Manual Therapy Interventions For Carpal Tunnel Syndrome: A Review

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ABSTRACT: Carpal Tunnel Syndrome (CTS) is a debilitating condition which affects majority of the middle aged people in the community. This condition is predominant in females than the males. The condition may be affecting the patient’s single hand (unilateral) or both hands (bilateral). The functional outcomes are very poor and patient may be deteriorating psychologically as well. Signs and symptoms of the CTS can be varied from mild to moderate to severe. This includes numbness or paresthesia along the distribution of the median nerve of hand, pain, atrophy of muscles, reduced hand grip strength etc. The people who are experiencing mild or moderate symptoms usually seek for conservative therapies including electro therapeutic modalities and manual therapy techniques. When the condition becomes chronic, the concern is more towards the surgical approaches that involves the carpal tunnel release and thereby releasing the median nerve compression. But majority of the patients with CTS are reluctant to follow the surgical interventions. This is mainly due to economic problems and secondary complications of the surgery. Therefore the evaluation of the effectiveness of the conservative therapies should be a major concern which are cost effective and lack of secondary complications. Many research have been conducted to see the efficacy of various conservative therapies. This includes electrotherapeutic modalities, manual therapy interventions, oral supplements and medications, wrist immobilizations such as with splints so on. Among all the aforementioned therapies, manual therapy interventions alone are known to be more effective in treating CTS. There are various manual techniques with primary focus on reducing the compression on median nerve and thereby inducing the optimum gliding of the nerve in the carpal tunnel. This is done by stretching the adhesions developed between the median nerve and the surrounding structures, removing the myofascial restrictions, improving the pliability and flexibility of the flexor tendons by eliminating the inflammation of the tendon sheaths. In summary this review focus on research which are conducted to evaluate the efficacy of manual therapy interventions in treating the CTS. Since a combination of various techniques is more advantageous than a single treatment alone, emphasis should be given to develop a protocol including manual therapy techniques with other conservative modalities in rehabilitating the patients with CTS.

Key words: Hand Grip Strength, median nerve, conservative treatments, numbness

1. INTRODUCTION

Carpal tunnel syndrome (CTS) can be defined as a compression neuropathy where the median nerve is entrapped at the carpal tunnel. Prevalence of the median nerve injury is much higher than the other compression neuropathies [1] where it accounts for 90% of all neuropathies [2]. Four to five percent (4-5%) of the population who are aged between 40 and 60 years are affected by this [3]. Females are more predisposed to this neuropathy than the male counterparts [2], [3]. Certain etiological factors are identified in literature including medical and occupational factors [4]. Medical factors further can be classified into intrinsic and extrinsic factors [5]. Chammas, (2014) [3] had classified them as idiopathic where the exact cause is unknown, and secondary CTS in which the abnormalities are associated with the contents. Idiopathic CTS is more common in females (65-80%) [6] and it has been shown that the age, gender, genetic factors and the anthropometric factors are the most influencing factors towards it [7]. Secondary CTS can be due to the abnormalities of carpal bones, distal radius or any pathologies of the wrist joint [3]. Abnormalities of fluid distribution such as in pregnancy [8] also can be taken under this. Dynamic CTS is identified as one of the most common occupational pathologies which affects the workers who are involved with repetitive manual work and are exposed to vibration repeatedly [2].

2. ANATOMY

2.1. Carpal tunnel

Carpal tunnel is an outlet made of flexor retinaculum and the carpal bones. Base of the tunnel is bounded medially by the pisiform bone and the hook of the hamate, and laterally by the scaphoid and trapezium bones. The roof of the tunnel is formed by the transverse carpal ligament which is a fibrous connective tissue ligament connecting the medial and lateral sides of the base of the tunnel [9]. Nine flexor tendons including four tendons of flexor digitorum profundus and four tendons of flexor digitorum superficialis and the tendon of flexor pollicis longus travel through this tunnel along with the median nerve. Other than this, carpal tunnel contains two tenosynovium of flexor tendons, two synovial bursae and subsynovial connective tissue, which lies between the flexor tendons and the visceral synovium of the ulnar tenosynovial bursa [10].

