
EVALUATION OF CLINICAL TESTS IN DIAGNOSIS OF CARPAL TUNNEL SYNDROME WITH SPECIAL REFERENCE TO MODIFIED DURAN'S TEST REGARDING SPECIFICITY AND SENSITIVITY

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Summary

A prospective study on 110 symptomatic patients (150 hands) with CTS. All were analyzed depending on history, clinical examination, EMG and NCS and 118 asymptomatic persons (150 hands) as control group. Five currently used clinical provocative tests were applied on both groups: original Duran's test, Phalen's test, reversed Phalen's test, tinels test and arm tourniquet test, in addition to our modification of Duran's test which was compared with the previous tests, regarding sensitivity, specificity and accuracy. It was concluded that modified Duran's test was the most sensitive (94.7%), specific (94.7%) and accurate (94.7) in relation to other provocative tests. The positivity rate of modified Duran's test in cases less than 1 month history of symptoms was 80% which is higher than the other tests. Modified Duran's test has the shortest reaction time (mean time 10.5seconds) as compared with other clinical tests apart from Tinel's test.

Introduction

Carpal tunnel syndrome (CTS) is the most common, most important, best defined and the most carefully studied of all nerve entrapment syndromes³.

It is defined as compression of the median nerve within the confines of the carpal tunnel which is created by the transverse carpal ligament and the carpal

bones, characterized by pain and paraesthesia in the sensory distribution of median nerve in the hand, which is most frequently nocturnal.

Clinical tests have a very important role in the diagnosis of CTS especially in early cases^{6,8}, the most important tests are:

1. Duran's carpal compression test.
2. Phalen's wrist flexion test.
3. Tinel's percussion test.
4. Arm sphygmomanometer test.

CTS can result from ischemia and mechanical compression of median

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nerve. In Duran's carpal compression test – transient reversible ischemia of median nerve is induced by direct pressure upon an already ischemic nerve by high pressure within the carpal tunnel and acute conduction block⁴.

In Phalen's wrist flexion test-the size of the carpal tunnel is reduces which compresses the median nerve⁷. , In Tinel's percussion test-median nerve conduction is blocked by sharp tapping upon the nerve⁵. Ischemic nerve becomes more sensitive to the tapping in its ischemic part, and in Arm sphygmomanometer test-venous congestion is induced in the hand, wrist and forearm which reduced the size of the CT and compresses the median nerve².

The aim of this paper is to evaluate the clinical tests in the diagnosis of carpal tunnel syndrome with special reference to modified Duran's test regarding specificity and sensitivity.

Patients and Methods

One hundred ten patients (150 hands) were studied prospectively in the period from August 1999 to August 2001, at Hammad Shihab Military hospital and AL-Yarmook teaching hospital. All had symptoms indicative of carpal tunnel syndrome and had definite abnormalities of EMG and NCS, this group was considered as disease positive group (group1), they consisted of 98 females and 12 males (female/male ratio= 8/1), in 40 patients, the condition was bilateral, in 60 patients was on right hand only and in 10 patients was on left hand, ages ranged between 28 to 62 years (the average was 40 years old). 60 patients were housewives, 33 clerical workers, 13 typists and computer workers and 4 dentists.

CTS was suspected because of history of pain, numbness and paraesthesia of the hand in the distribution of median nerve, these hands were tested electro

physiologically by EMG and NCS and proved to have CTS by positive findings, the criteria for abnormal EMG when the distal motor nerve conduction velocity across the carpal tunnel of more than 4.5 milliseconds or of 1 millisecond more than that of ulnar nerve on the same side or on the opposite (asymptomatic) median nerve side in unilateral cases, while for abnormal NCS when the sensory velocity of more than 3.5 milliseconds or of 1 millisecond more than that of ulnar nerve on the same side or on the opposite (asymptomatic) median nerve side in unilateral cases.

The control group consisted of 118 asymptomatic persons, (150 hands) all had no history of any symptoms of CTS, and was considered as disease negative group (group 2), they consisted of 96 females and 22 males (female / male ratio = 5/1), we examined 32 of their both hands, 68 only right hand and 18 only left hands, the range of ages was 24 to 65 years (average) age 41 years).

The clinical tests were performed on the two groups as follows:

1.Original Duran's test- consisted of a device that was constructed by connection of a rubber atomizer-bulb to aneroid pressure manometer from a sphygmomanometer producing direct pressure on the median nerve running deep to the flexor retinaculum by a pressure of 150 mmHg (20 kilopascals) as long as thirty seconds.

