Research Paper

Study Protocol for a Randomized Trial Comparing Tendon and Nerve Glide in Carpal Tunnel Syndrome Rehabilitation

Azadeh Fassaii[1], Somayeh Mohamadi[1*], Samaneh Hossein Zadeh[1], Mosleheddin Adibhesami[1]

1. Department of Physiotherapy, School of Rehabilitation, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran.

Use your device to scan and read the article online

Citation Fassaii A, Mohamadi S, Hossein Zadeh S, Adibhesami M. Study Protocol for a Randomized Trial Comparing Tendon and Nerve Glide in Carpal Tunnel Syndrome Rehabilitation. Physical Treatments. 2025; 15(1):59-68. http://dx.doi.org/10.32598/ptj.15.1.473.1

http://dx.doi.org/10.32598/ptj.15.1.473.1

Article info:
Received: 13 May 2024
Accepted: 17 Aug 2024
Available Online: 01 Jan 2025

Keywords:
Carpal tunnel syndrome (CTS), Nerve glide, Tendon glide, Exercise, Rehabilitation, Electrodiagnosis

ABSTRACT

Purpose: Carpal tunnel syndrome (CTS) is one of the most common neuropathies. Among the treatment modalities, exercise therapy, in addition to its therapeutic effects, does not require continuous clinic visits or a therapist's constant presence, saving the patient time and money. Accordingly, this study compares two models of therapeutic exercises, including nerve glide and tendon glide.

Methods: The participants were divided into two random groups (n=25 in each group). The first group received ultrasound and nerve gliding exercises; the second group received ultrasound and tendon gliding exercises. The treatment lasted 8 weeks (2 times weekly) and the participants conducted the exercises at home under supervision. Before and after the intervention, a visual analog scale (VAS), Boston questionnaire, dynamometer measures, and electro-diagnostic tests were done in both groups.

Results: Regarding the effects of the neural and tendon gliding techniques, there are contradictory findings in the studies, often due to the lack of standardized study protocols and the absence of gold-standard outcome measures.

Conclusion: With the establishment of standardized protocols and the use of reliable and practical outcome measures in the current study, doing exercises at home and having a follow-up to assess the sustainability of treatment effects, neural gliding may be more effective in the treatment of CTS, considering the nature of the injury.

*** Corresponding Author:**
Somayeh Mohamadi, Assistant Professor.
Address: *Department of Physiotherapy, School of Rehabilitation, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran.*
Phone: *+98 (912) 0616287*
E-mail: *mohamadisomayeh951@gmail.com*

Highlights

- The results of this study help us understand whether tendon gliding exercises or nerve gliding exercises are more effective for treating carpal tunnel syndrome (CTS).

- This study helps select a more appropriate treatment for patients with CTS, leading to better and faster outcomes with less time and cost investment.

- Using the results of this study, we determine which of the tendon gliding and nerve gliding exercises has a longer-lasting effect in the treatment of CTS.

Plain Language Summary

This study focuses on investigating and comparing the effects of two common therapeutic exercises in patients with CTS. The goal is to achieve the most sustainable and irreversible rehabilitation outcomes with minimal time and cost investment, benefiting the therapist and the patient. To accomplish this, we randomly selected two groups of patients with CTS. One group received ultrasound therapy (for pain and inflammation reduction) along with nerve gliding exercises, while the other group received the same ultrasound therapy along with tendon gliding exercises. We compared these two groups in terms of pain, functional ability, and results of standard diagnostic tests. Additionally, we assessed the long-term effects of their interventions. Accordingly, this study informs clinical decision-making for the treatment of patients with CTS.

Introduction

Carpal tunnel syndrome (CTS) is a mononeuropathy resulting from the compression of the median nerve within the confined space of the wrist bones and transverse carpal ligament [1, 2]. CTS is a costly complication that significantly diminishes an individual's quality of life [3]. Accounting for 90% of neuropathy complications, this syndrome has various symptoms, such as numbness, tingling in the hand, hand and wrist pain, and muscle dysfunction [4]. These sensory and motor impairments can disrupt various daily activities, such as buttoning clothes, holding a book while reading, or handling a phone [5]. Females aged 40 to 60 years are more susceptible to CTS compared to males, primarily due to having a smaller carpal tunnel [2, 6].

