CARPAL TUNNEL SYNDROME - A BATTERY OF TESTS CAN IMPROVE THE DIAGNOSIS

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ABSTRACT

INTRODUCTION: The gold standard for diagnosis of carpal tunnel syndrome (CTS) is not well defined. At times, patients of suspected carpal tunnel syndrome fail to respond to treatment if the diagnosis is based on symptoms alone or on one or two clinical tests probably because the diagnosis is not correct. The purpose of this study was to compare the relative merits of various diagnostic modalities in establishing the diagnosis of CTS and also to define the accurate test or combination of tests to help diagnose and manage CTS.

MATERIAL AND METHODS: Patients presenting with symptoms suggestive of CTS were evaluated using (i) Clinical Provocative tests - Durkan's test and Phalen's test, (ii) Tests for sensory perception thresholds using Semmes-Weinstein monofilament nylons (iii) Nerve conduction studies predominately sensory and motor and (iv) Gray scale sonography.

RESULTS: When a positive Phalen's test was taken as reference, the positive predictive value of Durkan's test and ultrasonography was 100%, Nylon perception test and neurophysiological studies had a value of 90 and 89% respectively. When Durken's test was used as reference, ultrasonography had a positive predictive value 0f 98% followed by nylon perception testing - 94%. Phalen's test and neurophysiological studies had values of the order of 92 and 88% respectively.

CONCLUSION: Our observations suggest that clinical history and physical examination can be used to screen the patients. The perception threshold testing with monofilament nylons and ultrasonographic examination of carpal tunnel (CT) improve the diagnosis. In addition, ultrasonographic examination of CT provides the information on anatomy and condition of the contents of CT and help planning the treatment. A combination of clinical provocative tests, Semmes-Weisntein monofilament testin and high frequency sonography could be considered as definitive diagnostic battery for diagnosing carpal tunnel syndrome.

KEY WORDS: Carpal tunnel; Monofilament nylon testing; nerve conduction studies; Median nerve; Wrist sonography

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INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common compression neuropathy seen in the upper extremity[1] and diagnosed on basis of clinical findings, symptoms and provocative test alone since no universally accepted gold standard exists at present, for the diagnosis of CTS[2]. Sensibility testing perception threshold test with Semmes-Weinstein-Monofilaments and innervation- density tests - (Two-point Discrimination) used in patients with CTS have shown variable results[3]. Although electro-diagnostic studies have been widely used for the diagnosis of CTS, it has substantial rates of false negatives[2] and cannot be fully relied on. Conventional radiographs are of little help in confirmation of diagnosis if bony structures are intact. Computarized axial tomography (CT) is of little help because of the similar attenuation values of carpal tunnel[1]. Magnetic resonance imaging (MRI) has shown to be helpful to study the anatomic relations of median nerve and underlying flexor tendons[2]. However the tool is expensive, time consuming and is at times unavailable. Ultra-sonography has also been tried and has shown promise and can be relied upon for pre-treatment / pre-operative confirmation of diagnosis[4]. A study was planned and carried out in the Department of Orthopedic Surgery, Kasturba Medical College, Manipal (India) during 2007-9. The objectives of the study were to compare different modalities for evaluation of case with symptoms suggestive of CTS and assess their relative efficacy for diagnosis CTS. The study was approved by the Department and Ethical clearance was obtained. Informed consent of the patients was obtained after explaining the issues to them.

MATERIAL AND METHODS

In the present study, we evaluated the patients a battery of tests which included

(i) Provocative tests - Darkan's test and Phalen's test
(ii) Tests for sensory perception thresholds using Semmes-Weinstein monofilament nylons
(iii) Nerve conduction studies predominately sensory and motor
(iv) Gray scale sonography for carpal tunnel

Fifty four hands in patients of either sex, who had symptoms suggestive of median nerve compression in the carpal tunnel based on their complaints, were included in the study. The symptom criteria used for selection of cases were