3. PATHOPHYSIOLOGY

Median nerve enters the tunnel in the mid line or somewhat radial to it. It is vulnerable to compression inside the tunnel 2-2.5cm distal to the origination of the canal where that area is more tapered [11]. Median nerve is located more anteriorly to the tendons within the canal [9]. Thenar motor branch of the median nerve branches off distal to the transverse carpal ligament (TCL), which is the intermediate part of the flexor retinaculum. Sensory branch of the median nerve supplies the three radial digits and the radial half of the fourth digit. As palmar sensory cutaneous branch which supplies the cutaneous skin of the
palm originates proximally to the TCL, it is not affected in CTS [11]. However the diagnosis is based on the clinical symptoms such as numbness, tingling sensation in the area of median nerve distribution of the hand etc. [12]. It is being concluded that this compression neuropathies are consequences of repetitive activity of the hands where it causes increased thickening of the synovial sheath of the tendons and thereby exerting more pressure on the nerves [12]. During the surgical release of the carpal tunnel, it is reported that the nerve is adhered to the flexor retinaculum by loose fibrous tissue [13]. This can be occurred also as a result of increased fluid pressure (eight to ten times) than the normal pressure thus causing compression of the nerve [14].

4. MANUAL THERAPY INTERVENTIONS

Interventions or treatment methods can be mainly surgical or non-surgical though there is no any consensus regarding the effectiveness of the treatment approach [14]. Conservative methods or non-surgical methods include the use of electro physical modalities such as magnetic field therapy [15], ultrasound [16], extracorporeal shock wave therapy [17], and low intensity laser therapy [18].

Development of multidisciplinary guidelines is essential in improving the quality of life of the patients with CTS [19]. Therefore, adequate evidences that support the effective treatment methods are needed to develop these guidelines [14]. Most of the people tend to use conservative therapies despite of less evidences of their efficacy [20] and avoid the surgical approaches [21]. For this reason this review primarily focuses on the scientific literature, which provide the evidences for the effectiveness of various manual therapy interventions to treat the CTS.

4.1 Osteopathic manipulation

Osteopathic structural examination and osteopathic manipulative treatment approaches are very essential in diagnosing and treating the CTS [22]. This treatment approach is known to be effective in relieving the compression over the median nerve and thereby decreasing the pain and numbness of the patients with CTS [23].

4.1.1 Opponens roll maneuver

Opponens roll maneuver along with the self-stretching exercises have been introduced to a group of patients who were diagnosed with CTS with palpatory assessment methods and nerve conduction tests [23]. In this procedure patient’s thumb was abducted, slightly extended and was brought into lateral rotation along the axis of the first metacarpal bone. This brings the thumb into a position opposite to the opposition which is known as retro position. In this case, maximum rotation occurs at the first carpo metacarpal joint as it is a saddle joint which imparts a wide range of mobility to the thumb. Subsequently vigorous lateral rotation of the thumb had been introduced which had resulted in traction force on the opponens pollicis as well as the abductor pollicis muscles. Furthermore, the TCL was elevated up off the median nerve relieving the direct pressure on the nerve itself. The results have shown an increased range of motion of the wrist joint with a reduction of the palpatory restrictions. Also it has been shown that several electro diagnostic test improvements including a decrease in sensory and motor latency and an increase in response amplitudes. This in turn indicates the improvement of nerve conduction velocities and decrease of conduction blocks by improving the nerve axons functions. Another study was done by Sucher et al., (2005) [24] using 20 cadaver limbs (ten males and ten females). The method was performed with four study protocols introducing static loading (weights) and osteopathic manipulation (OM) and reversing of the sequence of procedures in order to see the effect on the transverse carpal arch. Greater responses were noted for all the interventions specifically for the female group. Furthermore, application of OM prior to the weights was founded to be more effective in lengthening of the TCL than the reverse method. This OM had included distal and proximal transverse carpal extensions which applied a transverse distraction force across the carpal canal in order to lengthen the TCL. Secondly, Guy-wire maneuver which involved maximum abduction along with the extension to the thumb and the little finger adding a greater stretch to flexor pollicis longus and flexor digitorum profundus tendon of the little finger pulling TCA further apart. Thirdly opponens roll maneuver which was described earlier [23]. Out of all the maneuvers, combined distal transverse extension with Guy-wire maneuver had shown the greatest response as the manual technique.

