Carpal tunnel syndrome: A new objective evaluation technique

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Thumb abduction strength is impaired progressively in patients with carpal tunnel syndrome (CTS). In advanced cases abductor pollicis brevis (APB) weakness and wasting are evident. The APB muscle recovers power significantly after carpal tunnel release. A technique that objectively measures this function is described. The results of a study comparing 175 patients suffering from CTS with 132 controls are presented. No previous study has looked exclusively at the APB motor deficit preoperatively and at the postoperative recovery in CTS patients. Preoperatively, bilateral thumb abduction power was measured in patients with CTS by using a micrometer spring scale. The results were compared with those from a control group. A significant APB strength deficit was present in all CTS patients (P=0.001). A standard carpal tunnel release was performed by the same surgeon in all cases. The transverse carpal ligament was incised under direct vision with the use of an open technique. Thumb abduction strength was measured again four weeks postoperatively; significant recovery was observed in strength compared with the preoperative value (P=0.001). Thumb abduction power was, however, still lower than that of the control group (P=0.001). This test is a simple, inexpensive and reproducible way to evaluate the severity of CTS and to help diagnose patients with CTS objectively. It is a useful adjunct to monitor and follow CTS patients postoperatively.

Key Words: *Abductor pollicis brevis, Carpal tunnel release, Carpal tunnel syndrome*

Syndrome du tunnel carpien : nouvelle technique d'évaluation objective

RÉSUMÉ : La force abductrice du pouce est graduellement diminuée chez les patients atteints du syndrome du tunnel carpien (STC). Dans les cas plus avancés, on note une faiblesse et une fonte du court abducteur du pouce. Le muscle retrouve significativement sa puissance une fois le tunnel carpien dégagé. On décrit ici une technique qui sert à mesurer avec objectivité cette fonction. Les résultats d'une étude où l'on comparait 175 patients atteints d'un STC à 132 témoins font l'objet du présent article. Aucune étude n'avait auparavant mesuré exclusivement le déficit moteur du court abducteur du pouce avant et après l'opération chez les patients atteints. En préopératoire, la puissance d'abduction bilatérale des pouces a été mesurée chez les patients atteints au moyen d'une échelle à ressort micrométrique. Les résultats ont été comparés à ceux du groupe témoin. Un déficit significatif a été observé chez tous les patients atteints (p = 0,001). La technique normale de dégagement du tunnel carpien a été effectuée par le même chirurgien dans tous les cas. Le ligament carpien transverse a été incisé sous vision directe au moyen d'une technique ouverte. La force d'abduction du pouce a été mesurée à nouveau quatre semaines après l'opération. Une récupération significative a été notée sur le plan de la force en comparaison avec les valeurs préopératoires (p = 0,001). La puissance d'abduction du pouce a, toutefois, été moindre que dans le groupe témoin (p = 0,001). Ce test est une façon simple, peu coûteuse et reproductible d'évaluer la gravité du STC et de poser un diagnostic objectif chez les patients atteints. C'est une mesure d'appoint utile pour exercer un suivi postopératoire chez les patients atteints de STC.

Carpal tunnel syndrome (CTS) is a common median nerve compression neuropathy involving both sensory and motor components. Its prevalence has been reported to be as high as 5.8% in females and 0.6% in males (1). A diagnosis of CTS requires a combination of patient history, subjective findings and objective testing (2). The most sensitive, nonspecific subjective complaint is numbness (3). Nerve conduction study is the gold standard diagnostic test. Although 90% sensitive (4), this test is expensive and time consuming to subject all patients to this test. We order nerve conduction testing selectively for patients with equivocal findings or history. Numerous provocative tests exist to diagnose CTS, each with its own specificity and sensitivity (5-7). Direct compression over the flexor retinaculum, the