(i) Tingling and numbness in hand in median nerve, median and ulnar nerve or glove distribution (all cases had to meet this criteria).
(ii) Paresthesias aggravated by activities such as working with hands raised, holding objects.
(iii) Paresthesia and pain in the hand that awakens the patient from sleep.
(iv) Paresthesia relieved by shaking the hand or holding it in dependent position
(v) Subjective weakness of the hand
(vi) Clumsiness of the hand or dropping objects

Detailed clinical history, physical examination, sensibility testing, nerve conduction study and sonography were performed. Laboratory investigations to diagnose secondary cause(s) of CTS were performed to exclude patients suffering from pregnancy, diabetes mellitus, polyneuropathy, failed carpal tunnel release, cervical radiculopathy, hypothyroidism, trauma and rheumatoid arthritis. Only idiopathic CTS (with no etiological factors) were included.

Provocative tests - Darkan's test and Phalen's test were performed as originally described. Phalen's Test[1] is performed by unforced complete flexion of the wrist, sustained for 60 seconds. In this position the symptoms of tingling and numbness will either be reproduced or exaggerated in the median nerve distribution of the hand. Durkan's test[5] is done by applying direct pressure on the median nerve running deep to the flexor retinaculum. Examiner exerts even pressure with both thumbs on to the median nerve in the carpal tunnel. The interval from the application of compression to the onset of numbness, pain or paresthesias in the distribution of the median nerve distal to the level of the carpal tunnel is recorded. It is 30 seconds or less if the test is positive.

Testing for sensory perception thresholds was done with Semmes-Weinstein monofilaments nylons manufactured by North Coast Medical, Inc., California, USA. Both hands of each patient were tested, and all tests were performed by the same examiner using standard technique[6]. Nylon number 2.83 (equal to 70 mg pressure) was taken as normal.

Nerve conduction studies were done for all cases as per American Association of Electrodiagnostic Medicine recommendations[7,8] using NIHON KOHDEN neuropack system. All tests are done in the same room and in similar temperature conditions. Measurements used in the study included -

a) Sensory nerve conduction velocity in two-digit / wrist segments
b) Median distal motor latency from the wrist to the thenar eminence,
c) Comparative median / ulnar distal sensory latencies,

d). Motor conduction velocity.

The diagnostic criteria as recommended by The American Academy of Electro-diagnostic Medicine (AAEM), [7,8] were used.

Ultrasonographic evaluation was carried out with Voluson expert machine and 12 MHz linear array transducers. All cases were subjected to high-resolution real-time sonography of the carpal tunnel. It took about 15 minutes on an average to examine each case.

The examiner was requested not to enquire about symptoms and patients were asked not to speak about their symptom during examination. The sonographic examination was performed with the patient seated in a comfortable position facing the sonographer, with forearm resting on the table and the palm facing up in the neutral position. The median nerve was assessed in both transverse and longitudinal planes.
The median nerve is located superficial to the echogenic flexor tendons and its size was noted. Area of constriction was noted in longitudinal and transverse planes both. The median nerve diameter was measured by tracing with electronic calipers around the margin of the nerve at the time of sonography. Axial scans were obtained at proximal and distal tunnel.

$$\text{Cross sectional area of the median nerve} = \frac{\text{Transverse diameter at pisiform x Anteroposterior diameter}}{4}$$

The mean cross sectional area (MCSA) of the median nerve in controls at this level - proximal end of the tunnel is 7.8mm^2 or less as reported by Yesildag et al [9]. Any value greater than this was taken as swelling of the median nerve.

Surgery in the form of open release of flexor retinaculum by Taleisnik[10] incision was performed in all 54 hands.

STATISTICAL METHODS

Sensitivity and specificity statistical measures were used in the present study. The sensitivity measures the proportion of actual positives which are correctly identified as such and the specificity measures the proportion of negatives which are correctly identified. Ranking was done based on the percentage result obtained for both sensitivity and specificity.

OBSERVATIONS

Fifty four hands with clinically diagnosed carpal tunnel patients were evaluated. Of these 54 hands, 42 were in female cases. Majority of patients (36) were in 31 to 50 year age group and right and left sides were more or less equally affected.