4.1.2 Carpal mobilization

Carpal bone mobilization is a technique used in physical therapy which focuses on increase wrist extension or flexion either by gliding proximal carpal row dorsally or palmarly respectively. However the efficacy of this technique in reducing the symptoms has been evaluated in several studies [25]-[27]. A study had done by Gunay, and Alp, (2015) [25], using 40 patients diagnosed with CTS clinically as well as electro physiologically. Carpal mobilization including 3 techniques; dorsal-palmar glide at radio carpal joint and distraction at the mid-carpal and radio-carpal joints was used in combination with neutral volar wrist splint.

(a) Dorsal-palmar glide

Patient’s hand was rested on a table extending off the surface. Distal radio-ulnar joint was stabilized. Dorsal or palmar glides had been provided at the radio carpal joint by holding the proximal carpal row in order to improve the extension or flexion respectively.

(b) Mid carpal distraction

Styloid processes were stabilized and the distraction was given at the distal carpal row.

(c) Radio-carpal distraction

Styloid processes were stabilized and the distraction was given at the proximal carpal row.

The results have shown significant improvements in functional activities, pinch grip strength, symptom severity, distal sensory latency and sensory nerve action potentials of the median nerve. It is also demonstrated that the application of mid carpal distraction along with the median nerve neuro-mobilization than the neuro-mobilization alone [28]. Another study has evaluated the
scaphoid and hamate bone mobilizations along with splinting in CTS [26]. Forty participants with CTS were given the treatment three times a week for eight weeks. Ventral surface of the forearm was placed on a table and the hand was placed out of the table surface.

(d) Scaphoid mobilization
Distal radius was stabilized and the volar or dorsal glide was provided on the scaphoid bone

(e) Hamate mobilization
Proximal carpal bone was stabilized and the hamate bone had been glided volarly or dorsally on the triquetrum.

Pain and severity symptoms and functional status had been significantly improved though there was no any significant difference in sensory and motor latencies between the intervention group and the splinting alone group.

4.2 Active release technique
A pilot study had been carried out to see the efficacy of active release technique on CTS in five patients (four females, one male) who were diagnosed with CTS [29]. Treatment protocol was performed by taking the tissue into a short position. And then while maintaining a manual contact with the tissue being treated, active lengthening of the tissue was performed. Treatment was applied to the median nerve at the sites of thenar muscles, carpal tunnel, flexor digitorum superficialis, pronator teres and ligament of struthers. Symptom severity (SS) and functional status (FS) both had been improved according to the Boston Carpal Tunnel Questionnaire (BCTQ). But nerve conduction studies had shown no improvement. This also may be due to an application of a single treatment session. Quality of the study and the validity of the results have to be improved by increasing the number of patients and can be generalized to all the patients with CTS.

