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REHABILITATION IN CARPAL TUNNEL SYNDROME

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Abstract

Carpal Tunnel Syndrome (CTS) is a common condition where compression of the median nerve in the wrist leads to symptoms like pain, numbness, and weakness in the hand and wrist. Effective rehabilitation for CTS involves a comprehensive approach aimed at reducing symptoms and enhancing wrist function. Physical therapists play a crucial role in this process by tailoring treatment plans based on the severity of the condition, patient preferences, and any contraindications. Early diagnosis and intervention are pivotal to prevent irreversible nerve and muscle damage. Physical therapy strategies include targeted exercises, manual therapy, and possibly electrotherapy to alleviate pain and sensory disturbances while improving muscle strength and coordination. Patient education on ergonomic practices and lifestyle modifications further supports symptom management and reduces recurrence risk. By adopting evidence-based practices and personalized care, physical therapists optimize outcomes for individuals with CTS, aiming for sustained symptom relief and improved quality of life. Individualized rehabilitation programs are recommended to address the specific needs of each patient, promoting long-term functional recovery and overall well-being

Keywords: Carpal Tunnel syndrome, kinesiotaping, ESWT, treatment

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INTRODUCTION

Carpal tunnel syndrome is a common peripheral entrapment neuropathy that occurs when the median nerve, which passes over the lower part of the palmaris longus tendon and above the flexor tendons in the carpal tunnel, is compressed at the level of the transverse carpal ligament. While the upper part of the tunnel is formed by the flexor retinaculum, the palmar cutaneous sensory branch separates from the proximal side and receives the sensation of the thenar region of the hand, while the motor branch advances in the distal palm and innervates the 1st and 2nd lumbrical muscles (Çırakoğlu & Kurt,2016). Although there are many causes that can cause CTS, most of the cases encountered are idiopathic. While an increase in the volume of the structures in the carpal tunnel or a decrease in the size of the carpal tunnel causes CTS, these two possibilities can also be seen together.. While it is thought that idiopathic cases may be caused by tenosynovitis seen in the transverse carpal ligament, there are very few signs of inflammation in the examinations. While its prevalence varies between 1% and 5%, it is mostly seen in women between the ages of 40-50. While the prevalence in women is between 3.0% and 3.4%, it varies between 0.6% and 2.1% in men (Ostergaard et al.,2020; Seven & Doğan,2017).

Symptoms of CTS include paresthesia, pain, numbness, thenar atrophy and loss of muscle strength, which are seen in the area of the hand innervated by the median nerve and can wake you up at night, while vasomotor problems such as sweating and loss of reflexes may occur due to the effects of the symptoms. These symptoms that occur during CTS manifest themselves mostly on the radial side of the thumb, middle finger, index finger and ring finger, in other words, in the distribution of the median nerve. Risk factors include female gender, diabetes, obesity, repetitive wrist movements, rheumatoid diseases (osteoarthritis-rheumatoid arthritis...) Ecological risk factors include strains in wrist flexion or extension and monotonous use of flexor muscles. Repetitive wrist movements have made carpal tunnel syndrome a common problem among manual workers (Seven & Doğan,2017; Genova et al. ,2020).

CTS is graded in 3 groups: mild, moderate and severe, depending on the decrease in the conduction velocity of the nerve fibers containing myelin sheath as a result of chronic or regional deformation of the median nerve. While conservative treatment is applied since the risk of denervation is not high in the mild form of CTS, our first treatment option is conservative treatment in moderate cases. In more advanced and severe forms where axon loss occurs, surgical treatment known as median nerve release is applied (Seven & Doğan, 2017; Sucher & Schreiber,2014) A good anamnesis is required during the diagnosis of CTS. It should be questioned whether there are any factors that predispose to CTS, whether the symptoms occur at night or during the day, and whether repeated hand and wrist movements cause the symptoms. In the first stage of clinical diagnosis of CTS, pain and numbness are felt without swelling in the hand, and this may wake the patient from sleep. The patient may experience numbness and tingling in the hands and fingers, along with pain that can spread from the wrist to the shoulder. In the second stage of the clinical diagnosis of CTS, symptoms begin to appear during the day when an activity involving repetitive hand or wrist movements is performed or when the hand and wrist are held in a certain position for a long time. At the same time, weakening of comprehension skills occurs. In the final stage of CTS, atrophy in the thenar region and an accompanying sensory symptom are also observed (Genova et al. ,2020).

