CARPAL TUNNEL SYNDROME

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Definition:

It is a symptomatic compression neuropathy of the median nerve at the level of the wrist (1).

History:

The first description of carpal tunnel syndrome in the literature was by Paget in 1854(2). Learmouth is credited to have been the first surgeon to divide the "annular ligament" at the wrist as treatment of CTS secondary to trauma(3). The first description of an operation for idiopathic carpal tunnel syndrome (CTS) was in 1946 by Canon and Love (4). However Phalen is credited with one of the earliest description of idiopathic CTS from an anatomical, pathological and clinical view point and also suggest the correct surgical treatment (5). Chow described endoscopic carpal tunnel release in 1989(6).

Aetiology:

Idiopathic CTS is the commonest cause of CTS. Other conditions which predispose patients to CTS are Diabetes, Hypothyroidism and pregnancy. The condition affects women more than men and bilateral incidence is common. CTS can also be a component of double crush syndrome which has a co-existent proximal compression of the same nerve or its roots. The microangiopathy caused by Diabetes produces endoneural ischemia which makes the nerve susceptible to compression. This combination leads to impaired axonal transport leading to nerve degeneration. Hypothyroidism produces CTS due to excess deposition of Mucinous substances on the nerve leading to compression within the carpal tunnel.

Relevant anatomy:

The carpal tunnel is centred in the area between the thenar and hypothenar muscles and is enclosed by the transverse carpal ligament **(Fig.1).** Ten important structures form the contents of the carpal tunnel. They are the four slips of the flexor digitorum sublimus, four slips of the flexor digitorum

profundus, flexor pollicis longus and the median nerve. The median nerve is the most superficial structure. The transverse carpal ligament is attached medially to the Pisiform and hook of Hamate. Laterally it is attached to the Scaphoid tuberosity and Trapezium. Proximally this blends with the antebrachial fascia. The distal part gives attachment to the thenar and hypothenar muscles (7). The term flexor retinaculum and transverse carpal ligament have been used interchangeably and also described as one being part of another (8, 9). However this is not important from a surgical point of view as complete release from the proximal to the distal extent of the transverse carpal ligament is necessary for successful outcome.

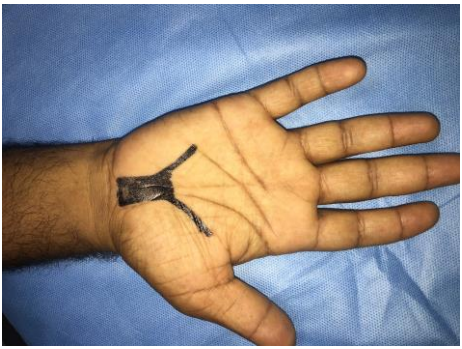

Fig.1. The diverging lines represent the boundaries of the thenar and hypothenar regions and the shaded area is the area of the carpal tunnel

The carpal tunnel is narrowest at the level of the hook of Hamate and this corresponds to the place of nerve constriction (10).Integrity of the carpal arch is not significantly affected after sectioning the transverse carpal ligament (11). The median nerve can have varied anatomy. It can be bifid being split in the middle by an accessory lumbrical muscle (12). The motor branch of the median nerve can be extraligamentous, transligamentous or subligamentous (13). **(Fig.2).**The extraligamentous variety is the commonest variation.

Fig.2. *Phalen's test. The wrist is allowed to passively drop to the available flexion and the test is performed for a minimum of 30 seconds*

Pathophysiology:

Pressure → breakage of blood-nerve barrier → endoneural edema → fibrosis → localised demyelination → axonal degeneration → sensory and motor deficits(14).

Clinical presentation:

Clinical findings of CTS are reflective of the histopathological changes taking place in the nerve following compression(15).Sensory disturbances progress from intermittent paresthesia to constant paresthesia to persistent numbness.Superficial fascicles will undergo changes sooner than others and hence sensory disturbances in the middle and ring fingers happen earlier than other fingers. For the same reasons, the motor deficit is noted much later as the motor fasicles are located deeper in the median nerve . Nocturnal symptoms are very disturbing and happen because the wrist goes into postural flexion while the patient is asleep. This replicates the "Phalen's test" producing nocturnal symptoms.

