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CARPAL TUNNEL SYNDROME: A SYSTEMATIC REVIEW OF LITERATURE ON LATEST TECHNIQUES IN PHYSIOTHERAPY FROM LAST 10 YEARS

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Abstract

Introduction: Carpal Tunnel Syndrome (CTS) is one of the most common peripheral upper limb's neuropathy. It can affect up to 4% of the human population. There is not one specific CTS's reason. Predisposing factors include: include obesity, monotonous wrist activity, pregnancy, genetic heredity,rheumatoid inflammation,injuries, overloading of the wrists, frequently repetitions of the same activities, and acromegaly. It is also define as a common medical condition that remains one of the most frequently reported forms of median nerve compression. CTS occurs when the median nerve is squeezed or compressed as it travels through the wrist. The syndrome is characterized by pain in the hand, numbness, and tingling in the distribution of the median nerve.

Material and methods: A systematic review of the literature was based on publications from the last 10 years. Articles concerned the physiotherapy of people with carpal tunnel syndrome (CTS). Publications from the PubMed and ScienceDirect scientific databases have been analyzed. The inclusion and exclusion criteria were introduced and based on an analysis of the titles and abstracts related to carpal tunnel syndrome (CTS).

Results: Out of over 20,000 CTS articles, 10 were selected to meet all inclusion and exclusion criteria. The publications concerned physiotherapeutic treatment in the conservative treatment of CTS. The analyzed publications examined the effectiveness of wrist manual therapy, median nerve mobilization, kinesiotaping, soft tissue therapy and fascial manipulations as well as other physiotherapy treatments.

Conclusions: The reviewed publications show that physiotherapeutic procedures bring significant benefits and improve CTS symptoms within the hand. The development of physiotherapy and research on rehabilitation in the carpal tunnel syndrome (CTS) allow for more effective conservative treatment.

Keywords: Carpal Tunnel Syndrome, Diagnostic Tools, Clinical Features, Management, Carpal Tunnel Release, Alternative Therapy, Braces, Physiotherapy Management, Conservative Treatment, Corticosteroid Injection, Exercise, Treatment Outcome.

Introduction: Carpal tunnel syndrome (CTS) is the most common of the entrapment neuropathies (1). While the published incidence and prevalence of CTS is variable and complicated by the method of diagnosis, various investigations have produced estimates of population incidence ranging from 0.125 to 1% [2]. Carpal tunnel syndrome represents the compression of the median nerve within the carpal tunnel. The borders of the carpal tunnel are wrist carpal bones on the medial, lateral and dorsal aspect and the transverse carpal ligament on the volar aspect. The median nerve and nine of the finger and thumb flexor tendons pass through this space. CTS is characterized by symptoms of numbness, tingling and paraethesias, which are not always limited to the median nerve distribution. Individuals with CTS tend to initially present with intermittent symptoms that may be worse at night or with repetitive upper-extremity activity. The symptoms may improve with splinting, repositioning or vigorous shaking of the hand [3–6]. Physical examination findings in more involved cases may present with neurologic deficits, including impaired sensation, two-point discrimination in the median nerve distribution or thenar weakness. Milder cases may only present with positive carpal tunnel provocative maneuvers (e.g., with Phalen's test and Tinel's sign) with normal neurologic examination findings. Nerve conduction studies (NCS) are frequently performed for confirming the diagnosis of CTS. Conservative treatment may include physical therapy, bracing, steroid injections and alternative therapies. However, surgical decompression (carpal tunnel release) is often elected. While the reported incidence and prevalence of CTS varies widely based on the diagnostic criteria and study methods, it does appear that repetitive trauma disorders and CTS are increasing [1]. Prevalence of CTS in the general population can be difficult to estimate and is frequently reported in specific groups [7]. A Swedish study found that 3.8% of the population have a clinical diagnosis of CTS, and 4.9% have electrophysiologic evidence. A total of 2.7% of the population were found to have both [7]. CTS of a severity indicating surgery has been found in 0.7% of a general population [8]. In the general population, CTS prevalence has been estimated at 3.72% in the USA and 5.8% in The Netherlands [1,9].