The treatment of CTS is typically categorized into surgical and conservative approaches. Surgical intervention is recommended for severe cases, while conservative treatments are suggested for mild to moderate instances [7]. Common conservative treatments include various anti-inflammatory medications, orthoses, transcutaneous electrical nerve stimulation, low-level laser therapy, ultrasound, shockwave therapy, magnet therapy, iontophoresis, manipulation, mobilization, and specific exercises [8, 9].

Although previous studies have shown the positive impact of physiotherapy treatment programs in alleviating pain and improving symptoms among patients with CTS, the effects of two distinct types of therapeutic exercises, namely tendon glide and nerve glide, on both valid and reliable subjective and objective outcomes measures, including visual analog scale (VAS) and Boston questionnaire, electrodiagnostic test parameters and functional measures have yet to be explored. Among the spectrum of available therapeutic modalities, according to studies, the efficacy and effectiveness of therapeutic exercise in CTS have been demonstrated [10]. Furthermore, the specific effects of nerve and tendon gliding exercises have been investigated and compared together in limited studies [8, 11-13]. Some of these studies lack a standardized protocol, blinding and appropriate control group, or have not utilized valid and practical outcome measures or gold standard assessments. Additionally, they have not included home exercises or follow-up for investigating long-term sustainability of the result. Accordingly, considering the existing research gaps, examining these two therapeutic exercise methods under a standard and comprehensive protocol could help clarify the actual effects of these two common treatment approaches.

To the best of our knowledge, this is the first study to compare the effects of nerve glide and tendon glide using a standardized protocol, including home exercises and follow-up, to assess the long-term sustainability of treatment effects with valid objective and subjective outcome measures.

Materials and Methods

Study design

Following the approval of the research proposal at the University of Social Welfare and Rehabilitation Sciences and obtaining ethical clearance from the university's Ethics Committee, we were authorized to conduct the research project at the Rofeydeh Hospital, Iran. During in-person visits to the hospital in 2023, the participants were diagnosed with CTS by neurology or physiatrist specialists.

If the patients met the inclusion criteria, they would sign an informed consent form. Before starting the treatment, the patients completed demographic data and Boston questionnaires. Pain levels were measured using VAS [14, 15]. Meanwhile, hand grip strength was measured by a dynamometer [16, 17]. Furthermore, sensory and motor latency, nerve conduction velocity, and amplitude using electrodiagnostic tests will be assessed by a physician [18, 19].

Following the completion of the initial phase, the first group underwent the treatment with ultrasound therapy and nerve glide exercises, while the second group received ultrasound therapy combined with tendon glide exercises. The sample allocation process was executed through a random lottery mechanism by concealed envelope allocation, conducted by a blinded examiner. The research was carried out at the rehabilitation clinic located within Rofeydeh Hospital, Iran.

Sample size

According to the article by Brininger et al. [20], the standard deviation (SD) of symptom severity scale scores was determined for two groups as SD_1=0.8 and SD_2=0.9, respectively. The mean difference between the two groups was d=0.7. Considering the power of 80% (z=0.85) and a confidence level of 95% (z=1.96), the sample size for each group was calculated at 23, resulting in a total sample size of 46 individuals (Equation 1).

1. $$n = \frac{(z_{1-\beta} + z_{1-\frac{\alpha}{2}})^2(\sigma_1^2 + \sigma_2^2)}{(\mu_1 - \mu_2)^2}$$

This study included individuals with a confirmed diagnosis of CTS based on the following inclusion and exclusion criteria.

