HOW CAN OSTEOPATHIC MANIPULATIVE TREATMENT HELP CARPAL TUNNEL SYNDROME CONDITION

Thesis submitted in Partial Fulfilment of the Requirements for the Degree of Doctor of Osteopathy (DO)

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EMG - Electromyography

CT - computerized tomography

MR - magnetic resonance

TOS - thoracic outlet syndrome

1. INTRODUCTION

Carpal tunnel syndrome is an issue in which the median nerve is compressed, causing pain, tingling, numbness and weakness in the hand. Unless treated properly, this condition may worsen, disabling the patient to do the simplest tasks with the potential risk of permanent nerve damage can occur. The underlying problem of carpal tunnel syndrome cannot be treated by over-the-counter pain relievers or medicines alone. An osteopath can provide treatment and support without the need to go through surgery. Using a range of adjustments, myofascial release and different manipulative techniques, an osteopath may significantly improve the condition and functioning of nervous, lymphatic and circulatory systems. These manual techniques that osteopaths perform on the wrist and hand helps in releasing the pressure of the median nerve while improving range-of-motion, reducing inflammation and conditioning muscles. The improvement of circulation and blood flow of these areas, the median nerve functions are strengthened.

The present review and assessment of carpel tunnel syndrome provides an anatomical introduction and overview of nerve structures, pressure change effects, nerve fixation symptoms, diagnosis of the carpal tunnel syndrome and contradictions of manual treatments in the first chapter. Throughout the second chapter, the anatomy of carpal tunnel syndrome is explained along with its physiopathology, the double crashing effect and the exact diagnosis of carpal tunnel syndrome. The last chapter is an inventory of the treatment options for the carpal tunnel syndrome used and suggested by the author.

This current study is a cohesive work of the Author’s osteopathic and alternative movement and massage therapist experience along with the literature review of research studies and books elaborating on carpal tunnel syndrome and its treatment. All relevant references are listed in the beginning of each chapter as well as at the end of the document.

2. GENERAL VIEW ON TUNNEL SYNDROMES

Tunnel syndrome is a chronic peripheral nerve damage that occurs when a nerve passes through and is compressed within, a "tunnel", formed by bones, muscles, or ligaments. When these building elements lack responsivity nerve compression occurs. The elements of the tunnel that comprise the tunnel are unable to compensate for the expansive processes in the tunnel through widening, thereof the nerves running within might suffer from pressure.

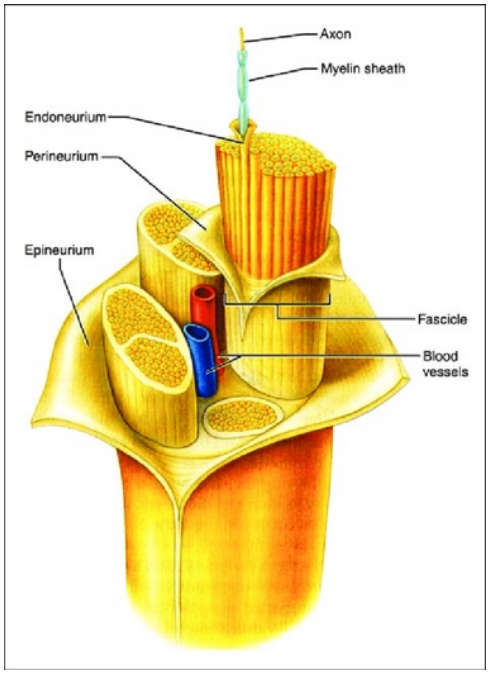
Even the slightest change or swelling of the tunnel's wall can lead to ischemia, which may result in nerve damage by altering the blood supply of the nerve, thus hindering its metabolism. This may be due to, for instance, a lesion caused by a tense muscle or a potential external trauma. The description that allows further understanding of tunnel syndromes is presented within this chapter, requires the elaboration of various concepts including the structure and nature of nerves and the comprehensive view of the effect of nerve pressure change, nerve fixation due to compression or tensile force, diagnostics of tunnel syndromes along with contraindications of manual treatments.

The current chapter is built on own experience, learnings and literature review, based on the works of Burton C, Chesterton LS, Davenport G.: Diagnosing and managing carpal tunnel syndrome in primary care; Ashworth NL. Carpal tunnel syndrome; Chammas, Michel et al. "Carpal tunnel syndrome - Part I; A Ghasemi-Rad, Mohammad et al. "A handy review of carpal tunnel syndrome: From anatomy to diagnosis and treatment; MacDermid JC, Wessel J. Clinical diagnosis of carpal tunnel syndrome: a systematic review; Wipperman J, Goerl K. Carpal Tunnel Syndrome: Diagnosis and Management; and Kómár József : Alagút szindrómák és egyéb kompressziós mononeuropátiák.

2.1. THE STRUCTURE OF NERVES

The nerve is consisted of a bundle of nerve fibres within the peripheral nervous system. The axons present in the nerve correspond to the long slender projections of the neurons.

Inside the nerve, each nerve fibre, as well as the nerve-fibre-supporting tissues located there, are surrounded by a layer of loose connective tissue, the endoneurium. Axons are grouped into bundles (fascicles) and each fasciculus is surrounded by a loose connective tissue of the perineurium, thus separating the fasciculus from each other. Finally, the bundles of nerve fibres will be surrounded by a strong, resistant connective tissue sheath, the epineurium.



