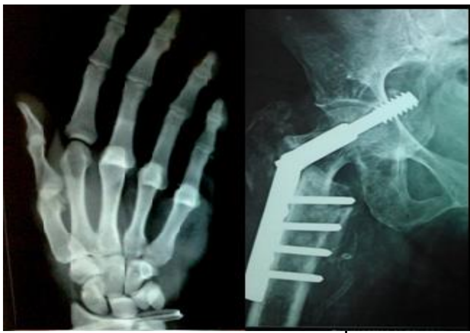
International Journal of Orthopaedics Sciences 2023; 9(2): 352-357



International Journal of Orthopaedics Sciences

E-ISSN: 2395-1958
P-ISSN: 2706-6630
IJOS 2023; 9(2): 352-357

https://www.orthopaper.com
Received: 18-02-2023
Accepted: 22-03-2023

Christina Tservinioti
PT, Physical Therapy Department, International Hellenic University, Greece

Evgenia Trevlaki
MSc, Academic Scholar, Physical Therapy Department, International Hellenic University, Greece

Anna Chalkia
Ph.D, Assistance Professor, Physical Therapy Department, International Hellenic University, Greece

Emmanouil Trevlakis
Ph.D, Scientific Laboratory Associate, Physical therapy Department, International Hellenic University, Greece

Corresponding Author:
Christina Tservinioti
PT, Physical Therapy Department, International Hellenic University, Greece

The efficacy of physical therapy interventions in carpal tunnel syndrome: A narrative review

Christina Tservinioti, Evgenia Trevlaki, Anna Chalkia, Emmanouil Trevlakis

DOI: https://doi.org/10.22271/ortho.2023.v9.i2e.3389

Abstract

Background: The medical condition known as carpal tunnel syndrome (CTS) occurs when the median nerve at the wrist joint is being compressed and is the most frequent form of nerve entrapment-related peripheral neuropathy. The purpose of the present review was to examine the evidence that was available on the clinical benefits of various treatments for CTS.
Method: Electronic research was conducted in Google Scholar, Pub Med, and Springer Link, in English and Greek language. Randomized controlled studies in either English or Greek language were included in the review, and there was no limitation to the publication date. The trials were required to focus on CTS and include the use of physical therapy, electrotherapy, or rehabilitation as key interventions.
Results: 10 studies each comparing a different treatment modality with either a control or alternative treatment, conducted by various authors, and published in different journals were included. The studies evaluated the performance of radial shock wave therapy, pulsed radiofrequency, interferential current therapy, transcutaneous electrical nerve stimulation, high-intensity Laser, low-level laser therapy, manual therapy, and extracorporeal shockwave therapy. The primary outcomes assessed in the studies were pain, electrophysiological parameters, and functional improvement.
Conclusions: The implementation of a physiotherapy program appears to be advantageous to the rehabilitation of CTS patients. Ultrasound-guided pulsed radiofrequency, radial shock wave therapy, interferential current therapy, and Laser therapy were associated with greater improvement in symptoms than TENS. Manual Therapy techniques have a greater impact on pain reduction and patients' functional capacity when compared to all the above electrotherapy approaches.

Keywords: Carpal tunnel syndrome, physical therapy, electrotherapy, rehabilitation

Introduction

Carpal Tunnel Syndrome (CTS), one of the most prevalent nerve entrapment disorders, describes the case when the median nerve is compressed inside the tunnel that runs through the wrist, known as the carpal tunnel [1-3]. According to statistics, 2.7/1000 of the worldwide population suffers from CTS [4]. The predicted incidence in the entire population ranges from one to five percent, and women are at greater risk to experience the syndrome (0.7 to 9.2%) than men (0.4 to 2.1%) [5].