During diagnosis, sensory examination can be performed along with the patient's complaints. Pain sensation examination is a subjective examination. Monofilament testing can be used to map sensory loss while adding objectivity to the examination. 2-point discrimination is used to examine those with more severe nerve damage (Sucher & Schreiber, 2014). Tests used for carpal tunnel syndrome include Tinel's sign, phalen test and Durkan test. The Phalen test is performed by keeping the elbow in full extension, providing extra pressure to the median nerve and bending the palms at the wrist level for one minute. Tinel test is performed by percussing in the direction of the median nerve over or proximal to the carpal tunnel of the affected side. The test is positive if symptoms are seen in the median nerve distribution. The Durkan test is performed by the examiner using both thumbs and applying pressure on the carpal tunnel for 30 seconds. The test is positive if symptoms occur along the distribution of the median nerve. Some studies support the view that the Phalen test and Tinel test used alone for the diagnosis of CTS are insufficient.. Evaluation of these tests together with clinical history and nerve conduction studies (NCS) reveals more reliable results. NCSs have high sensitivity to confirm the diagnosis of CTS. NCSs have high sensitivity to confirm the diagnosis of CTS. Sensitivities range from 49% to 84% and specificity ranges from 95% to 99% (Küçükakkaş & Yurdakul,2019).

Conservative approaches to CTS treatment include non-steroidal anti-inflammatory drugs, steroid injections, splint applications with the wrist in neutral position, physical therapy agents, and nerve and tendon exercises. Surgical median nerve release is also applied (Seven & Doğan,2017).

Treatment Methods in Carpal Tunnel Syndrome

While conservative treatment is preferred as the primary option for individuals diagnosed with mild and moderate CTS, surgical treatment is favored to relieve symptoms in those diagnosed with severe CTS (Karjalanen et al., 2022). Conservative treatment generally shows improvement in symptoms within 2-6 weeks, with its maximum benefit achieved by 3 months. If there is no improvement after 6 weeks, alternative methods should be considered (Wipperman & Goerl, 2016).

In cases where CTS symptoms persist for less than a year, there is no atrophy or weakness in the thenar region, and no denervation findings are observed on needle electromyography (EMG), conservative treatment should be considered initially. The effectiveness of conservative treatment is observed in thenar atrophy, objective weakness in the abductor pollicis brevis muscle, symptoms persisting for more than a year, two-point discrimination above 6 mm, presence of fibrillation potentials in EMG in thenar muscles innervated by the median nerve, and may be lower in uncooperative patients (Burton et al., 2016; Ertürk, 2018).

The Place of Splinting in the Treatment of Carpal Tunnel Syndrome

The most commonly used non-surgical treatment worldwide today is splinting the wrist with a rigid splint, typically at night and sometimes combined with other treatments. Wrist splinting aims to prevent wrist flexion, which increases pressure in the carpal tunnel (Atroshi et al., 2019). The purpose of splinting in CTS, often exacerbated by challenging and repetitive hand and wrist movements, is to alleviate pain and numbness by restricting wrist movements. It specifically targets reducing nocturnal paraesthesia, a common symptom, by preventing excessive wrist flexion and extension during sleep. Although immobilizing the wrist in a splint to prevent excessive flexion and extension is widely used, the specific type of splint to use remains unclear. Neutral wrist splints are often recommended because studies have shown lower carpal tunnel pressure in the neutral position compared to flexion and extension. Therefore, wearing neutral wrist splints at night is recommended in addition to other conservative treatments, particularly in patients experiencing significant nocturnal symptoms (Çırakoğlu & Kurt, 2016).

Despite being a straightforward and safe treatment option, wrist splinting has some drawbacks. Patients often find wearing a splint uncomfortable and limiting for certain work or daily activities, or both. Additionally, the costs associated with splints and therapy visits can be considerable (Korthals et al., 2006). For splinting to be effective, it should typically be worn for more than 4 weeks; however, studies indicate that 6 weeks of use is generally sufficient, with no additional benefit observed from using splints for longer durations (Gatheridge et al., 2020).

In a study comparing ultrasound-guided pulsed radiofrequency with nightly wrist splinting over 12 weeks, the mean symptom severity score in the splint group (n = 18) decreased from 3.0 at baseline to 2.0 at 12 weeks. Thus, although studies evaluating wrist splinting alone have reported conflicting results, most indicate modest improvements in symptom severity scores, even with splinting beyond typical clinical practice durations (Chen et al., 2015).

In a randomized controlled trial by Shikha et al. (2024), 44 patients were randomized using the sealed envelope method and divided into two groups: group A received a static volar wrist splint for 12 weeks, while group B received local injection and a static volar wrist splint for the same duration. The study observed significant effects of both treatment methods (splinting alone and splinting plus corticosteroid injection) in improving symptoms and enhancing functional and nerve conduction status. Notably, splinting plus corticosteroid injection showed slightly superior outcomes during the follow-up periods.