4.3 Soft tissue manipulation

4.3.1 Fascial manipulation
It is concluded that various manual techniques have an effect on reinstating the normal physiological state of the fascia, though there is less scientific evidence [30]. In literature it has been shown that lengthening and thereby restoring the myofascial tissue can release the pressure on nerves [31], blood vessels [32] and also restore the mobility of joints [33]. Poorly coordinated muscle fiber can be resulted in developing inflammation in the tendons. Therefore small areas of transformed fascia should be identified and isolated. However this transformation of connective tissue is not an isolated process but also can be occurred in muscle chains or myofascial sequences [30]. This myofascial sequences are made by joining the biarticular muscles with the unidirectional myofacial units [34], [35]. A myofascial unit is consisted of monoarticular and biarticular muscle fibers and surrounding fascia. Fascia is made up of collagen and elastic fibers which are arranged in separate layers and in different directions within the each layer. Fascia is considered as a three dimensional structure in fascial manipulation technique [36]. Fascial manipulation (FM) is a manipulation process, which works on deep muscular fascia [37]. In this technique, the body is divided into 14 segments; head, neck, thorax, lumbar, pelvis, scapula, shoulder, elbow, forearm, hand, hip, knee, ankle and feet [33]. Pratelli et al., (2016) [36] had compared the effectiveness of facial manipulation (FM) Versus Low Level Laser Therapy (LLLT) in the treatment of CTS. One set of patients who were diagnosed with CTS according to the clinical and electro physiological diagnosis were given FM for 45 minutes once a week in three sessions and was continued for three weeks. Deep friction was given over definite points which were identified as Centers of Coordination (CC) and Centers of Fusion (CF) confirmed by palpation for facial density, patient’s response and FM guidelines. CCs are located in deep fascia at the points where the vectoral forces of muscles in a particular movement are converged. CFs are confined in intermuscular septa and retinacula [30]. Deep friction was provided by elbow and knuckles and it was maintained for 2-4 minutes. The patients had shown significant (p<0.001) improvements in Boston Carpal Tunnel Questionnaire (BCTQ) and Visual Analogue Scale (VAS) and FM technique was effective than LLLT. Myofascial continuation develops between flexor carpi retinaculum, palmar aponeurosis antebrachial and brachial fascia as a thickening along the fascia [38]. This emphasizes how a treatment over a more proximal CC or CF points on brachial fascia can be resulted in improvements over the rest of the continuous fascia [36].

4.3.2 Massage therapy
Massage therapy is known to reduce the sympathetic activity and increase the vagal activity. Also it increases serotonin levels which result in reduction of pain [39]. It is found that patients anxiety and depression levels associated with diseases also can be decreased with massage therapy [40]. Significant improvement in pain, hand grip strength, median nerve peak latency scores had also been noted [41]. To evaluate the efficacy of the massage therapy on the CTS, a new hand massage technique had been introduced by [42]. It had included 30s-effleurage, 60s-friction, 30s-pettrissage, 30s-shaking and was ended by another set of 30s-effleurage for total of three minutes. Throughout the procedure, the patient’s neck and shoulder remained neutral, elbow in 90 degree flexion and supination. The patient was asked to hold the each position for 5s and to repeat each 10 times at least three times a day. Results have shown significant improvements in pain scores, hand grip strength scores and as well as in electrophysiological parameters. The effectiveness of each of these techniques have been identified [43]. Accordingly, effleurage is known to have a muscle relaxing and sedation effect on the nerves. Friction massage induces the lymphatic and venous drainage and consequently relieving the edema. This also has an effect on scar tissue and adhesions as well. Pettrissage results in prevention of atrophy of the muscles by removing metabolic products which are collected in the muscles. Shaking has an analgesic and strengthening effect.

4.4 Exercises
Median nerve is connected with the peritendinous subsynovial connective tissue (SSCT) [44] which lies inside the carpal tunnel as previously described. It is
found that this tissue is thickened in CTS which may cause limitation of the median nerve gliding in both transverse and longitudinal planes [45], [46]. Application of gliding exercises are known to stretch the adhesions and increase the gap between the TCL and the median nerve, facilitating the venous return from the nerve bundle and reducing the carpal tunnel pressure [47]-[49]. Therefore, this tendon and nerve gliding exercises are used as a conservative method in rehabilitation programs.