The clinical signs and symptoms include hand irritation, and tingling sensations on the palmar side of the thumb, the index and middle fingers, and the radial half of the ring finger. In addition, there are references to a decrease in thumb abduction and opposition, as well as in the ability to grip and general hand functionality [6]. It is a frequent phenomenon that individuals who suffer from CTS develop symptoms in various areas of the hand, either directly stimulated by the median nerve or not [7]. The syndrome's indications tend to be more severe at night, as 77% of the individuals who were diagnosed with CTS by electromyogram (EMG) described an overnight sensation of numbness or tingling [8-10-36]. It is more prevalent in women than in men, especially during pregnancy, which indicates that hormonal variables have a crucial role in its progression [11]. Some of the warning factors, including gender, age, genetic and anthropometric characteristics, such as carpal tunnel size, have been linked to idiopathic syndrome [12]. Obesity [14-15], along with diabetes [13], are two further indicators of risk. CTS is also linked to genetic factors, rheumatoid arthritis, distal radius fracture, and wrist osteoarthritis [16-18].

The pathophysiology is characterized by mechanical trauma, higher blood pressure, and ischemic nerve injury inside the area of the carpal tunnel [19-20]. According to reports, the normal carpal tunnel pressure lies between 2 and 10 mm/Hg. Various pathological changes that occur in the ligaments surrounding the nerves, including changes in the amount and flexibility of connective tissue, are believed to underlie increased pressure, which is believed to result in ischemic compression of the median nerve [21-33]. Most CTS cases lack a readily apparent explanation (idiopathic syndrome) [22].

Patient's discomfort and symptom intensity assessments, functional status scales, and objective grip strength tests are only some of the clinical and neurophysiologic outcome indicators used to evaluate the effectiveness of therapy. This is possible through the use of dynamometers, sensory and motor nerve conduction measurements, and ultra sonographical assessments [23-24].

The goal of this study is to evaluate the currently accessible literature on the success rate of multiple treatment options for the management of CTS. In more detail, the study aims to provide a comprehensive and evidence-based understanding of the available interventions for this syndrome, which can inform clinical decision-making and guide the development of future treatment protocols.

Methods

Study protocol

The review was conducted following the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) reporting guideline, which provides a checklist and diagram to ensure comprehensive and transparent reporting of the review process [25].

Data sources and eligibility criteria

The search for article sources was carried out in Google Scholar, Pub Med, and Springer Link. To be included in the study, randomized controlled trials conducted in either English or Greek language without any publication date restriction were considered. The trials were required to focus on CTS and include the use of physical therapy, electrotherapy, or rehabilitation as key interventions. The aforementioned keywords were utilized during the search process.

Study selection

He eligibility screening process for the included studies was performed by two independent reviewers, Ev.T. and C.T., using a standardized and blinded approach. Initially, titles and abstracts were screened to identify relevant articles, and any duplicate publications were removed. Subsequently, full paper copies were obtained for further screening. The full-text screening was also conducted in a blinded manner by the same reviewers (Ev.T. and C.T.). In the event of any disagreements between the two reviewers, a third reviewer (Em.T.) was consulted to facilitate a consensus decision.

Data extraction

Data extraction was conducted following the PRISMA guidelines. After removing duplicates and conducting a full-text review, a total of 10 unique studies were deemed eligible and included in the review. The extracted data from these studies are presented in detail in Table 1, including information on study design, sample size, intervention, outcome measures, and results.

Results

In research supervised by Chen *et al*. [26], the efficacy of ultrasound-guided pulsed radiofrequency (PRF) in patients with CTS was examined. Forty-four patients were separated into intervention and control groups at random. The treatment of the first group consisted of PRF and a night splint, while the patients of the second group were only given a night splint. The measurable values involved VAS, BCTQ, CSA, SNCV, and FP. The diagnostic tests, which were done at 1, 4, 8, and 12 weeks after therapy, showed significant enhancements in all values in the intervention sample.

Ke *et al*. [5] research examined the way individuals with CTS responded to radial shock wave treatment. Sixty-nine patients whose symptoms were evaluated to range from mild to moderate were randomly assigned into 3 groups. Patients in the first group completed one radial shock wave treatment course each week, while the second (Control group) completed one course of sham treatment (placebo) each week, for 3 weeks in a row. Patients in the last group underwent only one course of shock wave therapy. Finally, everyone who participated in the study used the night splint. The assessments consisted of the BCTQ, sensory nerve conduction velocity, and median nerve cross-sectional area, and they were measured after 4, 10, and 14 weeks following the initial course. Results revealed that the third-session group was linked to significant improvements in the BCTQ (in contrast with the control group) and that this impact was significantly greater in people who suffered from moderate symptoms of CTS. As for the effect of the single shock wave therapy session, it showed no significant differences.