Khosrawi et al. conducted a randomized controlled clinical study involving patients with severe CTS who were randomly assigned to two intervention groups. Group A was instructed to use a full-time neutral wrist splint, while Group B received a full-time neutral wrist splint along with a 40 mg Depo-Medrol injection (local steroid injection) for 12 weeks. The study concluded that combining splinting with local steroid injection resulted in greater long-term functional improvement in CTS (Khosrawi et al., 2016).

In another study, 24 female patients diagnosed with mild to moderate CTS were divided into experimental and control groups. Both groups received routine rehabilitation treatment, while the treatment group additionally used a limited dynamic wrist splint for approximately six to eight hours daily. Evaluation included the Boston questionnaire, Purdue pegboard test, manual dexterity assessment for grip and pinch strength, and sensory conduction velocity with distal sensory latency. Results indicated that the dynamic wrist splint significantly improved function, manual dexterity, and pinch strength in CTS patients (Jaladat et al., 2017).

The Place of Kinesiobanting in the Treatment of Carpal Tunnel Syndrome

The mechanism of action of kinesiotape remains incompletely understood. Clinical studies suggest that it may enhance joint mobility and muscle activity, promoting optimal muscle function early on and improving overall performance (Cai et al., 2016).

Kinesiology taping has emerged as a conservative treatment method, encompassing various techniques such as neural, mechanical correction, fascia correction, ligament/tendon correction, functional correction, lymphatic correction, and field correction. In the treatment of CTS, techniques like neural and field correction are used to alleviate pressure on the median nerve by lengthening the transverse carpal ligament. Additionally, it aids in reducing lymphatic edema, which hinders blood circulation, thereby facilitating tendon and fascia movement and reducing pain (Zinnuroğlu, 2017; Aktürk et al., 2018).

A prospective randomized single-blind study involving 44 CTS patients (58 hands, 38 women and 6 men) aged 20-65, divided them into two groups. The first group (28 hands) received kinesiotaping and exercise therapy, while the second group (30 hands) received splinting and exercise therapy. The study concluded that kinesiotaping demonstrated positive effects on electrophysiological changes and physical examination findings in patients with mild to moderate CTS, suggesting potential for halting disease progression (Aktürk et al., 2018).

In another study, Kinesiotaping was applied to 25 out of 42 patients with mild-to-moderate CTS for 4 weeks, while the remaining 17 patients wore static wrist rest splints for the same duration. The study concluded that both kinesiotaping and static wrist rest splints improved symptoms, activities of daily living, and hand grip strength in patients with mild-to-moderate CTS (Çalış et al., 2021).

Another study involving 80 individuals with CTS (16 men, 64 women) randomly divided them into two groups. The S group (40 patients) received only splint treatment, while the SKB group received both splint and kinesiotaping treatments. Both groups were prescribed a home program including median nerve and tendon shifting exercises. Significant improvements were observed in both groups, with no significant difference detected between them (Şen et al., 2020).

Park et al. divided 20 participants aged 20-40 with mild and moderate CTS symptoms into experimental and control groups. The experimental group received kinesiotaping twice a week for four weeks, while no intervention was applied to the control group. The study found that kinesiotaping reduced pressure on the median nerve and improved symptoms in the carpal area (Park et al., 2017).

In another randomized controlled study investigating the effects of kinesiotaping on pain levels, range of motion, and patient functionality, 32 participants (38 hands in total) were divided into experimental and control groups. The experimental group received kinesiotaping from the medial epicondyle to the wrist with 40 tension, while no treatment was applied to the control group. The study did not find any significant difference in outcomes between the kinesiotaping group and the control group (Nadgarstka & Kocjan, 2016).

Kurniawti et al. conducted a study comparing the effectiveness of kinesiotaping with joint mobilization. Twenty patients participated, with the first group (n=10) receiving joint mobilization and the second group receiving kinesiotaping. The results indicated that joint mobilization was more effective than kinesiotaping in reducing pain (Kurniawti & Hasbia, 2020).

The Place of Tendon and Nerve Slide Exercises in the Treatment of Carpal Tunnel Syndrome

Flexor tendon and nerve gliding exercises are commonly prescribed in the treatment of carpal tunnel syndrome (CTS) due to their ability to reduce synovial edema, promote venous return within nerve bundles, nourish tissues, and enhance axonal conduction velocity (Kuran, 2014). These exercises involve a distal-proximal sliding movement of tendons and the median nerve, mobilizing surrounding soft tissues and alleviating dynamic ischemia (Rozmaryn, 1998). By increasing the mobility of the median nerve and flexor tendons, these exercises also stretch adhesions, expand longitudinal contact area, and reduce intra-tunnel pressure, thereby improving symptoms (Dolhanty, 1986).