2-1. Figure Structure of a Nerve (https://www.researchgate.net/figure/Anatomical-structures-that-make-up-a-typical-peripheral-nerve-Do-You-Really-Need-Back_fig3_258145421)

The thickness of the latter is not uniform in all nerves, so nerves with a thicker epineurium are more resistant to external pressure. Nerves contain arteries and veins that run in the fascicules and the spaces between them. They provide the nerve with a supply of nutrients and energy. The blood supply to individual nerves is not the same, making more vascularized nerves more susceptible to ischemia. Such as for example the median nerve.

In addition, it is very important to find adipose tissue in the nerves as well, which aids with cushioning function so that it is better able to withstand external mechanical stimuli.

2.2. Effect of pressure changes

2.2.1. Nerve pressure increase

Nerves show high sensitivity to various pressure changes. As a result of the increased pressure, the circulation of the nerve changes and the altered circulation can damage the nerve, which might even lead to the necrosis of the axon and connective tissue sheaths.

Such pressure changes can occur in two ways. One possibility is, that inside the nerve dilation occurs due to tumour or bleeding, the fasciculus inside the nerve surrounded by a strong epineurium and through those the axons, are also compressed. In this case, an intraneural problem within the nerve is present.

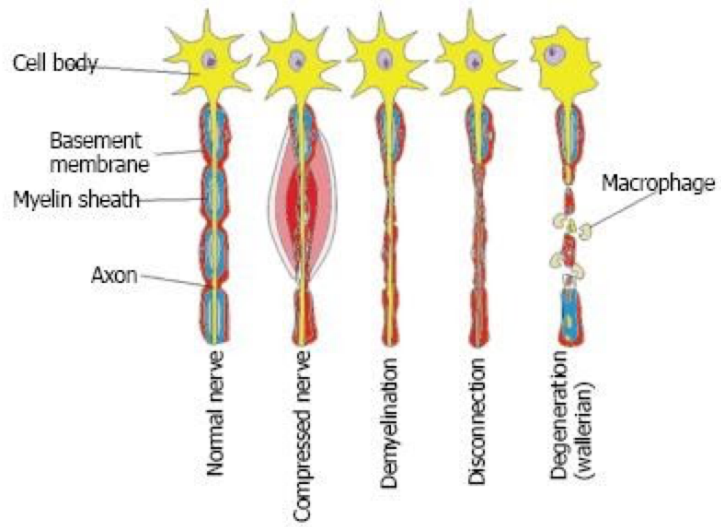
The other option is mechanical compression of the nerve from outside with the so called, compression or pulling effect on the nerve that causes the nerve fibres to be affected. Such may be the case of the pronator syndrome, where a tight pronator muscle compresses a nerve running between two muscle heads. In which case an issue outside of the nerve tissue or a perineural problem is present.

If the nerve is not affected by a purely motor or sensory pressure change, the symptoms cannot be predicted because the location of the sensory and motor fibres in the mixed nerves is inhomogeneous, so depending on where the pressure reaches the nerve, motor or sensory related symptoms occur.

2.2.2. AREAS AFFECTED BY PRESSURE CHANGES

While examining those areas that might be affected by the pressure change, the following are definitely worth reflecting on.

- Myelin sheath: May be damaged or even lost, implying slowed down signal transmission in these areas. If the pressure drops, the myelin sheath can regenerate.
    - Axon: Increased pressure reduces intra-axonal flow and thus degenerates the distal part. If it persists, it may even disappear. The first symptom is that the part falling proximal to the area under compression inflates like a balloon and is expand. At the same time, the distal segment contracts. If this condition persists for a prolonged time, the nerve can no longer regenerate.
- Connective tissue: As microcirculation decreases in the tissue and oedema appears the intraneural pressure will continue to increase. This will further increase the compression. As a result, intraneural fibrosis may appear in the nerve.



2-2. Figure Areas affected by pressure changes (https://www.wjgnet.com/1948-0210/figures/v7/i1/51.htm)

2.3. SYMPTOMS OF NERVE FIXATION

In case of a nerve fixation, partial or complete decrease in the sliding and elongation ability may occur. This phenomenon is caused by some external compression or tensile force.

- There may be a short-term force in effect due to trauma, such as hitting the elbow.
- There may be a prolonged force affecting a wider area, such as pressure of the operating table caused during anaesthesia.
- There may be frequent, short-term pressure, such as movements done during typing, or using a mouse.
- It is also possible that a nerve along the course of it, brakes on a hypomochlion. Then, if it is subject distally or proximally to a pulling force, the nerve will be affected above this area. If it is known that the patient shows complaints at this area, the course of the nerve should be examined both, distally and proximally from the location of damage.

In case of tunnel syndromes, either the intra or perineural pressure will increase due to the reasons outlined earlier. This shows a sensitivity to minimal external pressure at certain stages of the nerve conduction, as this will further increase the already elevated pressure.

Hardened areas can be found in the nerve. Obstruction of fluid flow causes oedema, which increases the pressure, which makes the nerve feel harder and more tense. Normally, the nerve is difficult to feel due to its flexible nature. If its contours are clearly and firmly felt, it is probably due to the increased pressure. Circulatory or functional dysfunctions appear as a result of pressure changes.

2.4. DIAGNOSIS OF TUNNEL SYNDROMES

Proper diagnosis, based on sound anatomical and clinical knowledge, is essential for the effective treatment of tunnel syndromes. The main areas of diagnostics are anamnesis recording, sensory tests and instrumental inspections which are discussed further within this sub-section.