The interval from the application of compression to the onset of pain or paraesthesia or numbness in the distribution of median nerve on the hand was recorded by a timer.

2. Modified Duran's test, consisted of a firm plastic board (7×11 cm) with central round edge rectangular piece (3×6 cm) which is enough to cover the volar aspect of an adult wrist and apply a pressure upon the median nerve running deep to the flexor retinaculum. This

board was incorporated in a blood pressure cuff, connected to a manometer from a mercurial sphygmomanometer. (figure 1) A pressure of 150 mmHg (20 kilopascals) was applied as long as thirty seconds. The interval from the application of pressure to the onset of pain, paraesthesia or numbness in the distribution of median nerve on the hand was recorded by a timer. The other provocative tests were:

3. **Phalen's wrist-flexion test.**
4. **Reversed Phalen's test.**
5. **Tinels test.**
6. **Tourniquet test-** (pneumatic arm sphygmomanometer test).

Statistical Analysis:

Data were translated into codes using a specially coding sheet, and then converted into a computerized data structure. Statistical analyses were done using SPSS version 7.5 computer software (statistical package for social science).

The statistical significance of difference in mean of certain quantitative outcome variable (like pressure needed to achieve a positive test) between 2 groups was assessed by t-test. The statistical significance of association between 2 categorical variables (like duration of symptoms and positivity rate of the test) was assessed by Chi-square test. P value less than 0.05 level of significance was considered statistically significant.

Test performance Characteristics (sorlied 1995)

The performance characteristics of a test or criteria, sometimes called test operating characteristics include, among others: sensitivity, specificity, positive predictive value and negative predictive value the formulas used in calculation are:

$$\text{Sensitivity} = \frac{\text{Number of true positives}}{\text{Number of diseased people}}$$

$$\text{Specificity} = \frac{\text{Number of true negatives}}{\text{No. of non-diseased people}}$$

$$\text{PPV} = \frac{\text{Number of true positives}}{\text{Number of positive test results}}$$

$$\text{NPV} = \frac{\text{Number of true negatives}}{\text{Number of negative test results}}$$

$$\text{Accuracy} = \frac{\text{No. of (true positives + true negatives)}}{\text{Total number}}$$

Results

The results of the clinical tests for the diseased positive group (150 hands) were as follows:

Modified Duran's test was positive in 142 hands (94.7 %) with mean time of 10.5 seconds from the application of the pressure to the onset of symptoms (range 8-18 seconds).

The pressure which was applied to induce symptoms is 150 mm Hg (20 kilopascals) for normotensive patients and 168 mm Hg (24 kilopascals) (range 160 – 185 mm Hg) for hypertensive patients with mean systolic blood pressure (160 mm Hg) (range 150 – 175 mm Hg) and mean diastolic blood pressure (103 mm Hg) (range 100 – 110 mm Hg).

Original Duran's test was positive in 127 hands (84.7 %) with mean time of 23.3 seconds (range 16-30 seconds). The pressure which was applied to include

symptoms is 150 mm Hg (20 kilopascals) for normotensive patients and 181 mm Hg (26 kilopascals) (range 170 – 195 mm Hg) for hypertensive patients with mean arterial systolic blood pressure (160 mm Hg) and mean diastolic blood pressure (103 mm Hg).

Phalen's wrist flexion test was positive in 117 hands (78 %) with mean time of 44.4 seconds (range 31 – 60 seconds).

Reversed phalen's test was positive in 111 hands (74 %) with mean time of 47.4 seconds (range 32 – 60 seconds).

Tinel's test was positive in 107 hands (70.7 %).

Arm sphygmomanometer test was positive in 82 hands (54.7 %).

In the control group of 150 hand the results of the clinical tests were as follows: (Table V,VI)

Original Duran's test was positive in 8 hands (5.3 %) with mean time of 24 seconds (range 20 – 28 seconds).

Modified Duran's test was positive 8 hands (5.3 %) with mean time of 18.1 seconds (range 15 – 22 seconds).

Phalen's test was positive in 23 hands (15.3 %) with mean time of 46 seconds (range 35 – 60 seconds).

Reversed Phalen's test was positive in 26 hands (17.3%) with mean time of 43.9 seconds (range 38 – 60 seconds).

Tinel's test was positive in 19 hands (12.6 %).

Arm sphygmomanometer test was positive in 34 hands (22.7 %).

The sensitivity, specificity and accuracy of the clinical tests were as follows (table II, figure 2).