In a randomized controlled study by Wulandari et al. involving 30 participants, both nerve gliding and tendon gliding exercises significantly alleviated pain compared to nerve gliding exercises alone, highlighting their effectiveness (Wulandari & Ariyanto, 2024). Similarly, a study by Minhas et al. divided 32 participants into two groups, applying carpal bone mobilization to one group and tendon gliding exercises to the other three times a week for four weeks. The group receiving tendon gliding exercises showed a greater reduction in pain severity and improvement in functional ability (Minhas et al., 2023).

Ying et al., in their study with 32 participants (23 women, 9 men), found significant improvements in pain scores, pinch strength, and grip strength following nerve gliding exercises (Ying & Singh, 2022). Moreover, Vaidya et al. randomized 60 hands diagnosed with moderately severe CTS into two groups, applying ultrasound, neural mobilization, and night splint to one group and ultrasound, nerve and tendon gliding exercises, and night splint to the other. Their findings suggested that neural mobilization was more effective than nerve and tendon gliding exercises in terms of recovery (Vaidya & Nariya, 2020).

Maneesha et al. (2021) conducted a study involving 30 participants whom they divided into two groups. Group A (n = 15) received conventional exercises (including tendon gliding exercises, median nerve stretching, and strengthening of intrinsic muscles) for 3 weeks. Group B (n = 15) underwent treatment using the C-TRAC machine for the same duration. The study concluded that there was no significant difference in terms of pain scores between both groups, but it suggested that the C-TRAC machine was more effective than conventional exercises.

The Place of Physical Therapy Modalities in the Treatment of Carpal Tunnel Syndrome

Ultrasound: Sound waves with a frequency range above 17,000-20,000 Hz, which can be used in imaging as well as in physical therapy modalities, are called ultrasound. While the frequency of the ultrasound devices we use in treatment is in the range of 1-3 Hz, they have two different mechanisms of action: thermal and non-thermal (mechanical). While those applied with high frequency are absorbed by the tissues, they provide heating of the deep tissues and the emergence of heat energy.

Thermal effect is seen. While the desired effect of non-thermal is increased regeneration and increased cell membrane permeability, the most important of its undesirable side effects is cavitation that may occur with non-thermal effect. It may cause serious problems such as cavitation formation in the tissue, bleeding and tissue necrosis. To avoid cavitation, constant application should not be made and high doses should be avoided. Ultrasound is used in CTS due to its regenerative and analgesic effects on nerves (Mark et al. ,2005).

In a randomized controlled study conducted by Alam et al., 48 CTS patients were divided into two groups, Group 1 and Group 2. Group 1 received neural mobilization, while Group 2 underwent ultrasound therapy. The study found that neural mobilization was more effective than ultrasound therapy in reducing pain intensity and functional limitations (Alam et al., 2018).

In a study by Lazovic et al., it was observed that ultrasound therapy combined with exercise had short-term positive effects on improving clinical and electrodiagnostic findings in patients with carpal tunnel syndrome (Lazovic et al., 2018).

In another randomized controlled study by Ansar et al., one group received therapeutic ultrasound and tendon gliding exercises, while the other group received local steroid injection and tendon gliding exercises. The study concluded that therapeutic ultrasound was more effective in reducing symptom severity, whereas patients treated with local steroid injections showed better healing outcomes (Ansar et al., 2017).

Low Dose Laser Therapy (LDLT): Laser light, which does not exist naturally in nature, is an artificial light that can be defined as concentrated light and has properties that natural light does not have. Laser beam has positive effects such as increasing metabolic activity, accelerating cell division, providing an analgesic effect and wound healing. (Uchiyama et al. ,2010)Low-dose laser therapy (LDLT) is thought to have photobiotic effects. While its anti-inflammatory and analgesic effects have been shown in experimental studies, it has been said that these effects may be due to selective inhibition of nociceptive activation in peripheral nerves. It also has effects such as accelerating collagen synthesis, activating angiogenesis and increasing microcirculation (İkbali & Yalbuzdağ,2014).

In a study conducted by Bartkowiak et al., 70 mild and moderate CTS patients were divided into two groups, and while group 1 was applied nerve and tendon gliding exercises in addition to ultrasound treatment, group 2 was applied nerve and tendon gliding exercises in addition to LDLT. While improvement was observed in both groups after treatment, no significant difference was found between the groups. (Bartkowiak et al. ,2019).

In a study conducted by Asadi et al., 45 patients diagnosed with CTS were divided into 3 groups. The combined treatment of laser and ultrasound was applied to one group, ultrasound treatment was applied to the other group, and low-level laser treatment was applied to the last group. As a result, ultrasound and laser treatment were individually effective in reducing pain and providing mild pain relief. -Although it was found to be effective in providing functional recovery in moderate CTS patients, it was thought that combined treatment may be more effective (Asadi et al. ,2021).