2.4.1. ANAMNESIS

Regarding tunnel syndromes, the most common symptom with which patients visit therapists is pain. Its appearance is usually intermittent, with after a few months of presence, occasional cessation for a longer period of time and reappearing later on.

If a sensory nerve is involved, the pain can be well delimited to the innervated area. Pain is a sharp, burning sensation that is often associated with paraesthesia. In contrast, with respect to motor nerve involvement, the pain is dull and deep, not definitively localized. It is usually found in the area of joints and large muscles.

The pain increases at night due to venous congestion. It can be well distinguished from inflammation of the tendons, as during periods of rest, or immobility, the pain does not disappear completely, while complaints of swelling of the tendons at night when not used reduce symptoms.

Depending on the nerve involved, complaints may include:

1. Sensory complaints:

   Sensory complaints develop when a sensory or mixed nerve is involved. In this case, various sensory disturbances may occur in the innervated area.

   These can be arousal symptoms such as pain, numbness or dropout symptoms such as insensibility.

2. Motor complaints:

   Motor complaints develop when motor or mixed nerves are involved.

   In case of symptoms of loss, the function of the innervated muscles decreases or disappear and weakness, as well as atrophy may appear. Additionally, there may be arousal symptoms: such as fasciculation.

3. Vegetative symptoms:

   Vegetative symptoms might include skin changes, ulcers, or sweating irregularity (anhidrosis, hyperhidrosis).

Recording an accurate case history is half the battle won! There is a dual purpose in taking the anamnesis, which are defining exactly where the compression is located along the course of the nerve and the etiological diagnosis.

If no pathoanatomical lesion is found to be responsible for compression, then the primary task is to identify the provoking factors. In this process there are key topics to consider, namely, the chronology of symptoms, which was the first symptom, what followed this or the initial

symptom passed but later symptoms persisted and whether there is a connection in between those. Analysing daily activities at home or at work can provide a wealth of useful information, knowing of what the patient does on a regular basis at work or at home that contributed to the development of symptoms is essential.

Everyday behaviour patterns are crucial to explore. It is worth finding out what the patient's job is. For example, are there regularly practiced duties involving movements above the head, such as a car mechanic does or is there an asymmetric position held, such as sitting for an extended period with crossed legs in the office? Ergonomic design of the environment is important. How high the table is at work or where the elbow is while working, is the monitor facing the patient or do she/he have to turn around all the time? Therapists may ask if a heavy bag is carried regularly and whether that is on shoulders or forearms? Additionally, the use of a mouse should be considered, while hands exposed to regular vibration from various machines can have an effect too.

Exploring topics including the above information, can already indicate whether everyday activities are related to the occurring tunnel syndrome. Furthermore, it is worth to consider a wider range of factors. Prolonged lying in unusual postures might lead to problems, putting constant pressure on the body. This may include sleeping in unnatural situations under the influence of drugs or alcohol, or even a prolonged extension of the elbow during surgical anaesthesia can be problematic.

Rapid weight loss can also be the cause of symptoms as nerves contain high amount of fat, which cushions those and dampens external mechanical stimuli. If the amount of this decreases, the nerve will be much more sensitive to these external effects.

The development of tunnel syndromes is clearly related to hormonal changes. It can often be linked to menopause, the last two trimesters of pregnancy, hypothyroidism, and other factors that predispose oedema. Then, due to the oedema, the lumen of the tunnel narrows and the nerve may come under pressure

All kinds of external injuries, fractures, bruises, surgical scars and subsequent tissue regeneration can also be the cause of tunnel syndromes. Therefore, these should always be addressed.

Tunnel syndromes can get worse at night due to which, patients might wake up in pain or numbness. This is due to a slowdown in venous circulation due to immobility. Contrary, if the problem is caused by inflammation of the tendons, the pain disappears at night because the muscle is not in use, if the tendons are not inflamed and there is a narrowing of the duct, for example, the symptoms appear at night because the high pressure on the nerve does not go away. may also increase.

2.4.2. SENSORY EXAMINATION:

V**isual inspection** starts with on one hand the skin's nutrient supply is greatly affected by the nerves, thereof nerve damage may arise. Dystrophic, infiltrative skin lesions where the skin thickens, loses its elasticity, peels or even cracks. On the other hand, a so-called shiny skin (Scleroderma) may develop, when the skin becomes thinner, smooth and shiny. Hairs fall out and the affected area is pale red. Blisters and later ulcers may appear in the area.

In the case of tunnel syndromes, richer hair or even a lack of hair can be observed in the affected area.

Typically, nail lesions can develop in tunnel syndromes involving the upper limb. An indication of tunnel syndrome can be the following:

- Nails become thinner, more fragile and longitudinal grooves may appear on those.
- The shape of the nail may change to a watch glass
- The nail bed may become exposed in a larger area

Looking for traces of previous injuries and surgeries, as well as areas of oedema or bleeding is necessary when screening for tunnel syndrome.

Visual inspection of the muscles reveals hypo or atrophy of the innervated muscles. Injury to some nerves creates characteristic postures from which the affected nerve inferred.

Tactile examination in the area aided by the injured nerve helps to reveal the impacted segments. The function of the sweat glands is reduced or lost, so that its tactile changes and the edge of the affected area can be determined precisely through palpation.

Tumours, calluses, bone outgrowths, or cervical ribs in leaner individuals that put pressure on the nerve can also be palpated. Examination of the pulse can determine how the circulation changes at different positions, so this is of paramount importance for the diagnosis of various neurovascular compression syndromes.