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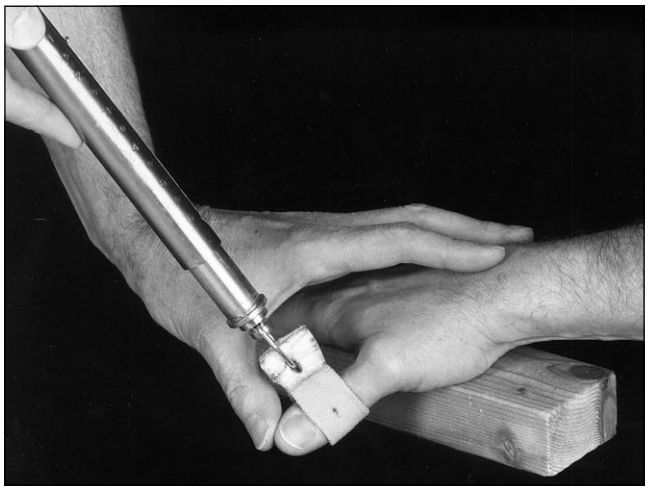

Figure 1) *Adjustable scale used to measure thumb abduction strength*

pressure provocative test, has been shown to be the most specific (90% accurate) and sensitive (87% accurate) bedside test (8).

Some studies evaluating pinch and grip tests have shown some long term (three to six months) improvement postoperatively (3,9,10). Pinch and grip testing involve a combination of forearm muscles, innervated by both the ulnar and median nerves, and are, therefore, poor indicators of a specific median nerve function. Katz et al (6) looked at median nerve impairment by evaluating abductor pollicis brevis (APB) strength preoperatively. A simple gradation system (normal or impaired) was used. With this gross evaluation, they found that 36% of patients were weak preoperatively. Rhoades et al (11) also had a simple gradation system (1,3-5,9) to evaluate preoperative versus postoperative thumb abduction strength. No accurate description of the method was reported. Mild improvements were demonstrated with mild CTS, but no improvement was shown with severe CTS. Many studies have looked at the improvement of median nerve conduction after carpal tunnel release; all patients have shown improvement (10,11). Knowing that the thenar muscles are predominately innervated by the median nerve and that the APB is solely innervated by the median nerve, we have designed and evaluated a new test that measures isolated thenar abduction strength. We believe that this test allows an objective measurement specifically of median nerve function.

The purpose of this study was to evaluate the improvement in thenar muscle abduction power after carpal tunnel release at four weeks.

PATIENTS AND METHODS

Materials

A graduated micrometer with an adjustable 6 kg scale (Chatillon Scale E487, Chatillon & Son, New York) was purchased at LL Bean (Maine). Other materials used included an attachment loop for thumb insertion made of leather/nylon (2.5 cm wide) and a hard wood block (3.5 cm thick, 20 cm long and 5.5 cm wide).

Measuring method

Measurements are taken with the patient sitting on an examining table with the elbow slightly flexed, relaxed and resting against the ribs. The thumb and wrist are extended. The hand rests on a wood block in a pronated position. The thumb is secured in the small strap of the scale and sits at a right angle to the edge of the wooden block. The thumb is in contact with the examining table. The thumb strap encircles the thumb precisely at the proximal edge of the nail bed. The measurer instructs the patient to maintain the thumb in contact with the table (thumb abduction) while resisting the upward pull of the scale. The measurer pulls the scale upward in line with the thumb abduction axis and watches the thumb as it lifts off the surface of the table. At the moment of lost contact the measurer reads the result on the scale (Figure 1).

Specific care is taken to try to eliminate all other muscle groups that could be used to give a false high value. By placing a hand directly on the top of the patient's hand, the examiner can detect unwanted pronation quite accurately. The patient's elbow must be against the side of the body, and the shoulder relaxed and depressed.

Statistical evaluation

Results were reproduced by measuring 20 different hands on three different occasions. No significant variation was observed ($P<0.01$) between consecutive measurements. Observations between different observers were evaluated by measuring thenar muscle power in 10 different hands; both observers were blinded to the other's results. No difference between results was observed ($P<0.01$). All data were collected by the authors.

Methods

Beginning in February 1993, data were collected over one year at the Ottawa Civic Hospital from 121 female patients and 54 male patients suffering from CTS. All patients underwent a carpal tunnel release and complied with a follow-up postoperative visit at four weeks.