In a study by Badawy et al., 35 mild and moderate CTS patients were randomized into two groups. LDLT was applied to 18 patients in group 1, while nerve gliding exercises were applied to 17 patients in group 2. In addition, all patients were given a neutral wrist splint. As a result, it has been observed that LDLT is more effective than nerve gliding exercises when applied together with wrist splint (Badawy,2017).

In a study conducted by Saffan et al., 40 patients were divided into two groups. While LDLT and nerve-tendon shifting exercises were applied to one group, phonophoresis and nerve-tendon shifting exercises were applied to the other group. As a result, LDLT plus nerve shifting exercises were applied to patients with mild and moderate CTS. -Phonophoresis with tendon gliding exercises plus tendon-nerve gliding exercises were effective in the 4-week follow-up and were superior to phonophoresis with exercises aimed at improving the pain level (Saffan et al. ,2017).

Extracorporeal shock wave therapy (ESWT): Extracorporeal shock wave therapy (ESWT) is a treatment method based on high-amplitude sound waves focusing on the desired area of the body and performing the treatment function there. (Baloğlu et al.,2005) The first use of shock waves was in urology to break up ureteral stones. This procedure, called lithotripsy, is routinely used in urology. Shock waves are generated by three principles. These are electrohydraulic, electromagnetic and piezoelectric techniques.. Electrohydraulic system is a system used in shock wave machines.. In the electromagnetic system; An electromagnet is used, which can create a strong magnetic field on the aluminum plate and cause movement.. In piezoelectric technique; A large number of crystalline materials with contraction-expansion properties inside the elliptical-shaped generator create shock waves with this contraction and expansion feature as a result of electrical loading (Schmitz et al. ,2015; Wang, 2012).

There are two types of shock wave therapy: focused shock wave therapy (FSWT) and radial shock wave therapy (RSWT). In focused ESWT, waves are focused on the target area to be treated, while radial extracorporeal shock wave therapy shock wave technology is used effectively (Kıvrak & Oral,2005).

In a study by Paoloni et al., 25 patients with mild to moderate CTS were randomized to receive ultrasound (US), cryo-US, or ESWT. As a result, improvements in pain and functionality were observed in all groups, while patients in the ESWT group showed more significant improvements in pain (Paoloni et al. ,2015).

Seok et al. They compared ESWT and local corticosteroid injection in 36 patients, and while the ESWT group showed a significant decrease in symptom severity after 1 and 3 months, a significant decrease occurred in the local steroid injection group after 3 months. While no significant improvement was observed in the ESWT group in terms of nerve conduction parameters, local steroid injection A significant improvement was observed in the group (Seok & Kim, 2013).

In a randomized controlled study conducted by Xu et al., ESWT was applied to 30 patients and local corticosteroid injection was applied to 25 patients, and while significant improvements were seen in the ESWT group, the results supported that ESWT provided a better recovery than local corticosteroid injection (Xu et al. ,2020).

In a randomized controlled study conducted by Gesslbauer et al., 30 patients were divided into two groups and ESWT was applied to the experimental group, while sham therapy was applied to the control group. Significant improvements were observed in the experimental group in terms of pain, hand grip strength and nerve conduction velocity. As a result, ESWT treatment was mild and moderate. It has been found to be an effective, noninvasive treatment method for CTS patients (Gesslbauer et al. ,2021).

Conclusion

Conservative treatment options for Carpal Tunnel Syndrome are typically the first line of management before considering invasive measures. Physical therapy is integral to the comprehensive treatment of this condition. Physical therapists employ various interventions aimed at alleviating symptoms and improving functional outcomes for individuals with CTS. These interventions often include exercises designed to enhance wrist and hand flexibility and strength, thereby alleviating pressure on the median nerve.

Wrist splinting, a commonly prescribed conservative treatment, reduces median nerve pressure by maintaining the wrist in a neutral position. Exercises play a crucial role in strengthening and improving flexibility in the hand and wrist, which can relieve CTS symptoms. These conservative approaches not only alleviate symptoms but also promote long-term functional recovery.

Physical therapy also educates patients on proper body mechanics and ergonomics to prevent symptom flare-ups. Electrotherapy methods such as transcutaneous electrical nerve stimulation (TENS) and neuromuscular electrical stimulation (NMES) are used to manage pain and enhance muscle function in CTS patients. Integrating physical therapy and electrotherapy underscores a holistic approach to rehabilitation, focusing on both symptom management and functional recovery.

Studies evaluating physical therapy interventions in CTS patients have demonstrated improvements in pain relief, grip strength, and functional abilities. Long-term follow-up studies confirm sustained benefits, including reduced symptom severity and prevention of recurrence. By emphasizing a holistic treatment approach that integrates physical therapy and rehabilitation, individuals with CTS can achieve optimal outcomes and improved quality of life.