In general, the temperature of the skin area affected by peripheral nerve injury is lower, with a cooler feel to the touch. Furthermore, the punctum maximum of pain can be determined, which is often obscured by radiating symptoms. The decreased tone of the innervated muscles can also be felt, and the pressure on the nerve can trigger the Tinel sign, meaning that at the site of

the nerve injury, a sharp lightning-like pain radiating to the nerve runs distally from the injury along the nerve.

In case of sensory tests few points should be remembered universally. This is one of the most important test methods. It plays a crucial role in determining whether the symptom is radiating or whether the peripheral nervous system is more affected.

Examination can be done:

- Touch with a brush or cotton wool
- pain with a needle
- the feeling of heat with a test tube filled with cold or warm water
- discrimination between two points with a Weber compass
- vibration with a tuning fork

It requires a lot of attention and patience, it is worth repeating several times in case of uncertain answers of the patient.

Examination of motor innervation:

Muscle strength can be determined and classified based on working against resistance on a five-point scale, which is the following:

Grading:

- Grade 0: No contraction or muscle movement
- Grade 1: Trace of contraction, but no movement at the joint
- Grade 2: Movement at the joint with gravity eliminated
- Grade 3: Movement against gravity, but not against added resistance
- Grade 4: Movement against external resistance, but less than normal
- Grade 5: Normal strength

In the same way, by observing the active movement of the muscles, the movement pattern of the damaged innervation can also be noticed. By examining motor innervation, important conclusions regarding the top-down orientation of the affected area can be drawn regarding the nerve involved.

While examining reflexes, loss of self-reflexes is the result of reflex interruption or a large decrease in muscle tone. Because self-reflexes are usually associated with a single segment, their omission may indicate involvement of this spinal cord segment.

2.4.3. ELECTRICAL TESTS AND USE OF VARIOUS DIAGNOSTIC TOOLS

Competence drawn from medical tools includes several elements. One of the most significant of these is the EMG scan. X-rays may play a major role in the detection of bone lesions leading to the development of symptoms, while ultrasounds can be used to detect nerve tumours as well as nerve thickening proximally from the affected area. CT and MR scans are suitable for detecting nerve tumours or even for determining atrophied muscles.

2.5. THE CONTRAINDICATIONS TO MANUAL TREATMENTS

Contraindication of manual therapy includes but is not limited to the below conditions:

- non-mechanical neuropathies
- great pain, radiation on touch
- severe circulatory or blood pressure problems
- cancer, radiation therapy
- active herpes zoster
- skin disease in the area covered by the nerve
- aneurysm

3. CARPAL TUNNEL SYNDROME

As explained in the previous part of this study, tunnel syndrome is a chronic peripheral nerve damage occurring due to a compressed nerve within, a "tunnel", formed by bones, muscles, or ligaments. A common condition affecting functionality of wrists and hands occurs when the meridian nerve is affected by the above-mentioned problem, while traveling through the carpal tunnel. Within this current chapter, the framework of carpal tunnel syndrome is explained including anatomical nature, ethology and implications.

The chapter is based on own experience and the research of Wertsch JJ, Melvin J. Median nerve anatomy and entrapment syndromes; Dale AM et.al. Prevalence and incidence of carpal tunnel syndrome in US working populations; Solomon DH, Katz JN, Bohn R, Mogun H, Avorn J. Nonoccupational risk factors for carpal tunnel syndrome, Werner RA, Andary M. Carpal tunnel syndrome: pathophysiology and clinical neurophysiology and; Current Uchiyama S, Itsubo T, Nakamura K, Kato H, Yasutomi T, Momose T. Current concepts of carpal tunnel syndrome: pathophysiology, treatment, and evaluation.

3.1. ANATOMY

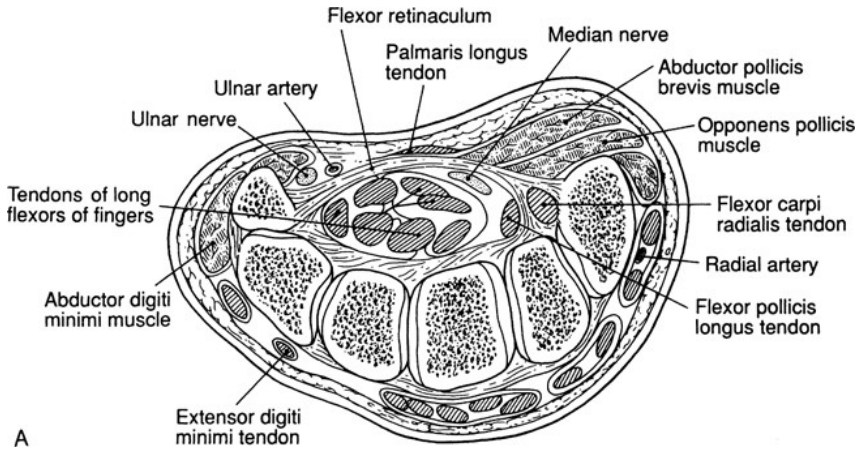
3.1.1. ANATOMY OF THE CARPAL TUNNEL

The carpal tunnel is a narrow passageway found on the anterior portion of the wrist formed from the carpal bones that is concave toward the palm (sulcus carpi) and covered by the transverse carpal ligament (flexor retinaculum), which is a strong connective tissue plate. Its function is to hold the tendons running in the channel in place during the various movements of the wrist.

