificity, LR+, LR-, PPV, NPV and the area under ROC curve of modified Phalen's test were 54.3%, 76.9%, 2.4, 0.6, 86.9%, 37.5% and 0.66, respectively. Subgroup analysis, sensitivity of modified Phalen's test in mild, moderate and severe CTS were 47.1%, 55.2% and 63.0%, respectively. The correlation coefficient between a duration of positive modified Phalen's test and electrodiagnostic severity was -0.2. (P = 0.010)

The original Phalen's test was described as a wrist flexion test with sensitivity and specificity of 34% - 59% and 51 - 93%, respectively.[3] The sensitivity and specificity had a wide range depending on each study.[10, 11, 12, 13, 14] The Phalen's test was developed to increase the diagnostic accuracy such as modified Phalen's test, reverse Phalen's test, or Phalen's test combined with median nerve compression test.[5, 12, 15] The authors used a modified Phalen's test because it was highly

sensitive and specific in diagnosis of CTS.[5, 15] The previous study reported the diagnostic accuracy of the modified Phalen's test sensitivity 70%, specificity 62%, LR+ 1.82, LR- 0.49, PPV 93%, and NPV 22% at prevalence 88%.[5] In this study, sensitivity was lower but specificity was higher than the previous study. The modified Phalen's test increases the pressure in the carpal tunnel and has the effect of compressing the median nerve. Sensitivity usually depended on the severity of median nerve compression.[4] The number of patients with severe CTS were lower in ratio than patients with mild to moderate CTS that might be causing a low sensitivity of modified Phalen's test in this study.

However, sensitivity of modified Phalen's test increased following the electrodiagnostic severity of CTS. Sensitivity was high in severe CTS which was similar to the previous study.[13, 5] Patients with severe CTS had more vulnerably compressed median nerves than patients with mild to moderate CTS.[4]

There was no correlation between a duration of positive modified Phalen's test and electrodiagnostic severity that was similar as the previous study.[16, 17] However, the previous study reported that the clinical stage of CTS was correlated with electrodiagnostic severity.[11, 16] Therefore, the duration of modified Phalen's test could not be a screening tool for evaluation of CTS severity. The electrodiagnosis must still be use to evaluate the severity of CTS.

Retrospective study design was a limitation of this study. Many CTS patients were lost to analysis because the electrodiagnostic reports did not record a modified Phalen's test.

In conclusion, A diagnostic accuracy of the modified Phalen's test was fair in diagnosis of CTS. The sensitivity of modified Phalen's test increased following the severity of CTS. There was no correlation between a duration of positive modified Phalen's test and electrodiagnostic severity.

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Potential conflicts of interest

All authors report no conflicts of interest relevant to this article.

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บทคัดย่อ

ความสัมพันธ์ของการตรวจ Modified Phalen's test กับระดับความรุนแรงจากการตรวจไฟฟ้าวินิจฉัย ในกลุ่มอาการเส้นประสาทมีเดียนถูกกดทับในอุโมงค์ข้อมือ

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** สำนักวิชาเวชศาสตร์ชะลอวัยและฟื้นฟูสุขภาพ มหาวิทยาลัยแม่ฟ้าหลวง

วัตถุประสงค์: เพื่อศึกษาหา 1) ความแม่นยำจากการตรวจด้วยวิธีการงอข้อมือ เปรียบเทียบกับการตรวจไฟฟ้าวินิจฉัยในการวินิจฉัยกลุ่มอาการเส้นประสาทมีเดียนถูกกดทับในอุโมงค์ข้อมือ 2) ความไวของการตรวจในแต่ละระดับความรุนแรง 3) ความสัมพันธ์ระหว่างเวลาการตรวจให้ผลบวก กับความรุนแรงของโรค

รูปแบบการศึกษา: การศึกษาจากเหตุไปหาผลแบบย้อนหลัง

วิธีการศึกษา: ผู้ป่วยจำนวน 354 ราย ส่งตรวจไฟฟ้าวินิจฉัยที่โรงพยาบาลธรรมศาสตร์เฉลิมพระเกียรติ ระหว่าง 1 มกราคม 2557 ถึง 30 เมษายน 2562 แพทย์เวชศาสตร์ฟื้นฟูตรวจผู้ป่วยด้วยวิธีงอข้อมือ และตรวจไฟฟ้าวินิจฉัยตามคำแนะนำของ American Association of Electrodiagnostic Medicine (AAEM)

ผลการศึกษา: ผู้ป่วย 153 ราย (297 มือที่มีอาการ) นำมาวิเคราะห์ พบว่าการตรวจด้วยวิธีการงอข้อมือมี ความไว 54.3%, ความจำเพาะ 76.9%, LR+ 2.4, LR- 0.6, PPV 86.9%, NPV 37.5%, และพื้นที่ใต้กราฟ 0.66. ความไวของการตรวจตามระดับความรุนแรงน้อย ปานกลาง และมาก ได้แก่ 47.1%, 55.2% และ 63.0% ตามลำดับ ความสัมพันธ์ระหว่างเวลาการตรวจให้ผลบวก กับความรุนแรงของโรค เท่ากับ -0.2. (P= 0.010)

สรุปผลการศึกษา: การตรวจโดยวิธีการงอข้อมือ เพื่อการวินิจฉัยกลุ่มอาการเส้นประสาทมีเดียนถูกกดทับในอุโมงค์ข้อมือ มีความแม่นยำอยู่ในระดับปานกลาง โดยพบว่าความไวของการตรวจเพิ่มขึ้นตามระดับความรุนแรงของโรค แต่ไม่พบความสัมพันธ์ระหว่างเวลาการตรวจให้ผลบวก กับความรุนแรงของโรค

คำสำคัญ: การตรวจร่างกายโดยวิธีงอข้อมือ, ระดับความรุนแรงแบ่งตามไฟฟ้าวินิจฉัย, อุโมงค์พังผืดรัดเส้นประสาทบริเวณข้อมือ