All carpal tunnel releases were done by Dr Bigelow with the assistance of a surgical resident or intern. The flexor retinaculum was completely transected longitudinally under direct vision with the use of an open technique. A gauze Coban bandage (3M) was used postoperatively. Patients were instructed to remove the bandage and move the hand gently by the second postoperative day. Sutures were removed one week following the surgery, and a follow-up appointment was scheduled for four weeks postoperation. Thenar muscle strength was measured at four weeks postcarpal tunnel release. Note that at one week, pain was significant enough to prevent most patients from giving maximal effort when measurement was attempted. In a small number of patients who had only minor incisional discomfort, muscle strength was increased from the preoperative measurement, suggesting that muscle recovery may be rather rapid following decompression. Functionally, most people have too much incisional pain to test strength accurately before four weeks. In all cases, recorded strength at four weeks was greater than

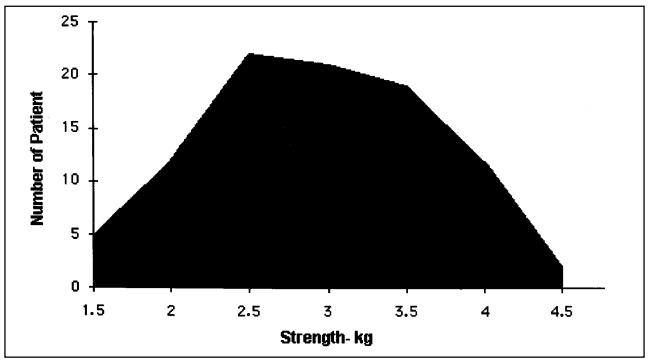

Figure 2) *Normal distribution of thumb abduction strength of female controls*

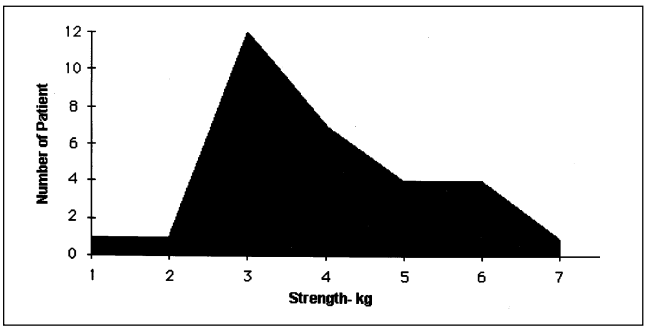

Figure 4) *Normal distribution of thumb abduction strength of male controls*

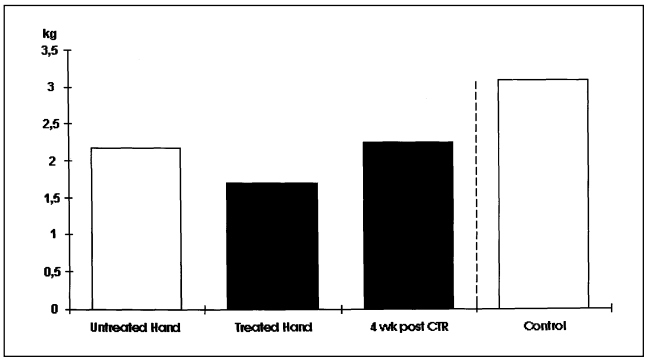

Figure 3) *Thumb abduction strength of 121 female carpal tunnel syndrome patients four weeks (wk) postcarpal tunnel release (CTR)*

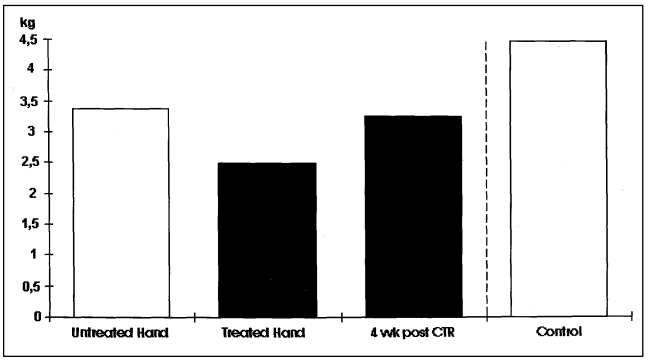

Figure 5) *Thumb abduction strength of 54 male carpal tunnel syndrome patients four weeks (wk) postcarpal tunnel release (CTR)*

preoperative strength, even in people who seemed to have complaints of significant incisional pain.