On the radial side, the retinaculum is connected to scaphoid tuberosity and tuberculum ossis trapezii. On the ulnar side, it connects to the pisiforme and the hook of hamanti, thus completely covering the canal. The narrowest part of the canal is located at the distal carpal tunnel.

10 anatomical structures pass through the tunnel, which are the tendons of 4 flexor digitorum profundus, 4 flexor digitorum superficialis and flexor pollicis longus as well as the Median nerve. Meaning, that muscles do not pass through the channel, only adherent tendons. The ulnar nerve and ulnar artery run above the canal through the Guyon canal, and the tendon of the flexor carpi radialis also does not run in the canal but between the fibres of the flexor retinaculum.

The shape and width of the tunnel changes significantly during wrist movements. This is because with each movement, the carpal bones move relative to each other, so they do not form a rigid wall for the canal. In flexion, the flexor retinaculum moves closer to the radius and thus narrows the proximal end of the canal, while in extreme extension, the lunate bone narrows the canal as it shifts into it, increasing the pressure in the canal during both movements. As a result of the changed pressure, the circulation changes and the regeneration and anti-inflammatory processes slow down. In order to prevent this, various wrist braces that keep the wrist in a neutral position can be used.



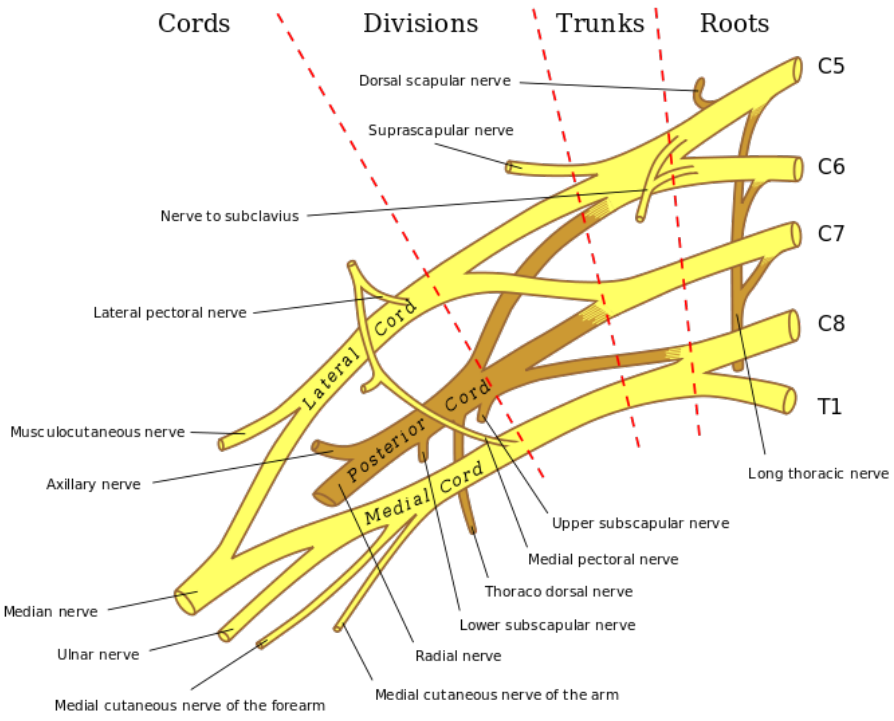
3-1. Figure Anatomy of the carpal tunnel (https://link.springer.com/chapter/10.1007/978-0-387-09515-8_19)

3.1.2. ANATOMY OF THE BRACHIAL PLEXUS

Regarding the full understanding of carpal tunnel syndrome, it is essential to know the affected section of the nervous system. The brachial plexus, develops from the anterior rami of the C5-T1 spinal nerve root. Above the collarbone, the bundles that make up the brachial plexus are called trunks, while those below the collarbone are called cords. The C5 and C6 segments form the superior trunk, the C7 segment the middle trunk medius, and the C8 and T1 segments the truncus inferior trunk.

The short, purely motor nerves running to the shoulder girdle and deep neck muscles originate from the trunks. All three trunks are then divided into an anterior and a posterior division. Those are named according to their position relative to the axillary artery. The 3 posterior divisions merge to form the posterior cords behind the axillary artery. From the anterior division of the superior and medius trunks, the lateral cord develops, on the lateral side of the axillary artery. The medial cord is formed from the anterior division of the inferior trunk, on the medial side of the axillary artery.

Subsequently, from the cords, the long and mixed nerves of the upper limb are formed. From the posterior cord, the radial nerve and the axillary nerve develop. From the lateral cord, the lateral part of the median nerve and the musculocutaneous nerve develop. From the medial cord, the medial part of the median nerve and the ulnar nerve develop.



3-2. Figure Anatomy of plexus brachialis (https://en.wikipedia.org/wiki/Brachial_plexus)

3.1.3. ANATOMY OF THE MEDIAN NERVE

The median nerve develops from the lateral and medial cords below the clavicle, consisting of the anterior divisions of the trunks from the C5,6,7,8 and T1 spinal cord segments. From there, it runs in the medial bicipital groove in the septum between the biceps and triceps, on the lateral side of the brachial artery. It then travels between the brachial and biceps brachii muscles in the direction of the elbow.