4.4.1 Tendon gliding exercises

A study was conducted by Akalin et al., (2002) [47] using total of 28 patients (26 females, two males) with clinical and electrophysiological evidence of CTS. In tendon gliding exercises, patients were demonstrated five separate finger positions including straight, hook, fist, table top and straight fist positions. During this procedure, shoulder and neck were held in neutral, elbow was supinated and 90 degree flexed. Each position was maintained for five seconds. Each exercise was performed five sessions daily and ten times per each session. Efficacy of the interventions had been evaluated according to patient satisfaction questionnaire, symptom severity scale and functional status scale. Small number of patients and lack of electrophysiological evidences are considered as limitations of the study. Significant changes have been found in the cross sectional area (CSA) of the median nerve during the movement from straight to hook position and from hook to fist position in tendon gliding exercises. CSA was increased in straight finger position, where the fingers were extended fully. CSA was decreased in subsequent hook and fist positions, where the fingers were flexed, inducing maximum tendon gliding [44]. Although it is found that the hook, fist and straight fist positions increase the maximum gliding of both the flexor digitorum superficialis and profundus tendons [50], making a strong fist could even increase the compression of the median nerve. This position encourages the lumbricals to be moved into the carpal tunnel [44]. According to Yoshii et al., (2009) [51], when the fingers are involved in making a fist, the median nerve moves away from the flexor tendons and moves either ulnar or radial direction. Then it is compressed against the flexor retinaculum by flexor tendons which were displayed palmarly. Since strong fist can exacerbate the condition, it is avoided during the exercises [44]. This tendon movements are associated with synovial and extrasynovial structures located inside the carpal tunnel, and thereby stretching the subsynovial connective tissue. Also these tendon movements increase synovial fluid lubrication in the carpal tunnel bursae. Moreover, the gliding exercises provide adequate movement between the tendons and hence reduce the adhesions [52].

4.4.2 Neural gliding exercises

Certain upper extremity joint movements are capable of increasing or decreasing the strain on the median nerve [53]. It was demonstrated that the shoulder abduction, elbow extension, wrist and finger extension are the movements that induce the strain on the median nerve [53], [54], exerting the maximum strain of 3.5% during the elbow extension [53]. Nerve stretching of more than 15.7% can cause complete occlusion of blood flow to the nerve, where the blood flow is impaired when the strain is 5-10% [55]. Moreover, the strain on the nerve can even affects the axonal transport [56] and nerve conduction [57] as well. It is documented that a minimum of 3% stretch could be adequate for a nerve with local neural inflammation to be fired optimally with limb movements [58]. Coppieters, and Alshami, (2007) [59], have evaluated the longitudinal exertion and strain on the median nerve during collective movements of wrist and elbow joints using cadavers. In this study, neural sliding techniques had been assessed, in which one particular movement that increases the strain on the median nerve is counteracted by another movement done concurrently which causes decrease strain on the nerve. In tension techniques, similar movements performed simultaneously in adjacent joints had been evaluated. Six techniques were evaluated in embalmed cadavers (five males, one female), with no prior trauma to the spine or extremities. In first technique, elbow extension (loading) with wrist flexion (unloading) was followed by elbow flexion (unloading) with wrist extension (loading). Loading and unloading of the nerve were performed at two particular joints with simultaneous movements which resulted in increased and decreased strain on the median nerve respectively. In the second technique, elbow extension with wrist extension which caused loading of the nerve was followed by elbow flexion with wrist flexion which caused unloading of the nerve. In third, wrist flexion and extension were performed with elbow flexion. Fourth technique involved wrist flexion and extension while the elbow was fixed in extension. In fifth technique, elbow was moved with wrist in neutral where the sixth involved elbow movements with wrist in extension. All the techniques were performed five times, where the strain was calculated in final three repetitions and the range of motion remained same for all the techniques. Results have shown that optimum gliding can be occurred by concurrent motions of nearby joints while loading was counteracted by unloading. It was revealed that the increased strain on the median nerve was achieved distally by wrist extension at wrist with simultaneous elbow flexion, where the nerve strain was reduced proximally. In contrast, decreased strain on the median nerve was achieved distally by wrist flexion at wrist with simultaneous elbow extension, where the nerve strain was increased proximally. However, it was found that simultaneous extension in the two adjacent joints can be resulted in limited nerve stretching or strain either proximally or distally such as with tension technique. Anyway, the emphasis should be given to the nerve gliding exercises which are not aggravating the patients’ clinical symptoms in the rehabilitation set up [60]. Therefore, it is concluded that the sliding techniques have the largest longitudinal excursion and the optimum gliding without having any deteriorating effect on the nerve [59]. The results were confirmed by Coppieters, and Butler, (2008) [61], indicating that the greatest excursion of the median nerve occurs with sliding than the tensioning technique (12.6mm and 6.1mm respectively) and relatively a greater strain on the nerve was achieved in vise versa (6.8% , 0.8% for tensioning and sliding respectively). A study done by Akalin et al., (2002) [47], have also evaluated the efficacy of median nerve gliding exercises other than the tendon gliding exercises. In the median nerve gliding session, 6 different hand positions had been introduced. They were: 1. Wrist in neutral;
fingers and thumb in flexion, 2. Wrist in neutral; thumb and fingers in extension, 3. Wrist and fingers in extension; thumb in neutral. 4. Wrist, fingers and thumb in extension, 5. Forearm in supination, opposite hand applies a stretch on the thumb. During this procedure also, shoulder and neck were held in neutral, elbow was supinated and 90 degree flexed. Each position was maintained for five seconds. Each exercise was performed five sessions daily and ten times per each session. Significant improvements were noted in patient satisfaction questionnaire, symptom severity scale and functional status scales. Studies also have been implemented to see the position of wrist with lowest carpal tunnel pressure. It is found that carpal tunnel pressure was increased with flexion and extension of the wrist joint where it was lowered with wrist in neutral position [62], [63]. Weiss et al., (1995) [62] also have shown that the traditional wrist splints that hold the wrist in slight (20-30 degree) extension increases the pressure of the carpal tunnel. Furthermore, neutral wrist position had been recognized as the optimum position to alleviate the symptoms of CTS. In contrast, some studies have indicated that the alternative active flexion and extension exercises of the wrist joint can decrease the pressure inside the carpal tunnel [64].