The incidence of CTS in The Netherlands has been reported at 1.8 per 1000 people, with a female:male ratio of 3:1 and the highest rates in the 45–64-year-old age group [10]. Women are susceptible to the syndrome, and have been demonstrated to progress differently from males [11]. Blue-collar workers and housewives have been demonstrated to have an increased risk of CTS requiring surgery [12]. Manual

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labor, exposure to vibratory tools and repetitive flexion and extension of the wrist combined with gripping have been reported as risk factors for CTS, while the risk from using a computer mouse or keyboard is unclear [13–15]. Surgical decompression has traditionally been considered the definitive treatment for CTS. The most common hand surgery in the USA is carpal tunnel release, with 200,000 procedures carried out each year [16]. Surgical treatment appears to be more effective for the symptoms of CTS than splinting, which has been the mainstay of conservative treatment [17]. In order to evaluate the effectiveness of nonsurgical treatments for CTS, an understanding of the efficacy of surgical treatment, as well as the natural progression of untreated CTS, is beneficial.

Anatomy

The symptoms for CTS may tend to vary, which is the result of the variation in the anatomy. For instance, for the anatomical differences in the nerves, a bifid median nerve resulting from the high division is noted in 1% to 3.3% of the cases [18-222). This is associated with the tenacity of the median artery or with an additional division of the superficial flexor of the third finger. Another variation is noted in the motor branch of the median nerve. In this variation, there are five types of starting points and paths of the thenar division. The most frequent type of variation is the extraligamentous form, which assumes 46% of the cases, while the subligamentous form accounts for 31%, and the transligamentous form takes 23% of the cases [18-22]. The nerve bundles intended for the thenar branch may be situated on the radial, anterior, or central part of the median nerve. In other instances, the thenar branch passes through a tunnel before entering the thenar muscles. These differences illustrate the inconstant motor effect in cases of severe compression on the median nerve. Another variation occurs in the palmar cutaneous branch of the median nerve. In this respect, the palmar cutaneous division often starts from 4 cm to 7 cm above the wrist fold and moves along near the median nerve for 1.6 to 2.5 cm^3. The branch then enters a tunnel formed by the fascia at the medial edge of the flexor carpi radialis (FCR) and emerges 0.8 cm above the wrist flexion wrinkle, to innervate the skin of the thenar eminence. The palmar cutaneous branch may either go to the ulnar side of the median nerve or cross the transverse ligament of the carpus. Another variation, though rare, is the intratunnel positioning of the ulnar nerve. In the event of its occurrence, however, the irregularity shows the combined symptoms of the median and ulnar nerves [22]. Activities of the wrist joint also influence the form and size of the CT. During the normal range of wrist motion, the width of the tunnel decreases considerably, with the carpal bones moving relative to each other because of the bony walls of the tunnel being flaccid [21]. Flexion and extension also cause an increase in CT pressure. Conversely, the cross-section of the proximal opening of the CT decreases with the flexing of the wrist joint. This is because of the circular changes of the transverse carpal ligament (TCL) and the movement of the distal end of the capitates bone. Extreme extension causes the lunate bone to scrunch the passage while being pushed towards the interior part of the tunnel. The TCL is the dense, diminutive, and broad essential element of the flexor retinaculum (FR), ranging between 2 mm to 4 mm in thickness, an average width of 25 mm, and 31 mm in length [20-21]. It is a firm band, which forms from interwoven bundles of fibrous connective tissues. It also spreads from the distal part of the radius to the distal segment of the base of the third metacarpal. The average closeness to the central portion is 11 mm away from the capitate-lunate joint, while the average distal limit of the distal portion is 10 mm distal to the carpometacarpal joint of the third metacarpal [22].

Epidemiology

CTS is the most common entrapment condition affecting one or more peripheral nerves and resulting in numbness or weakness in the affected body organ. On average, at least 3.8% of people who complain of aching, unresponsiveness, and an itchy feeling in their hands have 2020 Genova et al. Cureus 12(3): e7333. DOI 10.7759/cureus.7333 2 of 8 CTS [10-11]. Diagnosis for CTS is conducted through medical assessments and electrophysiological testing, although idiopathic CTS is the most typical method of diagnosis for patients suffering from these symptoms. In addition, the events of CTS occurrence occur at a rate of 276 per 100,000 annual reports, with the incidence rates being 9.2% for women and 6%in men [10,12]. Although CTS incidences are common across all age groups, it is more prevalent for adults between the age of 40 and 60 years. In regions like the United Kingdom, CTS occurrence is between 7%-16%, which is relatively higher as compared to the 5% incidence rates in the United States [13-14]. Most western nations indicate a rise in the number of work-related musculoskeletal disorders (WMSDs). This is associated with increased strain and repetitive movements by individuals. Europe, in 1998, for instance, reported more than 60% of upper limb musculoskeletal disorders recognized as work-related being CTS incidences [10]. The prevalence levels may also vary across the different occupations and industries, with industries, such as the fish processing industries reporting the occurrence of CTS in their workers estimated at 73% [10]. These views on the occurrence rates of CTS illustrate the weight of the challenge, making it a significant area of concern, which would require effective strategies for management.