In 51 (94.4%) Durkan's test was positive whereas 48 (88.8%) hands were found positive to Phalen's test. Raised sensory perception thresholds to monofilament nylons were observed in 50 (92.5%) hands whereas in 4 thresholds were normal, Neurophysiological studies showed that 48 (88.8%) hands showed abnormal findings where as in six hands it was normal according to the diagnostic criteria recommended by AAEM. In one hand, symptoms were on left side but nerve conduction study suggested right sided carpal tunnel syndrome, whereas sonogrpahic study and sensibility testing showed bilateral carpal tunnel syndrome. Patient underwent decompression of left side on the basis of clinical, sonographic and sensibility testing and was relieved of the symptoms following surgery. In the six neurophysiologically normal hands and in one ultrasound negative, release of flexor retinaculum was done and patients were relieved of their symptoms.

On ultrasonographic evaluation, median nerve edema was noted in all cases. The shape, size, echogenecity and relationship of median nerve to overlying retinaculum, amount of synovial fluid and presence of any mass(es) was recorded. The anatomy of median nerve and its continuity was noted. The measurements of cross-sectional area of median nerve at the inlet of carpal tunnel proximally and outlet distally were taken.

The value of MCSA was >9mm^2 in 53 hands and was suggestive of median nerve swelling.

In two patients, ganglionic cysts were seen projecting into the carpal tunnel, in one of them cyst was found at the level of distal radius and in another posterior to the flexor carpi radialis tendon. This finding was confirmed on surgical release of the carpal tunnel and the cyst was excised. In one hand median nerve appeared mildly flattened at the proximal tunnel. None of the patients experienced any discomfort in their hands during the study.

DISCUSSION

It has been suggested that the diagnosis of CTS must be based on the clinical symptoms and the outcomes of the provocative tests findings. In clinical practice this has its own limitations. Katz et al[11] observed that symptoms in median distribution may not be supportive of the diagnosis in up to 13% cases. The specificity of the symptoms is only 35% at its best. Mondelli et al[12] have noted that a battery of clinical test does not offer any advantage over the use of a single test and the outcome of test

depends upon the severity of CTS. The sensory perception testing using monofilament nylons have similar problems of reliability though inter-observer and intra observer reliability is satisfactory [13]. Golding et al[14] noted in their studies that in patients who are suffering from acroparesthesia, the provocative test and sensory testing are not reliable and therefore offer no help. Padua et al[15] have observed that a large section of CTS patients with severe symptoms showed minimal functional impairment or no electrophysiological abnormality. Gunnarson et al[16] found neurophysiologic examination to be false positive in 13% instances.

Evaluating a diagnostic test is always comparative to some other diagnostic test, which is considered gold standard. The gold standard has not been well defined for the diagnosis of carpal tunnel syndrome. The purpose of this study was to compare the relative merits of various diagnostic modalities in establishing the diagnosis of CTS and also to define the accurate test or combination of tests to help diagnose and manage CTS.

We investigated the question of whether a single test or a combination of tests might be more powerful in establishing the diagnosis. Our findings support that clinical history and physical examination are the primary methods of screening the patient for carpal tunnel syndrome. The addition of perception threshold testing with monofilament nylons, neurophysiological studies and ultrasonographic examination of carpal tunnel was to compare the outcome of each of these with the clinical provocative tests.

We followed the AAEM recommendation with reference to the cut off values for nerve conduction measures, since it was found to be reliable. For ultrasound evaluation, we used median nerve cross-sectional area at the proximal carpal tunnel as the sole parameter since it has been reported to be more consistently associated with the severity of nerve compression[9,17].

We compared all these tests and ranked each of them in increasing order of their sensitivity. Considering Phalen's test as reference, we noted that Semmes- Weinstein monofilament testing (93.75%),: Durkan's test (92.16%), Nerve conduction studies (89.58%) and Sonography (88.68%) were in that order (Table-I).