Thenar muscle abduction power was measured in 122 control individuals. Ninety-four females and 28 males were studied, including volunteers of various body sizes and occupations. Exclusion criteria for the control group were symptoms of or suffering from CTS, previous wrist fracture or major hand injury, and any painful hand affliction. Both hands were measured at least once. Each patient measurement was classified according to whether it was taken from the dominant or nondominant hand.

RESULTS

The study included 121 female patients suffering from symptomatic CTS with an average age of 51.94 years; 94 female controls were also studied. The average age of females in the control group was 39 years.

Average APB strengths in the female control group were 3.2 kg and 3.0 kg for dominant and nondominant hands, respectively (Figure 2). Average abduction strength in female CTS patients measured at the preoperative visit was 2.2 kg in the less symptomatic hand. Average APB strength of the symptomatic hand was 1.7 kg at the first visit. Four weeks postcarpal tunnel release, APB muscle power averaged 2.5 kg in the surgically treated hand (Figure 3) and averaged 2.2 kg in the asymptomatic hand.

APB strength was greater in the control group than in the CTS group preoperatively ($P<0.01$). Four weeks postoperation, surgically treated hand strength improved significantly ($P<0.01$) compared with the preoperative measurement.

Fifty-four males with CTS with an average age of 49 years were evaluated; 28 male controls with an average age of 37 years were also evaluated (Figure 4). APB strengths of male controls averaged 4.4 kg and 4.5 kg for dominant and nondominant hands, respectively. The skewed graph shows the rather remarkable muscle strength of a few males who did heavy manual labour. This reflects their general physique. In male subjects with CTS, APB muscle strength averaged 3.4 kg in the less symptomatic hand and 2.5 kg in the symptomatic hand. At four weeks follow-up postoperatively, APB muscle strength in the surgically treated hand had improved to 3.3 kg (Figure 5).

APB strength was higher in both female and male controls than in CTS patients preoperatively ($P<0.01$). Four weeks postoperatively, strength of the surgically treated hand had improved significantly ($P<0.01$) but was still weaker than that of controls.

DISCUSSION

CTS has been conveniently divided into three phases: irritative, compressive and deficit (12).

The irritative phase is associated with paresthesia, hyperesthesia and mild pain. In the compressive phase, pain and hypoesthesia are noted, and many patients complain of loss

of dexterity and fatigue. In the true deficit phase, patients complain of anesthesia and loss of grip strength. Pain may be a less prominent feature as the condition progresses.

This classification suggests a logical stepwise progression in the CTS; however, it is rather structured and rigid and does not reflect the clinical picture where symptoms wax and wane from day to day and even from hour to hour depending upon wrist position changes and activity level. Regeneration of axons, reflected by a Tinel's sign, is a clinical sign that may be lost in the late phases, ie, secondary to persistent severe compression. Muscle weakness has been considered to be a late feature of CTS but in our study appeared to occur early. It is our impression that when numbness and pain improve subjectively in patients treated conservatively, muscle weakness as measured by the spring scale also improves. Improved APB strength was observed frequently in the less symptomatic hand when patients stopped working after surgery on the symptomatic hand.

In our study, all patients were seen by referral. Most patients had symptoms far longer than six months, and 56% had positive nerve conduction studies before referral.

This study, therefore, comprised patients with well established CTS, and no patient in the series had this condition for less than three months before presentation.

The APB strength test measures APB function specifically and objectively. Several patients with advanced CTS, particularly renal dialysis patients with severe amyloid synovitis, had profound thenar atrophy; the APB strength reading was 0 kg in these patients. Because the long thumb abductors and extensors were intact we conclude that a severe compressive neuropathy eliminates the ability of the patient to have a detectable score on APB strength measurement.