Meanwhile, the study by Koca *et al*. [27] compared interferential current therapy (IFC) with transcutaneous electrical nerve stimulation (TENS), and the use of splint in handling CTS. Three therapy groups were formed at random from the patients who participated in the study: splint (for 3 weeks), TENS, and IFC therapy group. TENS and ICF interventions were performed five times weekly until 15 courses were completed. The effectiveness of each treatment was assessed before, and 3 weeks after the intervention, by using VAS, BCTQ, mMDL, and mSNCV. Between TENS and splint treatment the enhancements of the clinical scores did not vary significantly. However, IFC treatment resulted in higher VAS, mMDL, and mSNCV improvement values than the simple use of a splint. Between IFC and TENS, the first intervention was linked to greater outcomes in symptoms, functional capacity, mMDL, and mSNCV values.

Casale *et al*. [28] in their randomized controlled trial compared the results of laser therapy with TENS when it comes to ameliorating pain, paresthesia, and the motor and sensory characteristics of the involved nerve in mild to moderate type of syndrome. Twenty individuals diagnosed with CTS were separated into two teams; the first one completed 15 sessions of TENS (100 Hz) and the second 15 sessions of Laser (830-1064 nm) treatment. Pain and paresthesia were assessed by VAS, mMDL, and SNCV. VAS-pain presented an improvement in Laser treatment (decrease=2.1, $p=0.024$) and a borderline improvement in TENS treatment (decrease=0.4, $p=0.047$). DML demonstrated an important advancement in the Laser team (decrease=0.3, $p=0.028$) and remained unchanged in the TENS team ($p=0.15$). SNCV had a noteworthy improvement in the Laser team (increase=3, $p=0.014$) and a non-significant change in the TENS team ($p=0.063$). Results revealed that Laser treatment improved patients' sensory symptoms, while TENS was only linked to pain reduction.

Dakowicz *et al*. [29] performed a randomized controlled trial in which they analyzed the long-lasting outcomes of two intervention methods in the treatment process of individuals with CTS. The therapeutic methods were low-level laser therapy (LLLT) and pulsed magnetic field (PMF). Thirty-eight participants were parted into 2 teams at random; the first one (18 patients) received LLLT while the second one (20 patients) was treated with PMF. The clinical evaluation consisted of functional tests (Phalen, Tinel), the sensation of paresthesia, the experience of both day and night pain, and the intensity of pain determined by the VAS. The evaluations were performed before treatment, after the completion of 10 courses, after a two-week pause in which no treatments were taking place, after the subsequent set of 10 courses, and six months following these final courses. The outcomes showed that post-LLLT treatment, day and night pain considerably decreased at all stages including the 6 months that followed the final set of courses. In addition, in the PMF team, the pain decreased remarkably only after the last courses. Although improvement in Phalen's symptoms was observed in all the patients, only the first team showed a noticeable change. Finally, at every step of the interventions, both groups showed an important reduction in the level of pain.

Another original research that evaluated the impact of LLLT in CTS was performed by Tezcan *et al*. [30]. Specifically, the role of LLLT in median nerve stiffness by using ultrasound elastography was examined. Thirty-four participants experiencing either mild or moderate CTS symptoms were placed into the control team (17 patients who were provided with a wrist splint for 3 weeks), or the treatment team (17 patients who received a combination of a splint and Laser treatment, 5 times a day for 3 weeks). The evaluation tools were SSS, FSS, cross-sectional area, and strain ratio (by elastography). The results showed a greater improvement in the intervention team, as the statistics included a 36% decrease in the level of pain (VAS) and a 19% increase in FP strength (intervention treatment).