Risk factors

Despite CTS being an idiopathic syndrome, there are still existing risk factors associated with the prevalence of this medical condition. Notable ecological risk factors include extended positions in excesses of wrist flexion or extension, monotonous use of the flexor muscles, and exposure to

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vibration [15]. Unlike environmental factors, medical risk factors for CTS are classified into four categories. These include extrinsic factors, which increase the volume within the tunnel on either side of the nerve; intrinsic factors that increase the volume within the tunnel; extrinsic factors that alter the contour of the tunnel; and neuropathic factors [15-16]. Increasing rates of CTS events are also attributed to the increased life span for workers, as well as the increased cases of risk factors, such as diabetes and pregnancies. Extrinsic factors that increase the volume within the tunnel include circumstances that change the fluid equilibrium within the body. Such factors include pregnancy, menopause, obesity, kidney failure, hypothyroidism, use of oral contraceptives, and congestive heart failure. Intrinsic factors within the nerve for increasing the occupied volume inside the tunnel include lumps and tumor-like strains. These could be the outcomes of fractures of the distal radius, directly or through posttraumatic arthritis.

Neuropathic factors include conditions such as diabetes, alcoholism, vitamin deficiency or toxicity, and exposure to toxins. These are significant factors since they affect the median nerve without necessarily increasing the interstitial pressure within the carpal tunnel. Diabetic patients have a higher propensity to develop CTS since they have a lower onset for nerve injury. In diabetic patients, the extent of incidence is 14% for patients without diabetes and 30% for patients with diabetic neuropathy, while the prevalence rate during pregnancy estimates at 2% [17].

Pathophysiology

The pathophysiology of CTS involves a combination of mechanical trauma, increased pressure, and ischemic damage to the median nerve within the carpal tunnel. Concerning increased pressure, normal pressure is recorded to vary between 2 mmHg and 10 mmHg. In the carpal tunnel, the change in the position of the wrist may result in dramatic shifts in the fluid pressure. As such, the extension increases the pressure to more than 10 times its initial level, while flexion of the wrist causes an eight times increase in the pressure [18]. Resultantly, repetitive motions in the wrist are significant risk factors for CTS incidences. In nerve injury, on the other hand, a noteworthy step in damage to the median nerve is demyelination, which occurs when the nerve is frequently exposed to automatic forces [19]. Demyelination of the nerve develops in the location of compression and spreads to the intermodal segment where the axons are left intact. With continuous compression, blood flow to the endoneurial capillary 2020 Genova et al. Cureus 12(3): e7333. DOI 10.7759/cureus.7333 3 of 8 system is interrupted, causing alterations in the blood-nerve barrier and the development of endoneurial edema. As a result, a vigorous cycle begins, which consists of venous congestion, ischemia, and local metabolic alterations [18-19]. Ischemic injury is also noted as a significant element in CTS because of the assessment that symptoms rapidly resolve after carpal tunnel release surgery. Limb ischemia increases paraesthesias in carpal tunnel patients. This occurs in three phases, including increased intrafunicularpressure, injury to the capillary with leakageand edema, and obstruction of arterial flow in the patients [19].

Stages of CTS

In the first stage of the clinical diagnosis of CTS, the patient tends to wake up from sleep feeling numbness or swelling on the hand, with no noticeable swelling. The patient may feel extreme pain from the wrist spreading to the shoulder, with a tingling in the hand and fingers, which is defined as brachialgia paresthetica nocturna. On most occasions, the pain ceases after shaking the hand though the hand may feel firm later. The second stage of CTS development in the patient is the occurrence of symptoms, which occur in the day. Such symptoms occur when the patient engages in a repetitive activity involving the hand or wrist or if they maintain a specific position for extended periods [8,20]. Similarly, the patients may also note clumsiness whenusing their hands to grip objects, causing them to fall. The final stage of CTS development appears when there is hypotrophy or atrophy of the thenar eminence [20]. The occurrence of this stage also entails the ability to engage in any sensory symptoms by the patients.