Implementing evidence-based interventions and personalized treatment plans allows physical therapists to effectively manage CTS symptoms and enhance long-term recovery. The integration of physical therapy and rehabilitation is essential in the comprehensive care of individuals with Carpal Tunnel Syndrome, addressing the underlying causes and tailoring treatment plans to individual needs.

References

Akturk, S., Buyukavci, R., Aslan, O., & Ersoy, Y. (2018). Comparison of splinting and Kinesio taping in the treatment of carpal.

Aktürk, S., Büyükavcı, R., Aslan, Ö., & Ersoy, Y. (2018). Comparison of splinting and Kinesio taping in the treatment of carpal tunnel syndrome: a prospective randomized study. Clinical rheumatology, 37, 2465-2469.

Alam, M., Khan, M., Ahmed, S. I., & Ali, S. S. (2018). Effectiveness of neural mobilization and ultrasound therapy on pain severity in carpal tunnel syndrome. Biomedical Research and Therapy, 5(4), 2187-2193.

Ansar, N., Adeel, M., Liaqat, S., Maqsood, I., & Ghafoor, I. (2017). The comparison of therapeutic ultrasound and local steroid injection in treatment of mild to moderate carpal tunnel syndrome: A randomized controlled trial. Annals of King Edward Medical University, 23(3). (Ansar et al. ,2017)

Asadi, M. R., Saremi, H., Radinmehr, H., Rahbar, S., Talimkhani, A., Hajvalie, G., & Majidi, L. (2021). Effect of low-level laser therapy combined with therapeutic ultrasound on hand pain and function following carpal tunnel syndrome: a randomized controlled trial. Middle East Journal of Rehabilitation and Health Studies, 8(4).

Atroshi, I., Tadjerbashi, K., McCabe, S. J., & Ranstam, J. (2019). Treatment of carpal tunnel syndrome with wrist splinting: study protocol for a randomized placebo-controlled trial. Trials, 20(1). doi:10.1186/s13063-019-3635-6)

Badawy, W. M. (2017). Comparative Effectiveness of Low Level Laser Therapy and Nerve Gliding Exercises on Patients with Carpal Tunnel Syndrome: a Randomized Clinical Trial. Chemtech, 10(2), 462-467.

Baloğlu, İ., Özsoy, M. H., Aydınok, H., & Lök, V. (2005). Ortopedi ve travmatolojide şok dalga tedavisi. TOTBiD Dergisi, 4(1-2), 33-49.

Bartkowiak, Z., Eliks, M., Zgorzalewicz-Stachowiak, M., & Romanowski, L. (2019). The effects of nerve and tendon gliding exercises combined with low-level laser or ultrasound therapy in carpal tunnel syndrome. Indian journal of orthopaedics, 53, 347-352.

Burton, C. L., Chesterton, L. S., Chen, Y., & van der Windt, D. A. (2016). Clinical course and prognostic factors in conservatively managed carpal tunnel syndrome: a systematic review. Archives of physical medicine and rehabilitation, 97(5), 836-852.

Cai, C., Au, I. P. H., An, W. C. R. T. H., & Cheung, R. T. H. (2016). Facilitatory and inhibitory effects of Kinesio tape: Fact or fad?. Journal of Science and Medicine in Sport, 19(2), 109-112.

Chen, L. C., Ho, C. W., Sun, C. H., Lee, J. T., Li, T. Y., Shih, F. M., & Wu, Y. T. (2015). Ultrasound-guided pulsed radiofrequency for carpal tunnel syndrome: a single-blinded randomized controlled study. PloS one, 10(6), e0129918.

Çalış, H. T., Aslaner, H., Sunkak, S. D., Sedefoğlu, N., Sütbeyaz, S. T., & Güler, E. (2021). Comparison of therapeutic effectiveness between kinesio taping technique and static resting splint in carpal tunnel syndrome. European Journal of Therapeutics, 27(1), 14-19.

Çırakoğlu, D., & Kurt, A. (2016). Karpal Tünel Sendromunda Egzersiz ve Splintleme. ODÜ Tıp Dergisi, 3(1), 41-46.

Dolhanty, D. (1986). Effectiveness of splinting for carpal tunnel syndrome. Canadian Journal of Occupational Therapy, 53(5), 275-280.

Ertürk K. (2018). Karpal Tünel Sendromunda Eswt Ve Düşük Yoğunluklu Lazer Tedavisinin Etkinliğinin Karşılaştırılması. Abant İzzet Baysal Üniversitesi. Yayımlanmamış Tıpta Uzmanlık Tezi.