In Wolny *et al*. [31] randomized controlled trial, the role of manual therapy (MT) was investigated in comparison with electrotherapy techniques in patients with mild and moderate CTS. One hundred and forty individuals were parted to either the MT or the electrotherapy team. The first contained neurodynamic techniques, functional massage, and wrist mobilization techniques, while the second consisted of LASER and ultrasound therapy. Median nerve conduction, pain and symptom intensity, and functionality determined by the BCTQ were tested not only in advance but also post-therapy. Both groups received 2 weekly courses until 20 courses were completed. The findings demonstrated that although both treatments improved the patients' nerve conduction, pain level, and functional capacity, the MT group's corresponding values were superior.

Pratelli *et al*. [32] performed a clinical trial to examine the effects of fascial manipulation (FM) and low-level LASER therapy on CTS. Forty-two diagnosed individuals participated in the trial and were randomly divided into the FM session team or the LLLT team. The patients received the VAS and the BCTQ at the beginning, end, and three months following the intervention. According to the study's findings, not only at the final stage of therapy but also during the follow-up period, the team receiving FM demonstrated a significant decrease in subjective pain perception and a gain in functionality. The BCTQ scores of the LLLT team upgraded after the therapy, but that improvement was not maintained after three months.

Huisstede *et al*. [33] conducted a systematic review in which the role of certain electrotherapy techniques compared to other physical therapy techniques in CTS was studied. In the review were included two reviews and twenty-two clinical trials. The interventions studied were deep tissue massage, ischemic compression, low-level LASER therapy, pulsed radiofrequency, radial shock wave therapy, short-wave diathermy, TENS, iontophoresis, phonophoresis, and the use of wrist splint. Due to the heterogeneity of the treatment parameters used in the included studies, it was not possible for the short- and long-term effects of the various physical therapy interventions to be determined and compared.

Kim *et al*. [34] also performed a systematic review, in which the effectiveness of extracorporeal shockwave therapy in improving symptoms, functionality, and electrophysiological parameters in patients with CTS was examined. The review included six randomized clinical trials with 281 participants, randomly divided into intervention (shockwave therapy sessions) and control groups. The researchers concluded that this specific treatment had a positive effect on the patient's symptoms, functional capacity, and electrophysiological (motor and sensory) parameters after a follow-up period of 12 to 24 weeks.

Table 1: Studies included in the review

Authors, years	Sample	Assessment tools	Results
Chen *et al.*, 2015	N=44	VAS, BCTQ, CSA, SNCV, FP	• 36% decrease in pain intensity (VAS score) • 19% increase in FP strength (intervention treatment)
Ke *et al.*, 2016	N=69	BCTQ, SNCV, CSA	• Great improvement in BCTQ and CSA values in week 14 in team A when compared with team C. • No remarkable change in the BCTQ scores (intensity or functionality) between teams B and C.
Koca *et al.*, 2014	N=75	SSS, VAS, BCTQ, mMDL, mSNCV	• No remarkable change between TENS and splint therapy in clinical values (p>0.05). • IFC therapy had greater scores in VAS, mMDL, and mSNCV than in splint therapy. • IFC therapy was linked to better VAS, SSS, BVTQ (functional capacity), mMDL, and mSNCV values compared to TENS therapy.
Casale *et al.*, 2012	N=20	VAS, mMDL, SNCV	• VAS-pain had an improvement in Laser treatment (decrease=2.1, p=0.024) and a borderline improvement in TENS treatment (decrease=0.4, p=0.047). • DML was linked to a better outcome in the Laser team (decrease=0.3, p=0.028) and remained unchanged in the TENS team (p=0.15). • SNCV had a significant improvement in the Laser team (increase=3, p=0.014) and a non-remarkable change in the TENS team (p=0.063).
Dakowicz *et al.*, 2011	N=38	VAS	• VAS: In both teams was shown a noteworthy improvement in pain severity after every set of interventions and six months after the final set ($p<0.05$).
Tezcan *et*	N=34	SSS, FSS, CSA	• SR, CSA, SSS, and FSS decreased remarkably after laser therapy ($p<0.001$) contrary to the control