Inclusion and exclusion criteria

The inclusion criteria were participants within the age range of 30 to 75 years, including both males and females; individuals diagnosed with CTS by a neurologist or physiatrist through clinical and electrodiagnostic tests; participants who had a positive Fallon and Tinel test [21, 22]. Meanwhile, the exclusion criteria were participants who had previously undergone carpal tunnel surgery; participants who had received corticosteroid injections within the last 6 months or any other treatment within the last 3 months; participants presenting with other neuromuscular problems; participants with immune system defects; pregnant women; and individuals with psychosocial problems.

All eligible patients who were willing to participate in the study formally signed an informed consent form. The participants experiencing an increase in pain during the study were not included [23]. Individuals expressing a desire to withdraw from the study at any stage were excluded [23]. This study has obtained approval from the Medical Ethical Review Board of the University of Social Welfare and Rehabilitation Sciences.

Data collection

The first group initiated their treatment, which consisted of two sessions per week for 8 weeks [11, 24, 25]. The treatment involved the use of ultrasound (215p NOVIN medical engineering company; 0.8 W/cm², 1 MHz, 1:4) for 15 min on the site of the median nerve entrapment beneath the transverse carpal ligament (Figure 1) [26], along with nerve glide exercises.

In these exercises, the patients were instructed to be in a seated position, ensuring relaxation of their proximal muscles, as their capabilities in performing exercises may vary with different arm positions. These exercises included six positions that are described as follows according to Kisner's therapeutic exercises textbook [27]:

1) In the first position, the wrist is maintained in a neutral posture while flexing the thumb and fingers; 2) The second position involves extending the fingers while keeping the thumb in a neutral position; 3) In the third position, both the wrist and fingers are extended, while the thumb remains in a neutral position; 4) For the fourth position, the wrist, fingers and thumb are all in the extended position. 5) The fifth position is a continuation of the fourth, where the forearm is moved into supination; 6) Similar to the fifth position, in the sixth position, the other hand gently stretches the thumb while maintain-

Figure 1. Ultrasound application on median nerve

PHYSICAL TREATMENTS

ing the extended positions of the fingers, wrist, and supinated forearm [24]. Each position will be held for 5 s. [12] and the exercises will be repeated ten times in each session, three times a day, over 8 weeks (Figure 2).

The next group's interventions involved ultrasound and tendon glide exercises. These exercises involve placing the hand in five different positions (Figure 3):

1) Neutral: All finger joints are in a neutral position; 2) Hook: The metacarpophalangeal joints are in extension, while the interphalangeal joints are in full flexion; 3) Full fist: All finger joints are in full flexion; 4) Tabletop: The metacarpophalangeal joint is in a 90-degree flexion position while the interphalangeal joints are in a neutral position; 5) Straight fist: The metacarpophalangeal and interphalangeal joints are in flexion, while the distal interphalangeal joint is in extension.