Gatheridge, M. A., Sholty, E. A., Inman, A., Pattillo, M., Mindrup, F., & Sanderson, D. L. (2020). Splinting in carpal tunnel syndrome: the optimal duration. Military Medicine, 185(11-12), e2049-e2054.

Genova, A., Dix, O., Saefan, A., Thakur, M., & Hassan, A. (2020). Carpal tunnel syndrome: a review of literature. Cureus, 12(3).

Gesslbauer, C., Mickel, M., Schuhfried, O., Huber, D., Keilani, M., & Crevenna, R. (2021). Effectiveness of focused extracorporeal shock wave therapy in the treatment of carpal tunnel syndrome: A randomized, placebo-controlled pilot study. Wiener Klinische Wochenschrift, 133, 568-577.

İkbali, S. A., & Yalbuzdağ Akçay, Ş. (2014). Karpal Tünel sendromu tedavisinde fizik tedavi modalitelerinin yeri: Derleme. Türk Osteoporoz Dergisi.

Jaladat, S. M., Abdolvahab, M., Attarbashi Moghadam, B., Ashraf, A., Jalili, M., & Baghestani, A. (2017). The effectiveness of limited dynamic wrist splints on the symptoms, function, and strength of women with carpal tunnel syndrome: a controlled trial study. Journal of Rehabilitation Sciences & Research, 4(1), 1-5.

Karjalanen, T., Raatıkaınen, S., Jaatınen, K. & Lusa, V. (2022). Update on Efficacy of Conservative Treatments for Carpal Tunnel Syndrome. J Clin Med, 11.

Khosrawi, S., Emadi, M., & Mahmoodian, A. E. (2016). Effectiveness of splinting and splinting plus local steroid injection in severe carpal tunnel syndrome: A Randomized control clinical trial. Advanced biomedical research, 5(1), 16.

Korthals-de Bos, I. B., Gerritsen, A. A., Van Tulder, M. W., Rutten-van Mölken, M. P., Adèr, H. J., De Vet, H. C., & Bouter, L. M. (2006). Surgery is more cost-effective than splinting for carpal tunnel syndrome in the Netherlands: results of an economic evaluation alongside a randomized controlled trial. BMC Musculoskeletal disorders, 7, 1-9.

Kuran, B. (2014). Ön Kol, El-El Bileği Ağrılarında Egzersiz Reçeteleme. Türk Fiziksel Tıp ve Rehabilitasyon Dergisi, 60(2), 43-49.

Kurniawti, I. R., & Hasbia, H. (2020). Comparison on effectiveness of nerve mobilization and Kinesio Taping toward changes in Carpal Tunnel syndrome. In Journal of Physics: Conference Series (Vol. 1529, No. 3, p. 032034). IOP Publishing.)

Küçükakkaş, O, & Yurdakul, O. V. (2019). The diagnostic value of clinical examinations when diagnosing carpal tunnel syndrome assisted by nerve conduction studies. Journal of Clinical Neuroscience, 61, 136-141.

Kıvrak, G., & Oral, A.(2005) Karpal Tünel Sendromunda Ekstrakorporeal Şok Dalga. İstanbul Üniversitesi İstanbul Tıp Fakültesi Fiziksel Tıp Ve Rehabilitasyon Anabilim Dalı Yayınlanmamış Tıpta Uzmanlık Tezi.

Lazović, M., Kocić, M., Hrković, M., Nikolić, D., Petronić, I., Ilić-Stojanović, O., & Soldatović, I. (2018). Effectiveness of combined ultrasound and exercise therapy in the treatment of carpal tunnel syndrome-randomized, placebo-controlled investigation. Srpski arhiv za celokupno lekarstvo, 146(9-10), 561-566.

Maneesha, P., Sharma, S., & Shiv, V. K. (2021). Comparative Effect of C-Trac Machine and Conventional Exercises In Case Of Carpal Tunnel Syndrome. METHODOLOGY, 9(1).

Mark AT GF, Avitel F, Mark Y. Peripheral neuropathy In Physical medicine and rehabilitation: principles and practice. DeLisa JA, Gans BM, Walsh NE, editors: Lippincott Williams & Wilkins; 2005.

Minhas, M. S., Khan, S., Majid, M., ul Aine, Q., Tahir, R., & Tariq, K. (2023). Comparing the effects of carpal bone mobilization and tendon gliding in patients with carpal tunnel syndrome. Journal Riphah College of Rehabilitation Sciences, 11(04).

Nadgarstka, U. P. Z. C., & Kocjan, J. (2016). Kınesıo Tapıng In Conservatıve Treatment Of Mıld-To-Moderate Cases Of Carpal Tunnel Syndrome Kınesıo Tapıng W Leczenıu Zachowawczym Łagodnego I.