This test can be administered by different observers with similar readings. The variation between two observers in the strength measurements of 10 hands was less than 5% (P=0.01). Variation in measurements on three different occasions were carried out in 20 hands with a variation of less than 5% (P=0.01).

This test demonstrates objectively and with precision the impaired APB muscle strength observed in CTS patients. It appears that loss of strength is evident even in patients who have early symptoms of CTS compared with the control population.

As with any physical strength test a consistent technique must be used to obtain the most accurate, uniform and reproducible results. Several factors must be controlled when obtaining the APB measurement. Flexion of the wrist, fingers or thumb must not be allowed. The elbow should be flexed and held against the ribs to eliminate any force from shoulder rotation, and pronation must be eliminated. By placing their hand on the dorsum of the patient's hand, observers can detect any pronation tendency, and the patient can be cautioned to relax the hand and to use only the thumb. In some patients it may be necessary to actually hold the elbow against the chest wall if they have problems pronating despite instructions. Falsely high readings may be obtained if these techniques are not used consistently. The first reading is used because CTS patients tire quickly with repeated or sustained effort. The first absolute reading in our CTS patients was uniformly and significantly lower than that in controls, and this was the measurement that we used.

This technique of measurement gives results that correlate extremely well with the subjective symptoms of CTS patients. We objectively demonstrated an often dramatic decrease in the strength of a number of patients who subjectively deteriorated over a period of conservative observation while using night splinting and anti-inflammatory medications. Anecdotally, a number of patients stated that they were "managing with their anti-inflammatory medications and splints". When shown how their strength reading had dropped over several months the patients decided to have the surgery done. We feel more comfortable advising patients not to delay surgery too long because we have an objective means of evaluating their condition in terms of muscle strength measurement.

This test is very 'low-tech', inexpensive, noninvasive, completely safe and quick to administer. Indeed, it may shorten a follow-up evaluation because the evident improvement in strength makes the patient dwell less on the subjective side effects of the surgery. It allows the physician to assure the patient that they are showing objective improvement.

In two Workers' Compensation Board patients, observers were not able to record a valid, consistent postoperative reading, several months after what should have been their final postoperative visit. Their lack of compliance was evident and demonstrable. The objective evaluation technique that we have described may provide objective, noninvasive, ongoing assessment of progress in complex patients.

The static nature of the test did not seem to cause undue discomfort for patients with painful basal joint arthritis of the thumb. We seek improvement in the postoperative abduction measurements; presumably other painful hand conditions will tend to cancel themselves and allow specific valid changes to be observed. We have found this to be a very sensitive test, with significant changes that correlate with the patients' clinical state being recorded objectively. Its specificity needs to be assessed over time, but with a compatible history, it appears to be quite specific for diagnosing CTS. It specifically measures APB strength, which is recorded as 'zero' in patients with median nerve lacerations and in several end-stage CTS patients.

In the two years since completion of the study we have continued to monitor patients preoperatively and postoperatively. Anecdotally, we have followed a number of patients who demonstrated objective improvement in their APB strength in their nonoperated hand before returning to work who have again presented with symptoms of CTS. We have been able to demonstrate a deterioration in grip strength in these patients, indicating that the stressful repetitive nature of their job is again causing conduction problems with their median nerve, resulting in a secondary objective loss of APB motor strength. This objectively confirms that the type of work that the patient is doing is in many circumstances a true

contributing factor to their symptoms and disability. The test is of course much more readily done than nerve conduction studies, with much less expense, and the objective measurements substantiate the patient's complaint of recurrent symptoms.

With experience, measurements can be reproduced accurately in almost all patients. Any deliberate attempt by the patient to use accessory muscles to score high or to score deliberately low is easily detected, and the patient can be advised to alter their behaviour during the test.

CONCLUSIONS

We present a simple, objective, sensitive test to evaluate patients with suspected CTS. The test has also demonstrated value in objectively monitoring the recovery of muscle function after surgical decompression of the median nerve.

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