Discussion

In group 1 modified Duran's test was positive in 142 hands (sensitivity 94.7 %), original Duran's test was positive in 127 hands (sensitivity 84.7 %), Phalen's test was positive in 117 hands (sensitivity 78 %), reversed Phalen's test was positive in 111 hands (sensitivity 74

%), Tinel's test was positive in 106 hands (sensitivity 70.7 %) and arm sphygmomanometer test was positive in 82 hands (sensitivity 54.7 %). (Table II)

In group 2 modified Duran's test was false positive in 8 hands (specificity 94.7 %), original Duran's test was false positive in 8 hands (specificity 94.7 %), Phalen's test was false positive in 23 hands (specificity 84.7 %), Reversed Phalen's test was false positive in 26 hands (specificity 82.7 %), Tinel's test was false positive in 19 hands (specificity 87.3 %), Arm sphygmomanometer test was false positive in 34 hands (specificity 77.3 %) (Table II).

Modified Duran's test was positive in cases with short duration of history less than 1 month with positivity rate 80%, which increases with the duration of symptoms reaching as high as 97% in more than 6 months duration of symptoms. This means that modified Duran's test remains higher in its positivity rates than other tests along all the duration of symptoms, this was statistically significant in chi-square $p = 0.02$ (table IV, figure 3).

In modified Duran's test the applied pressure was sustained and precise (stopage valve) by firm device (the physical advantage of the firm substance allows a better pressure transmission than soft one, this was utilized in designing the modified Duran's device) upon the median nerve running deep to the flexor retinaculum to induce transient reversible ischemia and direct pressure nerve conduction block in short duration using the mercurial sphygmomanometer which is documented to be more precise and accurate than aneroid type¹.

In original Duran's test, the applied pressure was through soft rubber atomizing bulb, which is difficult to maintain the standard pressure for the appropriate time because there is no

valve to stop the pressure on the recommended level.

Modified Duran's test was positive in interval mean of 10.5 seconds, original Duran's test in interval mean of 23.3 seconds, Phalen's test in interval mean of 44.4 seconds and reversed Phalen's test in interval mean of 47.8 seconds (Table I).

There have been few published studies on the highest sensitivity and specificity

of original Duran's test as compared to other provocative test in the diagnosis of CTS (Table V).

The size of this study (150 hands in group 1 and 150 hands in groups 2) compared to other published series (Table V) is considered the largest size study which adds to the accuracy of the studied test.

Table I. The cases control difference in mean of certain test criteria

	Final diagnosis of carpal tunnel syndrome	
	Positive (cases with EMG evidence)	Negative (general population control)
Pressure needed to have a positive Duran's test		
Minimum	150	150
Maximum	195	150
Mean	151.2	150.0
SD	6.3	0.0
SE	0.6	0.0
N	127	8
P (t-test) = 0.03		
Time interval (seconds) needed to have a positive Duran's test		
Minimum	16	20
Maximum	30	28
Mean	23.3	24.0
SD	3.7	2.9
SE	0.3	1.0
N	127	8
P (t-test) = 0.59^[NS]		
Pressure needed to have a positive modified Duran's test		
Minimum	150	150
Maximum	185	150
Mean	151.0	150.0
SD	4.6	0.0
SE	0.4	0.0
N	142	8
P (t-test) = 0.008		
Time interval (in seconds) needed to have a positive modified Duran's test		
M Minimum	8	15
Maximum	18	22
Mean	10.5	18.1
SD	2.0	2.4
SE	0.2	0.9
N	142	8
P (t-test) <0.001		
Time interval (in seconds) needed to have a positive Phalen's test		
Minimum	31	35
Maximum	60	60
Mean	44.4	46.0
SD	6.1	7.4
SE	0.6	1.5
N	117	23
P (t-test) = 0.28^[NS]		
Time interval (in seconds) needed to achieve a positive reversed Phalen's test		
Minimum	32	38
Maximum	60	60
Mean	47.8	43.9
SD	5.8	6.3
SE	0.5	1.2
N	111	26
P (t-test) = 0.002		

Table II. The validity parameters (sensitivity and specificity) of 6 different tests in the detection and diagnosis of carpal tunnel syndrome.