Ostergaard, P. J., Meyer, M. A., & Earp, B. E. (2020). Non-operative treatment of carpal tunnel syndrome. Current reviews in musculoskeletal medicine, 13, 141-147.

Paoloni, M., Tavernese, E., Cacchio, A., D'orazi, V., Ioppolo, F., Fini, M., & Mangone, M. (2015). Extracorporeal shock wave therapy and ultrasound therapy improve pain and function in patients with carpal tunnel syndrome. A randomized controlled trial. Eur J Phys Rehabil Med, 51(5), 521-8.

Park, Y. D., Park, Y. J., Park, S. S., Lee, H. L., Moon, H. H., & Kim, M. K. (2017). Effects of taping therapy for carpal space expansion on electrophysiological change in patients with carpal tunnel syndrome. Journal of exercise rehabilitation, 13(3), 359.

Rozmaryn, LM. (1998). Nerve and tendon gliding exercises and the conservative management of carpal tunnel syndrome. J Hand Ther, 11, 171-179.

Saffan, A. M., Zaky, L. A., Mohammed, M. M., & Eweda, R. S. (2017). Comparison of the effectiveness of low level laser therapy plus exercises and phonophoresis plus exercises in treatment of idiopathic carpal tunnel syndrome. Journal of Advanced Pharmacy Education and Research, 7(4-2017), 371-377.

Schmitz, C., Császár, N. B., Milz, S., Schieker, M., Maffulli, N., Rompe, J. D., & Furia, J. P. (2015). Efficacy and safety of extracorporeal shock wave therapy for orthopedic conditions: a systematic review on studies listed in the PEDro database. British medical bulletin, 116(1), 115.

Seok, H., & Kim, S. H. (2013). The effectiveness of extracorporeal shock wave therapy vs. local steroid injection for management of carpal tunnel syndrome: a randomized controlled trial. American journal of physical medicine & rehabilitation, 92(4), 327-334.

Seven, A., & Doğan, M. (2017). Karpal tünel sendromu tedavisinde farklı fizyoterapi yaklaşımlarının karşılaştırılması. Annals of Health Sciences Research, 6(1), 23-27.

Shikha, L. N. U., & Biswas, A. (2024). A Comparative Study of Effectiveness of Splinting and Splinting Plus Local Corticosteroid Injection in Patients With Carpal Tunnel Syndrome: A Randomized Controlled Trial. Cureus, 16(1).

Sucher, B. M., & Schreiber, A. L. (2014). Carpal tunnel syndrome diagnosis. Physical Medicine and Rehabilitation Clinics, 25(2), 229-247.

Şen, N., Ordahan, B., & Uğurlu, H. (2020). Effect of Kinesiology Taping in addition to Splint Therapy on Pain, Functional Condition, and Hand Grip Strength in Patients with Carpal Tunnel Syndrome. Spor Hekimligi Dergisi/Turkish Journal of Sports Medicine, 55(4).

Uchiyama, S., Itsubo, T., Nakamura, K., Kato, H., Yasutomi, T., & Momose, T. (2010). Current concepts of carpal tunnel syndrome: pathophysiology, treatment, and evaluation. Journal of Orthopaedic Science, 15(1), 1-13.

Vaıdya, S., & Narıya, D. (2020). Effect of Neural Mobilisation Versus Nerve and Tendon Gliding Exercises in Carpal Tunnel Syndrome: A Randomised Clinical Trial. Journal of Clinical & Diagnostic Research, 14(6)

Wang, C. J. (2012). Extracorporeal shockwave therapy in musculoskeletal disorders. Journal of orthopaedic surgery and research, 7, 1-8.

Wipperman, J., & Goerl, K. (2016). Carpal tunnel syndrom: diagnosis and management. American family physician, 94(12), 993-999.

Wulandari, R., & Ariyanto, A. (2024). Giving nerve and tendon gliding exercises to reduce pain in carpal tunnel syndrome. Physical Therapy Journal of Indonesia, 5(1), 29-31.

Xu, D., Ma, W., Jiang, W., Hu, X., Jiang, F., Mao, C., & Gan, K. (2020). A randomized controlled trial: comparing extracorporeal shock wave therapy versus local corticosteroid injection for the treatment of carpal tunnel syndrome. International Orthopaedics, 44, 141-146.

Ying, L. Y., & Singh, K. (2022). The Effect Of Nerve Gliding Exercise To Improve Range Of Motion And Grip Strength In Hand Exercise Program. Journal of Positive School Psychology, 6(3), 4047-4057. (Ying & Singh,2022)

Zinnuroğlu, M. (2017). D10. Kinezyobantlama tarihçesi, kullanım alanları ve literatür bilgiler eşliğinde kas iskelet system problemlerinde etkinliği.