It reaches the lower arm next to the tendon of biceps brachii muscle and then passes between the two heads of the pronator teres muscle. It passes between the forearm flexors and enters the carpal tunnel medially from the tendon of the flexor carpi radialis at the wrist, where it will pass between the tendons of the flexors and the flexor retinaculum.

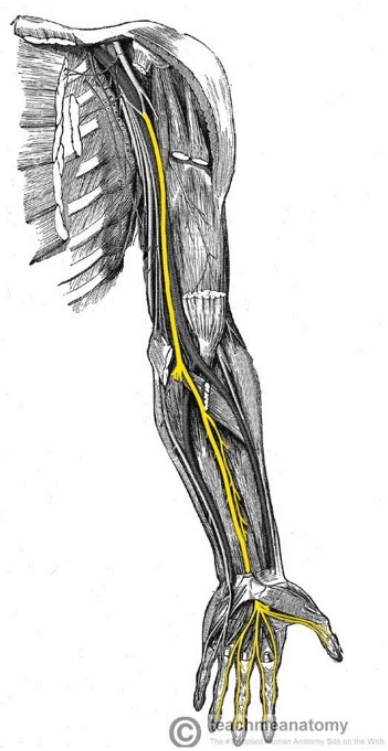
Through the arm, it does not give off neither into motor nor sensory branches. On the forearm, it motor innervates the flexor muscles and the muscles that create pronation. Among the flexors, the flexor carpi ulnaris muscle and the ulnar part of flexor digitorum profundus is supplied by the ulnar nerve. In the palm area, the muscular ramus of the nerve supplies the thenar muscles and the first two lumbrical muscles.

In sensory innervation, it is important that a sensory branch in front of the carpal tunnel, the ramus palmaris, detaches from the nerve that travels over the retinaculum and innervates the radial half of the palm. Thus, if the palm is also affected by the symptoms, it is likely that the nerve has been compressed proximally from the tunnel.

The section passing through the tunnel supplies the nerve that senses the skin of the volar surface of the first three and a half fingers which also extend to the dorsal side from approximately the middle of the second phalanx. So, if typical numbness of the fingers is encountered, the nerve is likely to be compressed in or distal to the tunnel.

In the following cases, it is definitely worth considering the involvement of the brachial plexus:

- cervical disc herniation
- neck pain
- TOS (thoracic outlet syndrome)
- limited shoulder movements
- cervicobrachial neuralgia
- whiplash
- Carpal tunnel syndrome
- Epicondylitis



3-3. Figure Anatomy of the median nerve (https://teachmeanatomy.info/upper-limb/nerves/median-nerve/)

3.2. ETIOLOGY OF CARPAL TUNNEL SYNDROME

Carpal tunnel syndrome is the most common of all tunnel syndromes. It is created when the median nerve is compressed in the carpal tunnel. Approximately, 3-4% of the population is affected and ranks second after spine surgeries according to international surgical statistics. It is 3-4 times more common in women than in men. It usually occurs over the age of 35-40, with half of the cases affecting both sides.

The first sensory symptom to appear is usually nocturnal, morning numbness of the hands, which becomes more common and pain, burning or numbness may appear later, up to the first three and half fingers, as discussed earlier in areas innervated by the median nerve.

In everyday life, prolonged loading of the wrist in the flexion or extension increases symptoms due to a rise in pressure in the carpal tunnel. At the same time, atrophy of the thumb muscles may appear as a motor symptom, which is well visible even when visually examined.

Approximately in half of the cases have no detectable pathoanatomical lesions. In such cases, the symptoms are most often due to occupational injuries, daily repetitive movements, and poor posture. Such might happen from continuous typing, mouse use, where the wrist is constantly broken. In case of musicians, gripping the string, catching strings, which also causes

overloading of the fingers and breaking of the wrist. Use of machines or devices that transmit continuous vibration to the palm, such as a rammer. Jobs where a lot of effort is required to keep the fingers flexed, which can lead to tendon overload and inflammation, leading to swelling and narrowing of the tunnel.

In the other half of the cases, the nerve may come under pressure in the tunnel for a variety of reasons. These can be, for example tumours, ganglia, exostoses, thrombosis or aneurysm of the median artery or even an increase in pressure. Common causes are hook of hamate fractures, hand bones, especially dislocation of the lunatum, and fractures of the radius or ulna. May be an accompanying symptom in various systemic diseases such as RA, gout, diabetes mellitus or Lyme disease. Endocrine causes may also be present in the background such as menopause, last 2 trimesters of pregnancy, hypothyroidism, myxoedema, scleroderma. In this case, an increased tendency to oedema develops in the body, but oedema may develop also due to kidney failure or heart failure. Burns around the wrists may also occur due to scarring and oedema. While developmental abnormalities may also hide in the background when the superficial abdominal muscles of the I and II lumbrical muscle or the flexor digitorum superficialis grow into the canal and create a spatial disproportion. The palmaris profundus muscle may appear as an anatomical variant, the tendon of which travels in the tunnel and can narrow the space as well.