al., 2019		SR	team.
Wolny *et al.*, 2017	N=140	BCTQ, SNCV, SSS, FSS	• Pain decrease level; 290% for the MT and 47% for the EM team. • FFS: improvement of 47% in the MT and 9% in the EM team. • SNCV: 34% faster in the MT, the EM team showed a nonsignificant 3% increase in speed.
Pratelli *et al.*, 2016	N=42	VAS, BCTQ, SSS, FSS	• FM treatment: great improvement between T0 and T1 and between T1 and T2, in BTCQ and VAS ($P<0.0001$). • LLLT treatment: great improvement between T0 and T1 ($p<0.001$) and decrease between T1 and T2.
Huisstede *et al.*, 2018	2 reviews and 22 RCTs		• The ideal treatment parameters could not be found due to the diversity in the intervention parameters utilized in the included RCTs.
Kim *et al.*, 2019	N=281	BCTQ, DASH, electrophysiologic parameters: DML, SNAP amplitude, SNCV	• Great improvement in symptoms, functionality, and electrophysiologic characteristics with ESWT treatment. • No remarkable change was observed when the impact of ESWT and local corticosteroid injections were compared.

DASH = Disabilities of the Arm, Shoulder, and Hand, SNAP = Sensory nerve action potential, SR = Strain ratio, VAS = visual analog scale, BCTQ = Boston Carpal Tunnel Syndrome Questionnaire, CSA = median nerve cross-sectional area, SNCV = sensory nerve conduction velocity, FP = finger strength, mMDL = mean motor distal latency, mSNCV = mean sensory nerve conduction velocity, SSS = Symptom severity scale, FSS = functional status score.

Discussion

The studies listed above all investigate the efficacy of physical therapy approaches in managing CTS. In total, there are 10 studies each comparing a different treatment modality with either a control or alternative treatment, conducted by various authors, and published in different journals. The studies evaluated the effectiveness of radial shock wave therapy, pulsed radiofrequency, interferential current therapy, transcutaneous electrical nerve stimulation, high-intensity LASER, low-level laser therapy, manual therapy, and extracorporeal shockwave therapy. The primary outcomes assessed in the studies were pain, electrophysiological parameters, and functional improvement.

According to the findings of this review, there are plenty of physiotherapy techniques that seem to benefit patients who experience mild to moderate symptoms of CTS during their rehabilitation. Regarding electrotherapy, there is evidence that ultrasound-guided pulsed radiofrequency is a successful therapeutic approach for the relief of CTS symptoms [26]. Radial shock wave therapy (over 3 sessions) is linked to great improvements in signs and symptoms, functionality, and electrophysiological features [5, 27].

The findings also demonstrated that IFC present superior results to TENS and was associated with greater improvement in symptoms, functional capacity, and mMDL and mSNCV values [27]. It is also known that the combined high-intensity Laser (830 nm and 1064 nm) is superior to TENS, as it is linked to better results in improving pain, paresthesia, and neurophysiological parameters [28]. Regarding low-frequency Laser therapy, results have shown that it contributes to nerve regeneration and improves vascular supply by reducing the cross-sectional area of the median nerve [29].

Meanwhile, the comparison of different electrotherapy forms (Laser, ultrasound) with MT techniques has shown that although both interventions contribute to nerve conduction, MT techniques are superior in reducing pain and improving patients' functional capacity [31]. Finally, there is evidence that LLLT contributes to the immediate treatment of the symptoms of the syndrome, while the positive effects have no long duration [37, 39].

Limitations

Despite the significant findings, this systematic review is not without limitations. Firstly, the sample size of the included studies was relatively small, and only a few studies had long-term follow-up periods. Additionally, there was substantial heterogeneity among the studies in terms of interventions, outcome measures, and follow-up periods, which makes it difficult to draw definitive conclusions. Finally, the publication bias could not be ruled out, as the included studies were limited to those published in English, which could have excluded some relevant studies.

Conclusion

The current research intended was to describe and analyze the influence of various physical therapy techniques on patients with CTS. According to the results, certain types of electrotherapies are superior compared to other types and techniques. More specifically, ultrasound-guided pulsed radiofrequency, radial shock wave therapy, interferential current therapy, and Laser therapy were associated with greater improvement in symptoms than TENS. While Manual Therapy techniques have a greater impact on pain reduction and patient’s functional capacity when compared to all the above electrotherapy approaches.