Motor changes affect the thenar muscles especially the abductor policies brevis. Associate flexor tenosynovitis

should always be recognised because this may require to be dealt with at the time of surgery. This is made out by asking the patient to actively flex the fingers and bring the pulps to the distal palmar crease. The distance between the crease and the pulp of the fingers is measured. This is followed by passive flexion of the patient's fingers by the examiner. Associated flexor tenosynovitis is to be considered when the active range of motion is more than the passive range of motion. Symptoms progress from intermittent weakness to severe weakness and atrophy. In Indian situation patients complain of significant difficulty while eating rice with the hand

Provocative manoeuvres:

Phalen's test: (Fig.2)

Described by George Phalen in 1966(16). The forearm is held vertically and the wrist is allowed to drop into 90 degrees of flexion under the influence of gravity. If stiffness of the wrist does not permit 90 degrees of flexion then the wrist should be allowed to fall as far as possible. The test is considered positive if the symptoms elicited are the same with which the patient presented. The test should be performed for

minimum of 60 seconds. The sensitivity ranges from 42 to 85 percent and specificity from 54 to 98 percent(17).

Durkan's test **(Fig.3)**

It was described by John Durkan in 1991(18). The test involves applying direct pressure with the thumbs over the median nerve in the carpal tunnel. The test is done for 30 seconds. The reproduction of tingling or numbness or both in the distribution of the median nerve distal to the carpal tunnel is considered positive. The test can also be quantified by observing the time difference between onset of pressure application to the beginning of symptoms.

Fig.3. Durkan's test – consists of applying manual pressure over the carpal tunnel for minimum of 30 seconds.

Tinel's sign:

This is elicited by percussing along the course of the nerve from distal to proximal. The test is considered positive if there is tingling sensation along the sensory distribution of the nerve(19). The sensitivity ranges from 58 to 100 percent and the specificity from 55 to 100 percent(20). The response to the test is variable with the instrument of elicitation(finger Vs tendon hammer)(21) and duration of symptoms. Results of provocative tests are likely to be negative if symptoms are of very long duration because the degree of remaining sensitive nerve fibres is so less to elicit a response(22).It is also important to rule out other causes of similar symptoms like proximal nerve compressions, double crush syndrome and space occupying lesions pressing on the median nerve.

Electro diagnosis:

Electro diagnostic modalities are useful in the

1.diagnosis of Carpal tunnel syndrome

2. differentiate Carpal tunnel syndrome from other conditions which produce similar symptoms

3. to assess severity of compression

4. to assess outcome after surgery(23).

Nerve conducting study(NCS):

The procedure involves stimulating the median nerve proximal to the wrist and recording Sensory Nerve Action Potentials(SNAP) in the index finger and Compound Muscle Action Potentials(CMAP) in the Abductor Pollicis Brevis. An additional motor or sensory nerve in the same limb is also studied to rule out underlying peripheral neuropathy or Brachial plexopathy. NCS suggestive of demyelination is reversible as long as the compression is released. NCS suggestive of axonal loss indicates greater injury and a prolonged or incomplete recovery following surgery(24).

Shortcomings of NCS:

NCS evaluate the larger myelinated fibres but compressive neuropathies involve more of the un-myelinated fibers at least early in the course of disease. Hence NCS can be normal in presence of clinical symptoms.

Electromyography:

EMG is usually not a component of the electro diagnostic routine for CTS. However it is useful in the following situations:

1. When the results of NCS can be affected by an underlying peripheral neuropathy
2. To objectively assess the success of return of thenar muscle function following carpal tunnel decompression

Ultrasound scan:

Buchberger was the first to quantify anatomic changes in CTS(25). The typical triad in CTS is

1. Palmar bowing of flexor retinaculum
2. Enlargement of nerve proximal to flexor retinaculum
3. Distal flattening of the nerve.