Diagnostic tests

The diagnosis of CTS patients requires the respective medical professional to develop a case history associated with the characteristic signs of CTS. The patient should be questioned on the frequency of occurrence of these symptoms, whether they happen at night or during the day, or whether certain positions or repeated movements provoke the symptoms [8]. In addition, the doctor may question whether the patients use vibratory objects for their tasks, the parts of the arm where the sensations are felt, or if the patient may already have predisposing factors for CTS incidence. In this case, they may assess the patients for conditions associated with CTS such as diabetes, inflammatory arthritis, pregnancy, or hypothyroidism [21]. Physical assessment of the patient's hand is a fundamental approach to the diagnosis of CTS since specific discoveries may indicate the availability of other factors. For instance, abrasions or ecchymosis on the wrist and hands may indicate that there has been damage to the tissue, which could also entail harm to the median nerve [22]. The initial medical tests for carpal tunnel syndrome are Tinel's sign and Phalen's maneuver. Tinel's sign elicits a positive result when tapping over the along the carpal tunnel produces symptoms in the median nerve distribution. On the other hand, during Phalen's maneuver, a patient flexes the wrist to 90 degrees, and the test is positive if the flexing produces symptoms along with the distribution of the median nerve. Additionally, monofilament testing, vibration, as well as two-

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point discrimination, could elicit sensory effects in carpal tunnel syndrome [22]. Using the patient's medical history and physiological assessment may produce limited results and have less specific areas of symptom occurrence. Patients may, therefore, be required to complete a self-diagnosis questionnaire, described as the Katz Hand Diagram. This enables the patient to specify the parts of their hand that experience the symptoms and classify the symptoms like numbness, pain, tingling, or hypoesthesia [8].

Differential diagnosis

During the diagnosis of CTS, it is essential to note that other conditions may also providesimilar symptoms to CTS, thus requiring vigorous diagnosis to assert the medical condition of the patients. The differential diagnosis is essential when dealing with cases, such as the diagnosis of CTS in patients, by weighing the probability of one disease against other diseases that the patient could likely be suffering from. Thorough physiological assessment is a 2020 Genova et al. Cureus 12(3): e7333. DOI 10.7759/cureus.7333 4 of 8 important strategy for a proper diagnosis to differentiate CTS from other health complications. The differential diagnosis distinguishes CTS from complications, such as carpometacarpalarthritis of the thumb, whose symptoms include excruciating thumb movement, positive grind evaluation, and radiographic outcomes [23]. Other conditions include cervical radiculopathy, whose symptoms include pain in the neck, numbness of the thumb and index finger, and positive results from the Spurling test; and de Quervain tendinopathy, which is responsible for tenderness at the distal radial styloid [22]. Others also include peripheral neuropathy, which shows a history of diabetes mellitus; pronator syndrome, whose symptoms include forearm pain, sensory loss over the thenar eminence, and weakness with thumb flexion, and wrist extension; and Raynaud syndrome, in which patients show symptoms associated with exposure

Physiotherapy Management

Paraffin wax bath

Paraffin is applied at a temperature of about 50 °C for 15-20 minutes on the anatomical projection of the carpal canal and the palm. UHFT is applied with athermic doses (lack of heat sensation) to oligothermic doses (minimal to moderate heat sensation). The capacitive electrodes are used in order to heat selectively the tissues with a lower water percentage. The distance from the patient's skin to the electrodes is about 2-3 cm. The duration of the procedure is 8-10 minutes. The therapeutic course consists of 10 procedures. Thermal procedures are used for analgesia, reduction of paresthesia, stiffness, and improvement of nervous conduction and trophy. They could also be used as an introductory procedure for subsequent ultraphonophoresis. Another heat factor alternative is the targeted radiofrequency therapy (Tekar therapy); it is a method where high-frequency electromagnetic waves cause warming in depth. The principle of this therapy is also known as long-wave diathermy. It has an anti-inflammatory effect and accelerates the regeneration of tissues. The devices combine two modes of operation: capacitive (460 kHz) and resistive (460 kHz) [15].