	Final diagnosis of carpal tunnel syndrome		Sensitivity %	Specificity %
	Positive (cases with EMG evidence)	Negative (general population control)		
1- Duran's test				
Positive	127	8	84.7	94.7
Negative	23	142		
2- Modified Duran's test				
Positive	142	8	94.7	94.7
Negative	8	142		
3- Phalen's test				
Positive	117	23	78.0	84.7
Negative	33	127		
4- Reversed Phalen's test				
Positive	111	26	74.0	84.7
Negative	39	124		
5- Tinel's test				
Positive	106	19	70.7	87.3
Negative	44	131		
6- Arm sphygmomanometer test				
Positive	82	34	54.7	77.3
Negative	68	116		

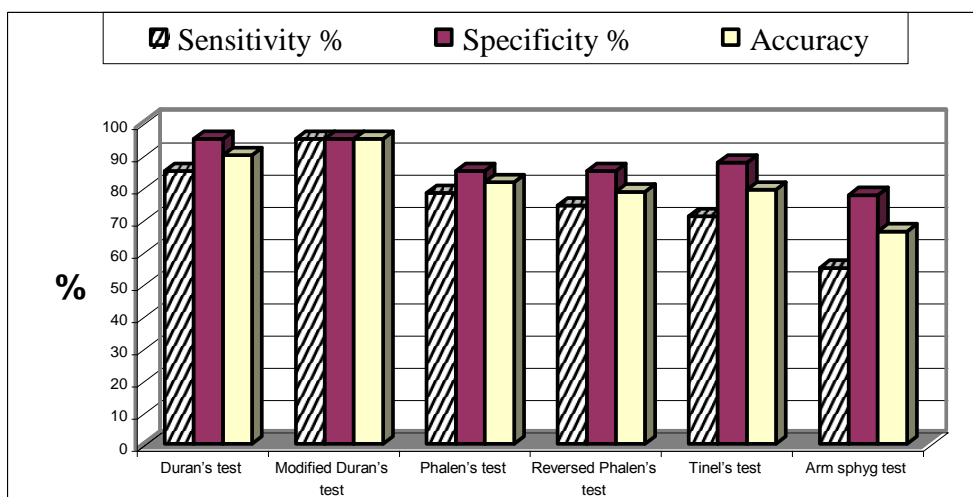
**Figure 2. Bar chart comparing the validity parameters sensitivity, specificity and accuracy of different tests in the detection and diagnosis of carpal tunnel syndrome.**

Table III. The validity parameters (PPV, NPV and accuracy) of a6 different tests in the detection and diagnosis of carpal tunnel syndrome.

	Final diagnosis of carpal tunnel syndrome		PPV	NPV	Accuracy
	Positive (cases with EMG evidence)	Negative (general population control)			
1- Duran's test					
Positive	127	8	94.1	86.1	89.7
Negative	23	142			
2- Modified Duran's test					
Positive	142	8	94.7	94.7	94.7
Negative	8	142			
3-Phalen's test					
Positive	117	23	83.6	79.4	81.3
Negative	33	127			
4- Reversed Phalen's test					
Positive	111	26	81.0	76.1	78.3
Negative	39	124			
5- Tinel's test					
Positive	106	19	84.8	74.9	79.0
Negative	44	131			
6-Arm sphygmomanometer test					
Positive	82	34	70.7	63.0	66.0
Negative	68	116			

Table IV: Positivity rate (sensitivity) of different tests in relation to the duration of symptoms duration of symptoms.

	Duran's test		Modified Duran's test		Phalen's test		Reserved Phalant's test		Tinel's test		Tourniquet test	
	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%
Duration of symptoms in month												
Less than 1 (n=10)	5	50.0	8	80.0	4	40.0	4	40.0	6	60.0	7	70.0
1-3 (n=43)	32	74.4	39	90.7	26	60.5	25	58.1	22	51.2	15	34.9
4-5(n=64)	59	92.2	63	98.4	57	89.1	52	81.3	50	78.1	38	59.4
6+ (n=33)	31	93.9	32	97.0	30	90.9	30	90.9	28	84.8	22	66.7
P(χ^2)@	<0.001		0.02		<0.001		<0.001		0.002		0.07^[NS]	