The advantages of sonography are that it is inexpensive and non-invasive. However, it is operator dependent and can vary with wrist position and activity. The sensitivity of sonography in diagnosis of CTS is 82 percent and specificity is 92 percent(26).

Non-operative treatment:

The two non operative modalities for treatment of CTS are steroid injections and splinting

Splinting:

The purpose of splinting is to immobilise the wrist thereby minimising symptoms of pain and numbness especially at night. The preferred position of immobilisation is in neutral because extreme flexion or extension are known to increase pressures in the Carpal tunnel(27). Studies also suggest that the metacarpophalangeal joint be positioned in extension because a flexed MP joint position can lead to migration of lumbricals inside the Carpal tunnel and increase pressures(28).

Steroid Injection:

Corticosteroid injections are thought to reduce symptoms by decreasing the inflammation of the flexor tendons(29). It has been shown to be helpful in the short term but long term results of success are variable(30).

Surgical treatment:

Failure of non-operative treatment in the form of increase in severity of pain or neurological deficit necessitates surgical treatment. Complete division of the transverse carpal ligament to relieve the pressure on the median nerve is the cornerstone of surgical treatment. This can be achieved by any of the two methods:

1. Open Carpal tunnel release
2. Endoscopic Carpal tunnel release

Open Carpal Tunnel Release(OCTR):

Before embarking on OCTR, it is important to remember the structures at risk of injury during the procedure and the anatomical landmarks which help in preventing them**(Fig.4).** It is also prudent to draw these landmarks with a marking pen before making the incision. The recurrent motor branch of the median nerve emerges from the main trunk at the intersection of the line drawn along the radial border of the long finger and the Kaplan's cardinal line(31). The palmar cutaneous branch of the median nerve lies anywhere between 6mm radial or ulnar to the thenar crease.

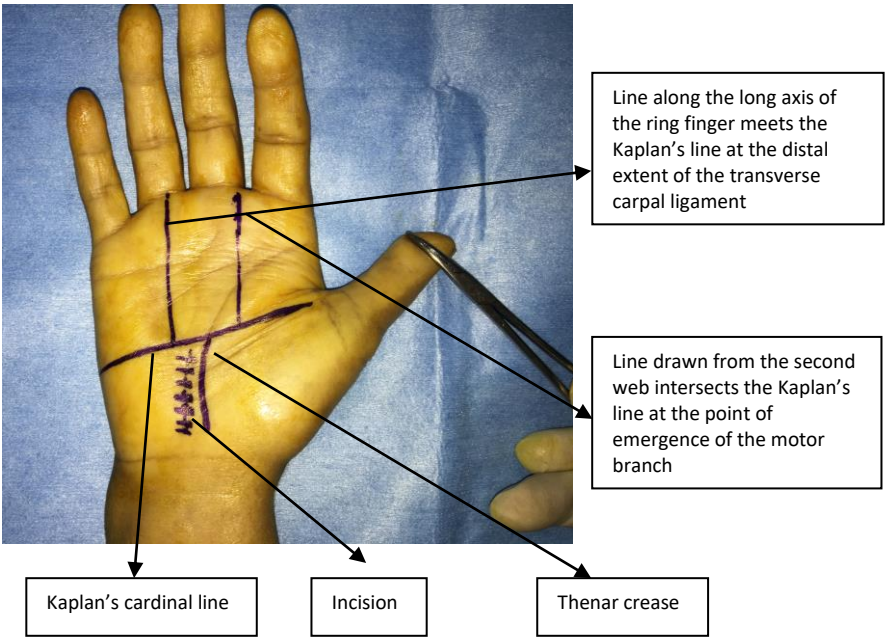

Fig.4. Important landmarks while performing open carpal tunnel release

An incision made on the crease could potentially endanger this nerve(32). The superficial palmar arch is located between the Kaplans cardinal line and the proximal palmar flexor crease(33). In addition, the skin over the thenar, hypothenar and the area between them is densely innervated by cutaneous branches from the median and ulnar nerve(34,35). It is almost impossible to make an incision in the palm

without injuring at least some of these nerves. However Seigmeth et al(36) randomised 84 hands in 42 patients with bilateral Carpal tunnel syndrome in two groups. One group underwent standard open Carpal tunnel decompression while the other underwent the same procedure with preservation of the cutaneous nerves at the site of surgical incision. There was no difference in scar pain between the two groups. However the surgical time was significantly longer in the group where the cutaneous nerves were identified and protected.