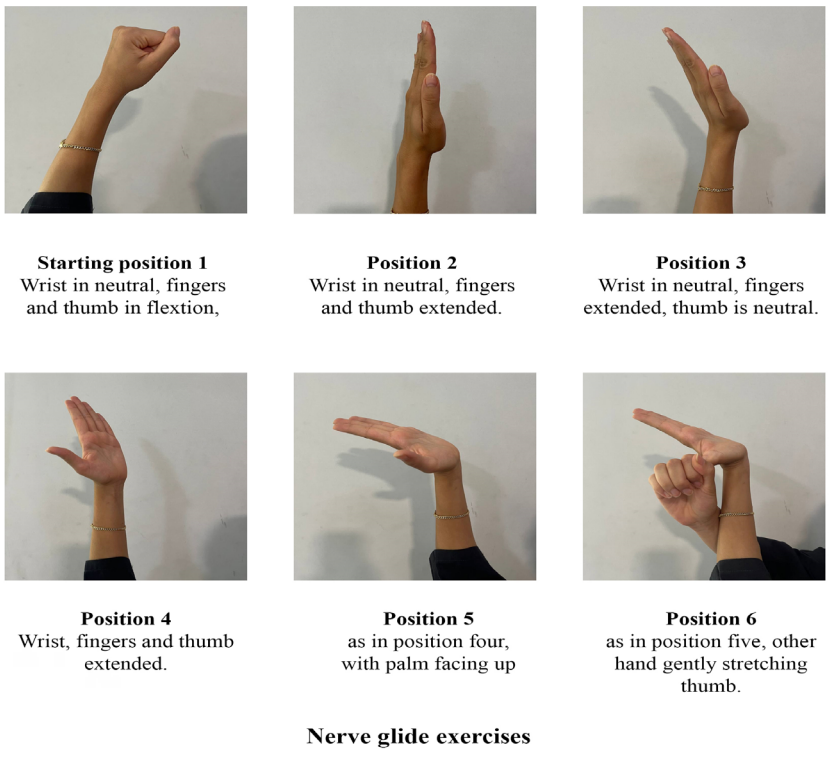

Figure 2. Nerve glide exercises

PHYSICAL TREATMENTS

Figure 3. Tendon glide exercises

PHYSICAL TREATMENTS

The exercises were repeated in the same manner as the first group. After completing the treatment, all tests and assessments were repeated in the final session [17, 28].

Additionally, the patients were instructed to perform these exercises at home, while the participants were monitored by the researcher through phone and video calls. A phone call or video call was made once a day. Three months after completing the study, participants underwent re-testing, and the long-term effects of the interventions were evaluated.

Figure 4. Dynamometer

PHYSICAL TREATMENTS

Outcome measures

To assess the severity of symptoms before and after treatment, various subjective, objective, and functional methods were employed. The assessments included VAS, the Boston questionnaire, dynamometer measurements, and electrodiagnostic tests.

The Boston questionnaire was designed to evaluate the symptoms and functional status of patients with CTS. It consists of two sections, namely the symptom severity scale with 11 questions to assess CTS symptoms and the functional status scale with 8 activities reflecting daily tasks, each question in both subscales, scored from 1 to 5 [29].

Grip strength can be measured by using a dynamometer (SH5000-3 Hydraulic Hand Evaluation Kit, 3pcs). To do that, we adjust it to the index finger's second joint, ensure it reads 0.0 kg/lbs., stand upright, hold it by one's side, squeeze for 4-5 s then relax, repeat twice per hand, record the highest reading, and sum for total score (Figure 4) [17].

The patients rated their pain using VAS, assigning a score from 0 (no pain) to 10 (the most severe imaginable pain) [30].

For definitive diagnosis and determining the severity of CTS, electrodiagnostic tests were employed. These tests involve stimulating the median nerve and recording sensory and motor responses to measure nerve response delay, conduction velocity, and amplitude [31, 32].

Patient flow

This randomized clinical trial had an inclusion period of 12 months and a follow-up of 3 months. The patient recruitment started in January 2023 and ended in December 2023.

Data analysis

For data analysis, IBM SPSS software, version 27 was utilized. The following statistical tests were employed to compare the two groups and assess pre and post-treatment comparisons: Independent sample t-test for comparing means between two independent groups; Mann-Whitney U tests when data distribution was not normal for comparing two independent groups; analysis of covariance for assessing the effectiveness of interventions and comparing them, considering the baseline differences. These statistical analyses are designed to provide in-depth insights into the comparisons and treatment effects observed in the study.

Results

Despite the number of studies conducted on the effects of therapeutic exercises in CTS, the results are contradictory, sometimes due to the lack of a standardized protocol, the absence of blinded evaluators or patients, and the lack of standardized outcome measures and follow-up visits. Some of these studies have limitations, including the following items.

Small sample size: Some studies included a small number of participants, which may limit the applicability of the findings to a broader context [33-36].

Lack of control group: In certain studies, the absence of a control group makes it difficult to assess the true effectiveness of therapeutic exercise compared to other interventions or no treatment [37].

Variability in exercise protocols: The exercise programs used in different studies varied in terms of duration, frequency, and types of exercises, making it challenging to compare the results and draw definitive conclusions [38].