Future research ought to prioritize larger sample sizes and long-term follow-up periods to augment the statistical power and broad applicability of the findings. Additionally, forthcoming studies should contemplate the implementation of more stringent research designs, such as double-blinded, randomized controlled trials, to mitigate the potential for bias. Furthermore, emphasis should be placed on delving into the optimal dosage, timing, and duration of interventions, while concurrently exploring the underlying mechanisms that contribute to the effectiveness of said interventions. Lastly, future research endeavors should strive to ascertain the potential advantages of amalgamating different interventions, and assess the cost-effectiveness of said interventions in the treatment of CTS.

Conflict of interest

The authors declare no conflict of interest.

References

1. Tascioglu F, Degirmenci N, Ozkan S, Mehmetoglu O. Low-level laser in the treatment of carpal tunnel syndrome: Clinical, electrophysiological, and ultrasonographical evaluation. Rheumatology International. 2012;32:409–415.
2. Wipperman J, Goerl K. Diagnosis and Management of Carpal Tunnel Syndrome. 2016, 94. www.aafp.org/afp. Accessed March 27, 2021.

3. Lytras D, Sykaras E, Semaltianou E, Myrogiannis IS. Physiotherapy Treatment in Nontraumatic Individual Nerve Entrapment Syndromes of the Brachial Plexus in Athletes: A Clinical Presentation Related to Injury from Sports Activities and Physiotherapy Management Clinical Guidelines. Crit Rev Phys Rehabil Med. 2020;32(4):285-297.
4. Tuppin P, Blotière PO, Weill A, Ricordeau P, Allemand H. Carpal tunnel syndrome surgery in France in 2008: Patients' characteristics and management. Rev. Neurol. 2011;167:905-915.
5. Ke MJ, Chen LC, Chou YC, Li TY, Chu HY, Tsai CK, *et al*. The dose-dependent efficiency of radial shock wave therapy for patients with carpal tunnel syndrome: A prospective, randomized, single-blind, placebo-controlled trial. Sci Rep [Internet]. 2016 Dec 2 [cited 2023 Jan 17];6. Available from: https://pubmed.ncbi.nlm.nih.gov/27910920/
6. Wipperman J, Goerl K. Carpal tunnel syndrome: Diagnosis and management. Am. Fam. Physician 2016, 94, 993–999.
7. Burton C, Chesterton L, Davenport G. Diagnosing and managing carpal tunnel syndrome in primary care. Br. J. Gen. Pr. 2014;64:262–263.
8. Fernández-de-las-peñas C, Arias-Buría JL, Ortega-Santiago R, De-la-Llave-Rincón AI. sensitization for advances in management of carpal tunnel syndrome [version 1; peer review: 3 approved] (F1000 Faculty Rev):605 https://doi.org/10.12688/f1000research.22570.1
9. Mccabe SJ. Diagnosisofcarpal tunnelsyndrome. J Hand Surg Am. 2010;35(4):646–8.
10. Katz JN, Larson MG, Sabra A, Krarup C, Atirrat CR, Sethi R, et al. The carpal tunnel syndrome: diagnostic utility of the history and physical examination findings. Ann Intern Med. 1990;112(5):3217.
11. Wainner RS, Fritz JM, Irrgang JJ, Delitto A, Allison S, Boninger ML. Development of a clinical prediction rule for the diagnosis of carpal tunnel syndrome. Arch Phys Med Rehabil. 2005;86(4):60918.
12. Aboonq MS. Pathophysiology of carpal tunnel syndrome [Internet]. Vol. 20, Neurosciences. 2015. Available from: www.neurosciencesjournal.org
13. Karjalanen T, Raatikainen S, Jaatinen K, Lusa V. Update on Efficacy of Conservative Treatments for Carpal Tunnel Syndrome. J. Clin. Med. 2022;11:950. https://doi.org/10.3390/jcm11040950
14. Pourmemari MH, Shiri R. Diabetes as a Risk Factor for Carpal Tunnel Syndrome: A Systematic Review and Meta-Analysis. Diabet. Med. 2016;33:10–16.
15. Mi J, Liu Z. Obesity, Type 2 Diabetes, and the Risk of Carpal Tunnel Syndrome: A Two-Sample Mendelian Randomization Study. Front. Genet. 2021;12:1119.