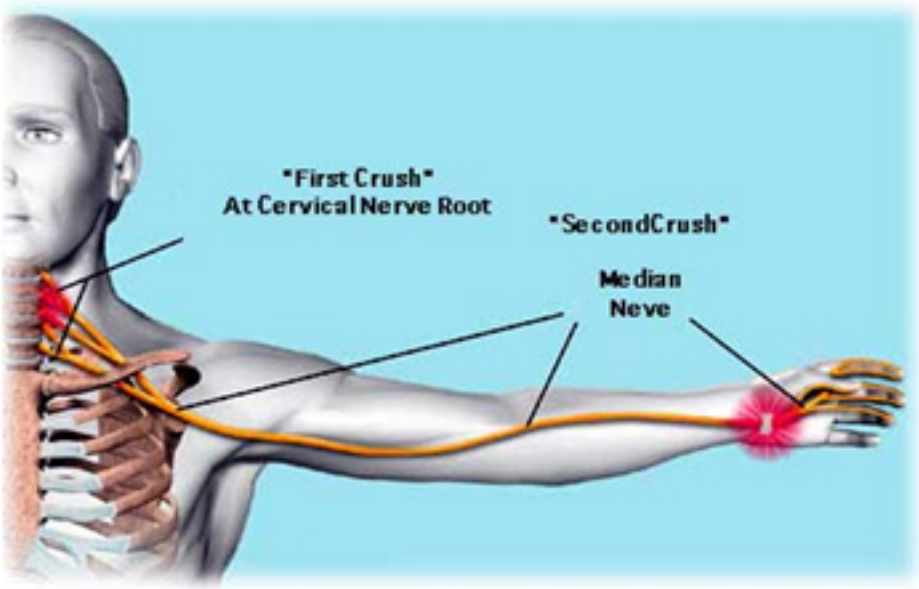
3.3. DOUBLE CRASHING EFFECT

Throughout this work, carpal tunnel syndrome is only viewed as a local problem, however, it is very important to examine the entire course of the median nerve and its possible compression sites starting from the cervical segments.

Initially, depending on how the brain perceives the extent of the injury, the patient may not feel any symptoms. However, prolonged nerve compression may begin to inhibit axoplasmic flow. Decreased nerve conduction can lead to a “double crashing effect”.

This term sheds light on the fact that an axon under compression at a given point may make the nerve more susceptible to injury at another location. Thus, for example TOS changes the flow of plasma in the axon and can make the nerve in the carpal tunnel more susceptible to compression. In this case, the symptoms may show signs of carpal tunnel syndrome, but local treatment will not produce lasting results because the problem was triggered by TOS.

Some areas to consider for hand tunnel syndrome are the cervical spine, scalenus muscles, clavicle, 1-2 ribs, pectoralis minor muscle, and the pronator teres muscle.



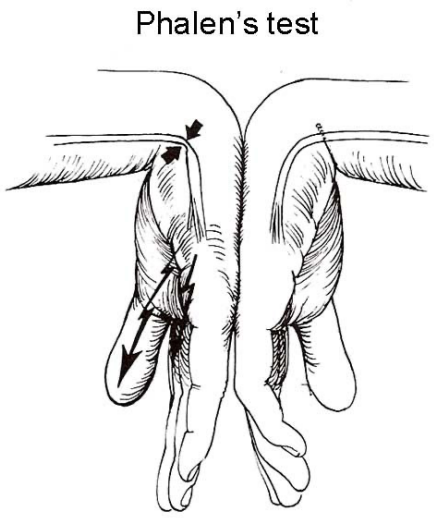
3-4. Figure Double crushing effect (http://naturalcuredoctors.com/carpal-tunnel-syndrome-2/)

3.4. DIAGNOSIS OF CARPAL TUNNEL SYNDROME

The diagnosis of the carpal tunnel syndrome shall start if pain and numbness at night is experienced, but weakness and sensation may be an indicator. Usually, the palm is not affected at this time.

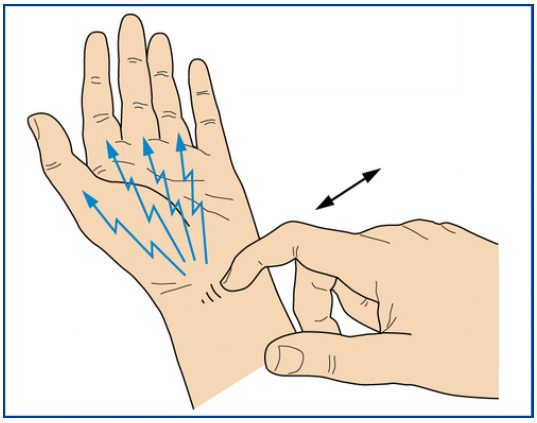
If symptoms are also seen in the palm, compression is likely to be located proximal to the tunnel and the ramus palmaris branch of the nervus medianus is also affected, which does not pass through the tunnel.

Phalen test (positive in 80% of cases)



3-5. Figure Phalen test (https://freedpt.wordpress.com/2016/10/07/phalens-test-phalens-maneuver/)

Tinel sign (positive in 45-60% of cases)



3-6. Figure Tinnel sign ((https://www.magonlinelibrary.com/doi/abs/10.12968/pnur.2012.23.7.344))

Atrophy of the thenar muscle and weakness of the thumb are signs of an advanced condition. In this case, the patient will probably need surgical care.

Tactile sensitivity test of the skin (positive in about 80% of cases)

4. TREATMENT OPTIONS FOR CARPAL TUNNEL SYNDROME

The last chapter of the study is based on the Author's own work and experience.

4.1. MANUAL TREATMENTS

1. Release muscles of the anterior forearm (flexors)

Apply myofascial release technique by soft fist toward medial epicondyle of the humerus assisted with wrist dorsal flexion.

4-1. Figure Forearm flexors (Author's image)

2. Release muscles of the posterior forearm (extensors)

Apply myofascial release technique by soft fist toward medial epicondyle of the humerus assisted with wrist palmar flexion.