Inconsistency and low validity and reliability of outcome measures: The use of different outcome measures in various studies makes it difficult to compare and synthesize the results [12, 24]. Electromyographic tests, due to their cost and the need for specialist administration, are infrequently used in studies [11, 36, 39].

Lack of blinding: In some studies, the assessors or patients were not blinded to the intervention, which may introduce bias in the evaluation of treatment outcomes [24].

Short follow-up duration or no follow-up: Some studies had a relatively short follow-up period, which may underestimate the long-term effects of therapeutic exercise in CTS [12, 20].

Considering these limitations, further well-designed studies with larger sample sizes, standardized protocols, blinded assessments, and robust outcome measures are needed to better understand the effects of therapeutic exercise in the CTS.

Discussion

Most studies have shown that the therapeutic effects of nerve- glide, and tendon-glide exercises are more significant than other non-invasive treatments [38], In a study by Alam et al. (2018), nerve mobilization therapy showed greater effectiveness in reducing pain and functional limitations compared to ultrasound in patients with CTS [37]. The confirmation of these effects, even in comparison with pharmaceutical treatment has the greater significance and effectiveness of these methods [40-42], In a study by Mohamed et al., median nerve mobilization showed a significant advantage over drug therapy for 28 individuals with CTS, based on Tinel and Phalen tests, the Boston questionnaire, and electroneurodiagnostic tests over six weeks [40]. In another study, Bartkowiak et al. compared ultrasound and low-level laser therapy combined with tendon and nerve gliding in seventy participants. Both groups showed improvement in VAS, Phalen, Tinel tests, dynamometry, and the Boston questionnaire but they did not have gold standard electrodiagnostic tests [24]. In a study conducted by Abdolrazaghi et al. the effect of 6 weeks of nerve glide and tendon glide exercises on the treatment of patients with CTS was investigated by the Boston questionnaire. In this study, no significant difference was observed in the experimental group who were using a splint [12]. The study's reliability depends on participant count and a control group, Meanwhile, in a 2020 study by Kurniawti et al., nerve mobilization and kinesiotaping improved VAS scores in 20 participants with CTS without a control group and gold standard assessment [34].

One similar study to our study was conducted by Horng et al. who studied the effects of tendon and nerve glide exercises on CTS. In this study, 60 participants were divided into three groups as follows: Tendon gliding with paraffin therapy and splint, nerve mobilization with paraffin therapy and splint and a group with paraffin therapy and splint. The Boston questionnaire and nerve conduction velocity were taken from the patients before and after treatment. the results showed that tendon gliding is more effective than nerve mobilization in improving CTS [11]. While we examine additional outcome measures, particularly functional objective tests in addition to subjective and electrodiagnostic ones, implementing double blinding with a larger sample size and incorporating follow-up visits will enhance our study's power. This approach will allow us to speak with greater certainty about the study results, especially given the controversy among similar studies.

Conclusion

This project can lead to more definitive clinical decisions regarding more effective treatments for patients with carpal tunnel syndrome, while saving time and costs.

Study limitations

In the present study, due to the limited time for sampling and the time-consuming nature of the sampling process, as well as the need to adhere to ethical considerations in providing fair treatment, a control group (without therapeutic exercise intervention) was omitted. Another limitation was the inability to examine and compare patients with three different severities of CTS, including mild, moderate and severe, in terms of their response to treatment. Therefore, in future research, it is recommended to consider these limitations and address them.

Ethical Considerations

Compliance with ethical guidelines

All eligible patients who were willing to participate in the study formally signed an informed consent form. This study has obtained approval from the Medical Ethical Review Board of the University of Social Welfare and Rehabilitation Sciences, Tehran, Iran (Code: IR.USWR.REC.1402.171).

Funding

The present article was extracted from the PhD thesis of the Azadeh fasaie, approved by Department of physiotherapy, Faculty of rehabilitation, University of social welfare and rehabilitation sciences.