16. Stallings SP, Kasdan ML, Soergel TM, Corwin HM. A Case-Control Study of Obesity as a Risk Factor for Carpal Tunnel Syndrome in a Population of 600 Patients Presenting for Independent Medical Examination. J. Hand Surg. Am. 1997;22:211-215.
17. Geoghegan JM, Clark DI, Bainbridge LC, Smith C, Hubbard R. Risk Factors in Carpal Tunnel Syndrome. J. Hand Surg. Am. 2004;29:315-320.
18. Wiberg A, Ng M, Schmid AB, Smillie RW, Baskozos G, Holmes MV *et al*. A Genome-Wide Association Analysis Identifies 16 Novel Susceptibility Loci for Carpal Tunnel Syndrome. Nat. Commun. 2019;10:1030.
19. Radecki P. The Familial Occurrence of Carpal Tunnel Syndrome. Muscle Nerve. 1994;17:325-330.
20. Padua L, Coraci D, Erra C, Pazzaglia C, Paolasso I, Loreti C, *et al*. Carpal tunnel syndrome: clinical features, diagnosis, and management [Internet]. The Lancet Neurology. Lancet Publishing Group; [cited 2023 Jan 17]. 2016;15:1273-84. Available from: https://pubmed.ncbi.nlm.nih.gov/27751557/
21. Huntley DE, Shannon SA. Carpal tunnel syndrome: a review of the literature. [Internet]. Vol. 62, Dental hygiene. [cited 2023 Jan 17]. 1988;62:316-20. Available from: https://pubmed.ncbi.nlm.nih.gov/32313774/
22. Werner RA, Andary M. Carpal tunnel syndrome: Pathophysiology and clinical neurophysiology [Internet]. Vol. 113, Clinical Neurophysiology. [cited 2023 Jan 17]. 2002;113:1373-81. Available from: https://pubmed.ncbi.nlm.nih.gov/12169318/
23. Newington L, Harris EC, Walker-Bone K. Carpal tunnel syndrome and work [Internet]. Vol. 29, Best Practice and Research: Clinical Rheumatology. Bailliere Tindall Ltd; [cited 2023 Jan 17]. 2015;29:440-53. Available from: https://pubmed.ncbi.nlm.nih.gov/26612240/
24. Abid Ali S, Ja'afar I, Hasan Z. Effectiveness of low-level laser in the treatment of carpal tunnel syndrome. Journal of the Faculty of Medicine, Baghdad. 2012;54:234-237.
25. Tascioglu F, Degirmenci N, Ozkan S, Mehmetoglu O. Low-level laser in the treatment of carpal tunnel syndrome: Clinical, electrophysiological, and ultrasonographical evaluation. Rheumatology International. 2012;32:409-415.
26. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. J Clin Epidemiol. 2009;62(10):1006-1012. doi: 10.1016/j.jclinepi.2009.06.005. PMID: 19545476.
27. Chen LC, Ho CW, Sun CH, Lee JT, Li TY, Shih FM, *et al*. Ultrasound-guided pulsed radiofrequency for carpal tunnel syndrome: A single-blinded randomized controlled study. PLoS One [Internet]. 2015 Jun 12 [cited 2023 Jan 17]. 2015, 10(6). Available from: https://pubmed.ncbi.nlm.nih.gov/26067628/
28. Koca I, Boyaci A, Tutoglu A, Ucar M, Kocaturk O. Assessment of the effectiveness of interferential current therapy and TENS in the management of carpal tunnel syndrome: a randomized controlled study. Rheumatol Int. [Internet]. Dec 1 [cited 2023 Jan 17]. 2014;34(12):1639-45. Available from: https://pubmed.ncbi.nlm.nih.gov/24728028/
29. Casale R, Damiani C, Maestri R, Wells CD. Pain and electrophysiological parameters are improved by combined 830-1064 high-intensity LASER in symptomatic carpal tunnel syndrome versus Transcutaneous Electrical Nerve Stimulation. A randomized controlled study. Eur J Phys Rehabil Med [Internet]. [cited 2023 Jan 17]. 2012;49(2):205-11. Available from: https://pubmed.ncbi.nlm.nih.gov/22820819/
30. Dakowicz A, Kuryliszyn-Moskal A, Kosztyła-Hojna B, Moskal D, Latosiewicz R. Comparison of the long-term effectiveness of physiotherapy programs with low-level laser therapy and pulsed magnetic field in patients with carpal tunnel syndrome. Adv Med Sci [Internet]. [cited 2023 Jan 17]. 2011;56(2):270-4. Available from: https://pubmed.ncbi.nlm.nih.gov/22037175/
31. Tezcan S, Ozturk FU, Uslu N, Nalbant M, Yemisci OU. Carpal tunnel syndrome: Evaluation of the effects of low-