When we considered Durkan's test as reference the, ranks were found to be -Phalen's test (97.92%), Semmes-Weinstein monofilament (96%), Sonography (94.3%) and Nerve conduction studies (93.8%) (Table- II). In both the situations, accuracy of clinical tests and Semmes- Weinstein monofilament topped the ranking amongst other tests.

When we consider Phalen's test as reference, the positive predictive value of Durkan's test and ultrasonography was 100%, Nylon perception test and neurophysiological studies had a value of 90 and 89% respectively.
When Durken's test was used as reference, ultrasonography had a positive predictive value 0f 98% followed by nylon perception testing - 94%. Phalen's test and neurophysiological studies had values of the order of 92 and 88% respectively.
We ranked the test in order of their accuracy as revealed by the present study (Table III).
It appears that a combination of clinical provocative testing with Phalen' s test and Durkan's test, testing for monofilament perception thresholds and ultrasonographic examination of carpal tunnel would provide an accurate assessment of the problem of carpal tunnel syndrome. These procedures are also easy to carry out.Neurophysiological studies do not provide special information about the nerve or its surroundings that could help in determining etiology. In addition, these are expensive, time consuming and may not relate to the extent of damage. Anatomical evaluation of the carpal tunnel is of great advantage in diagnosis and management. It helps the surgeon to anticipate the surprises during carpal tunnel release. In our series two patients were found to have ganglionic cyst seen projecting into the carpal tunnel. These finding were later confirmed on surgical release of the carpal tunnel and the cyst was excised.
Nerve conduction studies cannot detect early compression. They are of less value when there is involvement of small myelinated fibres that produce only subtle changes in nerve conduction measures. Sonogram may be more useful in the above mentioned occasions.

Table I: Relative efficacy of different investigative tools when Phalen's test is taken as reference

	Durkan's test		Ultrasono-graphic studies		Neuro-physiological studies		Sensory perception thresholds	
Phalen's test	positive	Normal	positive	Normal	positive	Normal	positive	Normal
Positive	47	1	47	1	43	5	45	5
Normal	4	2	6	0	5	1	3	1
Total	51	3	53	1	48	6	48	6
sensitivity true +ve	92.16		88.68		89.58		93.75	
specificity true –Ve	66.67		0.00		16.67		16.67	
false –ve	7.84		11.32		10.42		6.25	
false +ve	33.33		100.00		83.33		83.33	
predictive value of +ve test	100.00		100.00		89.58		90.00	
predictive value of -ve test	33.33		0.00		16.67		25.00	

Table II: Relative efficacy of different investigative tools when Durkan's test is taken as reference

	Phalen's test		Ultrasono-graphic studies		Neuro-physiological studies		Sensory perception thresholds	
Durkan's test	positive	Normal	positive	Normal	positive	Normal	positive	Normal
Positive	47	4	50	1	45	6	48	3
Normal	1	2	3	0	3	0	2	1
Total	48	6	53	1	48	6	50	4
sensitivity true +ve	97.92		94.3		93.8		96.0	
specificity true -Ve	33.33		0.0		0.0		25.0	
false -ve	2.08		5.7		50.0		4.0	
false +ve	66.67		100.0		100.0		75.0	
predictive value of +ve test	92.16		98.0		88.2		94.1	
predictive value of -ve test	66.67		0.0		0.0		33.3	

Table III: Ranking of the relative efficacy of different investigative tools

SENSITIVITY	Durkan's test	Phalen's test	Ultrasono-graphic studies	Neuro-physiological studies	Sensory perception thresholds
Phalen's test as screening test	92.16	-	88.68	89.58	93.75

CONCLUSION

Combination of clinical provocative tests, Semmes-Weisntein monofilament and high frequency sonography could be considered as definitive and diagnostic battery for diagnosing carpal tunnel syndrome. All these tests are less time consuming, less expensive, non-invasive, painless, patient friendly and have higher diagnostic accuracy when put together than any other test singly or in combination. With sonogrpahy one also gets anatomical picture of carpal tunnel which is helpful in treatment planning.

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