4-2. Figure Forearm extensors (Author's image)

3. Treatment of the pronator teres muscle

Treatment of the pronator teres muscle by muscle energy technique. It helps release of the pronator tunnel where median nerve goes through.

4-3. Figure Pronator teres muscle (Author's image)

4. Improve sliding of the layers (radial direction)

Hold the layers of the forearm with your hands in different depth and patient turns the forearm into pronation-supination directions.

4-4. Figure Layers sliding (radial direction) (Author's image)

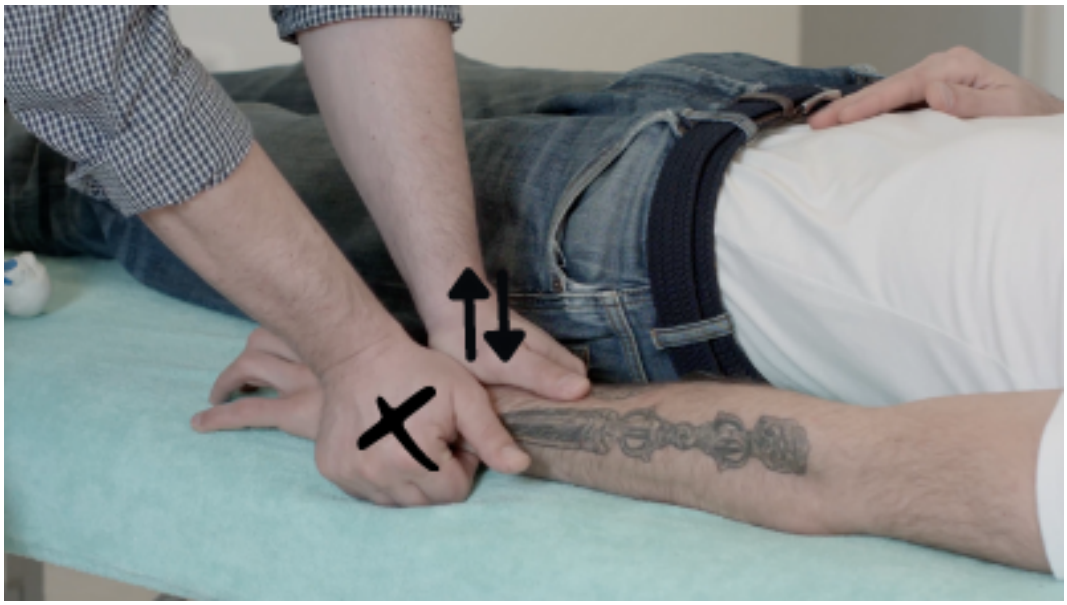
5. Improve sliding of the layers (axial direction)

Hold the layers of the forearm with your hands in different depth and let the patient reach out (elbow in 45 degrees).

4-5. Figure Layers sliding - axial direction (Author's image)

6. Mobilise the distal radio-ulnar joint

Hold the ulna with one hand and the other hand while mobilising the radius up and down.



4-6. Figure Distal radio-ulnar joint mobilisation (Author's image)

7. Movements of the wrist

Move the wrist into flexion, extension, ulnar deviation and radial deviation. Improve the movement direction by mobilisation techniques.

4-7. Figure Wrist mobilisation (Author's image)

8. Carpal bones

Hold carpal bones with your thumbs and create circle motion. Mobilise proximal and distal carpal bones.

4-8. Figure Carpal bones mobilisation (Author's image)

9. Carpal tunnel

Hold lateral carpal bones (scaphoid-pisiforme, trapezium-hamatum) and push them in the opposite direction with little circular motion in the wrist.

4-9. Figure Open carpal tunnel (Author's image)

10. Wrist joint play

Hold the forearm with one hand and hold patient's hand with the other hand. Create little traction and look for the joint play in different direction. Improve joint play with mobilisation.

4-10. Figure Wrist joint play (Author's image)

11. Carpal bones

Grab carpal bones on the medial and lateral side and twist them opposite direction.

4-11. Figure Carpal bones (Author's image)

12. Palmar aponeurosis

Release palmar aponeurosis to help releasing the pressure of the carpal tunnel. Try to stretch and mobilise into different direction.

4-12. Figure Palmar aponeurosis (Author's image)

13. Palmaris longus muscle

Put your thumbs at the muscle-tendon junction of the palmaris longus muscle. Push your thumbs opposite direction assisted by wrist dorsal flexion.

4-13. Figure Palmaris longus muscle (Author's image)

14. Median nerve

Hold the shoulder down, create wrist dorsal flexion, shoulder external rotation and elbow extension.

4-14. Figure Median nerve manual treatment (Author's image)

4.2. MOVEMENT EXERCISES

Hold shoulder down, and create external rotation within the shoulder, as well as elbow flexion and wrist extension. Tilt head to the opposite side.

1. Lift up the shoulder and release the tension of the median nerve and push down again. Repeat 3 times.

2. Flex the elbow and release the tension of the median nerve and extend again. Repeat 3 times.

3. Flex the wrist and release the tension of the median nerve and extend again. Repeat 3 times.

4-15. Figure Median nerve flossing (Author's image)

4.3. NUTRITION

The primary goal is to reduce inflammation. Right food choices can lead to this target.

To help healing or preventing carpal tunnel syndrome, the following foods are recommended: apples, beets, spinach, cabbage, onions, carrots, peppers, oranges, green tea.

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