level laser therapy with ultrasound strain imaging. Journal of Ultrasound in Medicine [Internet]. [cited 2023 Jan 17]. 2019;38(1):113–22. Available from: https://pubmed.ncbi.nlm.nih.gov/29892976/
32. Wolny T, Saulicz E, Linek P, Shacklock M, Myśliwiec A. Efficacy of Manual Therapy Including Neurodynamic Techniques for the Treatment of Carpal Tunnel Syndrome: A Randomized Controlled Trial. J Manipulative Physiol Ther [Internet]. [cited 2023 Jan 17]. 2017;40(4):263–72. Available from: httpa://pubmed.ncbi.nlm.nih.gov/28395984/
33. Pratelli E, Pintucci M, Cultrera P, Baldini E, Stecco A, Petrocelli A, *et al*. Conservative treatment of carpal tunnel syndrome: comparison between laser therapy and Fascial Manipulation(®). J Bodyw Mov Ther [Internet]. [cited 2023 Jan 17]. 2015;(1):113-8. Available from: https://pubmed.ncbi.nlm.nih.gov/25603750/
34. Huisstede B, Hoogvliet P, Franke T, Randsdorp M, Koes B. Carpal Tunnel Syndrome: Effectiveness of Physical Therapy and Electrophysical Modalities. An Updated Systematic Review of Randomized Controlled Trials. Archieves of Physical Medicine and Rehabilitation [Internet]. [cited 2023 Jan 17]. 2018;99(8):1623–34. Available from: https://pubmed.ncbi.nlm.nih.gov/28942118/
35. Kim JC, Jung SH, Lee SU, Lee SY. Effect of extracorporeal shockwave therapy on carpal tunnel syndrome: A systematic review and meta-analysis of randomized controlled trials. Medicine (United States) [Internet]. [cited 2023 Jan 17]. 2019;98(33). Available from: https://pubmed.ncbi.nlm.nih.gov/31415424
36. Pratelli E, Pintucci M, Cultrera P, Baldini E, Stecco A, Petroncelli A. Conservative treatment of carpal tunnel syndrome: Comparison between laser therapy and Fascial Manipulation®", Journal of Bodywork and Movement Therapies [Internet]. [cited 2023 Jan 17]. 2016;20(1):151 – 152. Available from: https://www.bodyworkmovementtherapies.com/article/S1360-8592(15)00200-4/fulltext
37. Ostergaard PJ, Meyer MA, Earp BE. Non-operative Treatment of Carpal Tunnel Syndrome. Curr Rev Musculoskelet Med [Internet]. [cited 2023 Jan 17]. 2020;13(2):141-147. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC717446/
38. Erickson M, Lawrence M, Jansen S, Coker D, Amadio P, Cleary C. Hand Pain and Sensory Deficits: Carpal Tunnel Syndrome. The Journal of orthopaedic and sports physical therapy [Internet]. [cited 2023 Jan 17]. 2019;49(5), CPG1–CPG85. Available from: https://pubmed.ncbi.nlm.nih.gov/31039690/