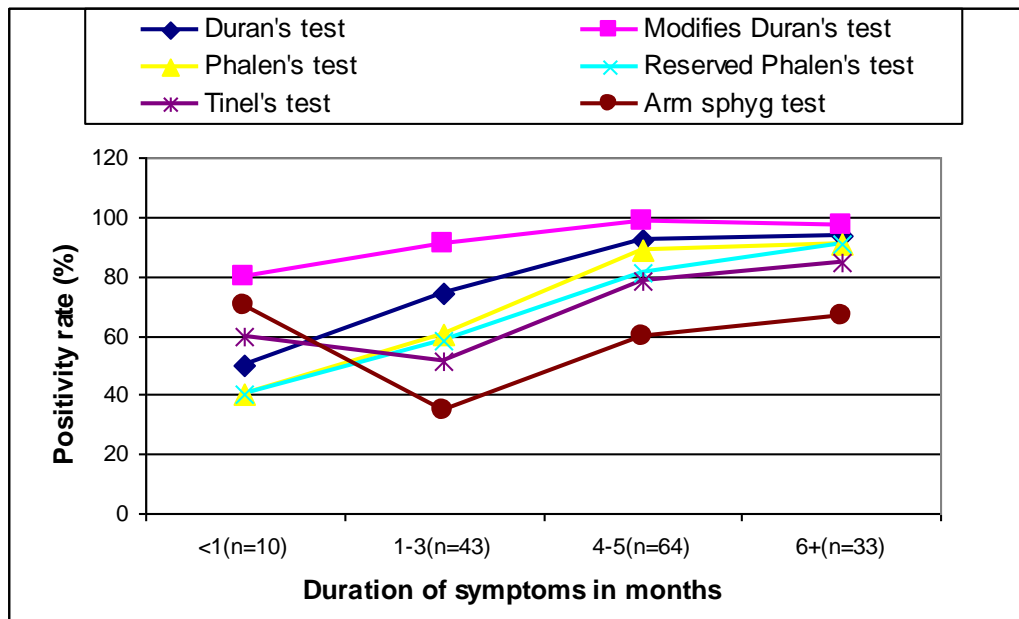


Figure 3. Line graph showing the difference in positivity rate (sensitivity) of different tests with the duration of symptoms.

Table V. Published studies were evaluated the clinical tests in diagnosis of CTS regarding sensitivity and specificity.

Author	Date	No. of patients	No. of control	Test	Sensitivity %	Specificity %
John A. Duran(10)	1991	50	50	Duran	87	90
				Phalen	70	84
				Tinel	56	80
Williams TM(41)	1992	30	30	Duran	100	91
				Phalen	88	85
				Tinel	67	81
Tetro AM(38)	1998	95	95	Duran	82	99
				Phalen	61	83
				Tinel	74	78
Kuschner SH(17)	1999	50	50	Duran	89	93
				Phalen	83	82
				Tinel	71	73
Richter M(30)	2000	54	54	Duran	87	96
				Phalen	64	87
				Tinel	70	75
Present Study	2002	150	150	O.Duran	84.7	94.7
				M.Duran	94.7	94.7
				Phalen	78	84.7
				Tinel	70.7	87.3

O. Duran = Original Duran's test

M. Duran = Modified Duran's test

Conclusions

For a test to be useful for diagnosis of a disease, it should be highly sensitive and specific for the disease being studied.

In the present study, the modified 4-Duran's test proved to be:

- 1- The most sensitive (94.7%) and the most specific (94.7%), compared to other provocative tests.
- 2- Has the highest PPV and NPV compared to other provocative test.
- 3- The most accurate test in relation to the other provocative tests in the diagnosis and screening for CTS especially in cases with typical history of the disease.
- 4- Simple non invasive and inexpensive technique.
- 5- Appropriate in painful wrist or with limited range of movement.
- 6- Has the least reaction time to be positive and can detect early cases of CTS compared to other clinical tests.

References

1. BL Andrews experiment of physiology, 9th edition, Churchill Livingstone, London. 1972.
2. Boland RA, Adams RD. Sphygmomanometer induced increases in forearm and hand volume. *J Hand Ther* 1990.
3. Douglas G, Tompkins MD, Larosse, et al. Median nerve neuropathy in the CTS caused by tumor like condition. *J Bone and Joint Surg* 1981; 21A(2): 373-83.
4. Duran JA. A new diagnostic test for CTS. *AM J Bone and Joint Surgery* 1991; 73(A): 535-8.
5. Gellman H, Gelberman RH, Tan AM, Botte MJ. CTS. An evaluation of the provocative diagnostic tests. *J Bone and Joint Surg* 1986; 86A(5): 735-7.
6. Kuschner SH. Reliability and validity of physical examination tests used to examine upper extremities. *J Hand Surg AM* 1999; 24(4): 868-9.
7. Phalen GS. Clinical evaluation of 598 hands with CTS. *Clinical Orthop and related researches* 1972; 83: 29-40.
8. Seror P. The sensitivity of various tests for the diagnosis of CTG. *J Hand Surgery Br* 1994; 19(6): 725-8.