Laser therapy

Laser therapy is used for symptomatic treatment: for pain and paresthesia [16]. The use of laser therapy in the treatment of CTS is one of the first methods approved by the FDA. The use of both low- and high-intensity laser beams using the corresponding dose regimen is appropriate

Ultrasound

Ultrasound therapy uses fibrinolytic, anti-inflammatory, and anti-irritant action of the ultrasound. The application is on the projection of the carpal canal using the low-frequency transducer for deeper effect or the high-frequency one for surface effect. The ultrasound intensity is 0.8 to 1.0 W/cm^2. The duration of the procedure is six minutes. The therapeutic course consists of 10-15 procedure

Mangnatotherapy

Magnetotherapy is used to counteract the oxidative action, stimulate oxidative processes and tissue trophic [18]. A low-frequency impulse magnetic field is assigned with parameters of 20-25 mT with period/break ratio 2/8 The therapeutic course consists of 10 procedures. Magnetotherapy is contraindicated in patients with pacemakers and is one of the disputed physical factors in the complex treatment of CTS. AAOS does not recommend its use due to a lack of sufficient evidence-based research [16]. Nevertheless, it remains one of the most commonly prescribed physical factors in CTS. Applied before electrophoresis, it significantly increases its therapeutic effect [19]. More and higher-quality research is needed to confirm the positive impact on patients' main complaints: pain, numbness, and stiffness.

Intophrosis

Iontophoresis is used for combining the analgesic effect of the galvanic or low-frequency current with the fibrinolytic effect of potassium iodide. The 5% solution of potassium iodide is used for the procedure and is placed on the hydrophile pillow around the negative electrode. The intensity of the current is dosed subjectively (up to 10 mA) to avoid burning and pain sensation. The duration of the procedure is 20 minutes. The therapeutic course consists of 10 procedures

Acupuncture can also be used to reduce the pain in CTS. When properly administered, its anesthetic effect is comparable to that of topical corticosteroid administration [22].

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Shockwave therapy (SWT) is considered to be one of the non-invasive and evidence-based physical approaches to the treatment of CTS [23]. It uses pneumatically generated shock waves with low frequency (5-20 Hz) and pressure of 1-5 bar applied locally in the affected area [24]. SWT is applied in the area of ligamentum carpi transversalis. The therapeutic course consists of 4-6 procedures, with 1-2 procedures per week (Figure(Figure7). It7). It is particularly effective in the early stages of the disease and in young patients where the CTS is associated with occupational overloadImmobilization is recommended in order to eliminate active movements in the affected hand [17]. The wrist is fixed in a neutral position so the tension in the carpal canal will be minimal. The carpometacarpal and the interphalangeal joints are fixed in slight flexion for the same purpose [25,26].

Kinesiotherapy, and in particular mechanotherapy, helps in maintaining the trophy of the paretic muscles of the thenar, improving nervous conduction and excitability, and restoring the motor function. Muscle hypotrophy is influenced by a light/attentive massage that should be performed daily [6]. Patients are taught how to perform kinesiotherapy including self-massage at home for a short duration, frequently and with low intensity. Patients should be informed that prolonged and intensive kinesiotherapy and massage are absolutely contraindicated. According to the degree of functional impairment and hypotrophy, an individual kinesiotherapeutic program is developed for the affected hand, varying according to the condition of the patient. It is mandatory to convey instructions on the loading of the elbow and shoulder joint of the eponymous side and of the contralateral limb for prevention. In some patients, despite the properly designed and performed rehabilitation program, the condition does not improve or even deteriorates. This usually is an indication for surgical treatment. In the postoperative period, physiotherapy and rehabilitation again play a key role. A number of authors recommend immobilization for two weeks after surgery [27-31]. Splinting is not a contraindication for active movements in the remaining joints of the upper limb and the contralateral limb. Once the immobilization is over, postoperative rehabilitation is initiated in order to influence the postoperative edema and pain and to prevent the development of fibrosis. The above-described physiotherapeutic factors and methods of kinesiotherapy are used, with emphasis on the active training of the muscles of the affected hand [36].

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