4.5 Combination of manual therapy techniques
Combination of several manual therapy interventions in a single treatment also have been evaluated [65]. In this regard, 22 patients (20 females, two males) who were diagnosed with CTS clinically and electro physiologically were provided with four sessions of manual therapy interventions. In the first session, deep transverse massage was used in cranio-caudal direction to treat the most thickened tissue of the hand palmar surface, wrist and forearm anterior surfaces for ten minutes. In the second and third sessions, radio-carpal and radio-ulnar joints were passively mobilized and the palmar surface of metacarpophalangeal joints were opened by maintaining the hand in the traction for fifteen minutes. Fourth session had included passive flexion, extension and transverse movements to improve the range of motion of the joints by maintaining the hand in traction. Moreover while the hand was maintained in open and extended position, palmar aponeurosis and the pollical and first palmar interosseus muscles were treated for additional fifteen minutes. The patients’ symptoms such as pain, paresthesia which were assessed according to BCTQ had improved significantly. But the nerve conduction studies had shown no improvements. This may be due to the short duration of treatment and the absence of home exercise program. This ensures the importance of maintaining manual interventions even after the initial treatment as well. Study quality was reduced due to reduced number of patients, absence of a control group and short period of follow up.

5. CONCLUSION
Various manual therapy techniques have been evaluated in literature in order to see the effectiveness on CTS. This includes Osteopathic manipulation, Active release technique, Soft tissue manipulation, Tendon and nerve gliding exercises. Studies have been conducted in vivo as well as in embalmed cadavers. Manual therapy techniques were more effective in reducing the patients’ symptoms and consequently improving the functional levels. All the techniques were known to have a positive outcome towards the pain scores, symptom severity scales, functional status scales and hand grip strength. Some studies have shown the improvements in electro physiological parameters including sensory and motor latencies of the median nerve. Maintenance or follow up of these techniques for a period of time even as a home based exercise program is very crucial. Furthermore it is evident that, among all the conservative therapies, manual therapy interventions are more beneficial. Thus, the employment of different manual therapy techniques along with the other conservative therapies would be more promising in treating CTS.

6. REFERENCES


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