Under appropriate anaesthesia, lighting and magnification, a curvilinear incision extending from the Kaplans line paralleling the thenar crease at approximately 6mm ulnar from it and extending it to just short of the wrist crease. After bluntly separating the subcutaneous fat, the palmar fascia is incised. Once this is done the confluence of the thenar and hypothenar muscle is exposed. This is again bluntly spread to expose the underlying transverse carpal ligament. This is longitudinally split to expose the underlying median nerve. Inserting a Freer elevator between the ligament and the nerve serves to protect the nerve from injury. The distal extent of the release is till the fat surrounding the superficial

palmar arch. The proximal extent of release is till the distal forearm. This is achieved by clearly dissecting the structures superficial and deep to the transverse carpal ligament. Once this is done the proximal part of the ligament along with the distal antebrachial fascia is sectioned with a scissors. The wound is closed as per the choice of the surgeon and a bulky dressing is applied.The above mentioned procedure carries the complications of neuroma formation, scar tenderness and pillar pain(37).In an attempt to minimise these complications which were predominantly attributed to the length of the incision, various modifications of the open technique were introduced. The principle changes were smaller incisions and assisting devices like ultrasound scan and forward cutting blades(38,39,and 40). However, the superiority of one technique over the others has not been proven conclusively(41,41).

Postoperative protocol:

Splinting and immobilisation have not been found to prevent wound complications and scar tenderness when compared to early mobilization(43,44). Hence it is preferable to start early

mobilization of the wrist and fingers along with care of the scar with massage.

Outcomes following OCTR:

Turner(45)et al. conducted a systematic literature review of papers published in English covering twenty years to ascertain factors associated with unfavourable outcomes following OCTR. Patients with Diabetes mellitus, Thoracic outlet obstruction, Double crush syndrome, smoking and alcohol have bad outcomes. Normal nerve conduction studies, Abductor Pollicis Brevis wasting and workers compensation patients also have been found to have bad outcomes. Age, gender and weight were not found to predict poor outcome.

Endoscopic Carpal Tunnel Release(ECTR):

ECTR was first introduced in 1989 by Chow. Endoscopic techniques use either a double(6) or single(46,47) portal to introduce the endoscope and visualise the median nerve and the Transverse Carpal ligament. This is followed by division of the transverse carpal ligament. Indications for ECTR are the

same as OCTR. ECTR is contraindicated in inflammatory arthritis, proliferation synovitis, limited wrist extension, altered carpal pathology and suspicion of space occupying lesion.

Advantages of ECTR are decreased pain, better hand grip and earlier return to work. Complications include injury to Neurovascular structures and a fairly steep learning curve. The early benefits of ECTR in terms of less pain, scar tenderness and early return to work have not found to be advantageous in mid and long term follow-up(48,49,50).

Conclusion:

1. Carpal tunnel syndrome is on of the commonest compressive neuropathies of the upper limb.
2. The carpal tunnel is located between the Thenar and hypothenar regions. There are many anatomical variations of the muscles and neurovascular structures in this region.
3. Nocturnal paresthesia in the median nerve distribution is an important symptom. It is important to do multiple

provocative manoeuvres because no one clinical test is conclusive

4. Electro diagnostic studies can be normal in a full-blown Carpal tunnel syndrome
5. Open carpal tunnel release is the gold standard procedure and has good to excellent outcomes
6. It is important to be cautious about the neurovascular structures while performing open carpal tunnel release
7. Endoscopic carpal tunnel release has the advantages of smaller scars and early return to work but mid and long-term results are similar to open release.

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