Authors' contributions

Conceptualization: All authors; Methodology: Azadeh Fassaii, Somayeh Mohamadi, and Samaneh Hossein Zadeh; Resources: Azadeh Fassaii and Somayeh Mohamadi; Software: Mosleheddin Adibhesami; Validation: Azadeh Fassaii; Investigation: Somayeh Mohamadi; Data curation: Azadeh Fassaii and Samaneh Hossein Zadeh; Formal analysis: Azadeh Fassaii, Samaneh Hossein Zadeh, and Mosleheddin Adibhesami; Writing the original draft: Azadeh Fassaii; Review and editing: Somayeh Mohamadi; Visualization: Azadeh Fassaii, Supervision: Somayeh Mohamadi; Project administration: Azadeh Fassaii, Somayeh Mohamadi and Mosleheddin Adibhesami.

Conflict of interest

The authors declared no conflict of interest.

References

[1] Omole AE, Awosika A, Khan A, Adabanya U, Anand N, Patel T, et al. An integrated review of carpal tunnel syndrome: new insights to an old problem. Cureus. 2023; 15(6):e40145. [DOI:10.7759/cureus.40145]

[2] Urits I, Gress K, Charipova K, Orhurhu V, Kaye AD, Viswanath O. Recent advances in the understanding and management of carpal tunnel syndrome: A comprehensive review. Current Pain and Headache Reports. 2019; 23(10):70. [DOI:10.1007/s11916-019-0800-2] [PMID]

[3] Kristanti TN, Nugraha MH, Winaya IM, Dewi AA. Uji validitas dan reliabilitas kuesioner quick disabilities of the arm, shoulder and hand versi indonesia pada pasien carpal Tunnel syndrome. Majalah Ilmiah Fisioterapi Indonesia. 2021; 9(2):110. [DOI:10.24843/MIFI.2021.v09.i02.p09]

[4] Ibrahim I, Khan WS, Goddard N, Smitham P. Carpal tunnel syndrome: A review of the recent literature. The Open Orthopaedics Journal. 2012; 6:69-76. [DOI:10.2174/1874325001206010069] [PMID] [PMCID]

[5] Sucher BM, Hinrichs RN. Manipulative treatment of carpal tunnel syndrome: Biomechanical and osteopathic intervention to increase the length of the transverse carpal ligament. Journal of Osteopathic Medicine. 2023; 98(12):679-86. [DOI:10.1515/jom-1998-0118]

[6] Paget J. The first description of carpal tunnel syndrome. The Journal of Hand Surgery, European Volume. 2007; 32(2):195-7. [DOI:10.1016/J.JHSB.2006.12.010] [PMID]

[7] Page MJ, Massy-Westropp N, O'Connor D, Pitt V. Splinting for carpal tunnel syndrome. The Cochrane database of Systematic Reviews. 2012; 2012(7):CD009899. [DOI:10.1002/14651858.CD009899]

[8] Kim SD. Efficacy of tendon and nerve gliding exercises for carpal tunnel syndrome: A systematic review of randomized controlled trials. Journal of Physical Therapy Science. 2015; 27(8):2645-8. [DOI:10.1589/jpts.27.2645] [PMID] [PMCID]

[9] Lee HS, Park SB, Lee SH, Chung YS, Yang HJ, Son YJ. The effect of cervical radiculopathy on the outcome of carpal tunnel release in a patient with carpal tunnel syndrome. The Nerve. 2015; 1(1):11-4. [DOI:10.21129/nerve.2015.1.1.11]

[10] Mooar PA, Doherty WJ, Murray JN, Pezold R, Sevarino KS. Management of carpal tunnel syndrome. The Journal of the American Academy of Orthopaedic Surgeons. 2018; 26(6):e128-30. [DOI:10.5435/JAAOS-D-17-00451] [PMID]

[11] Horng YS, Hsieh SF, Tu YK, Lin MC, Horng YS, Wang JD. The comparative effectiveness of tendon and nerve gliding exercises in patients with carpal tunnel syndrome: A randomized trial. American Journal of Physical Medicine & Rehabilitation 2011; 90(6):435-42. [DOI:10.1097/PHM.0b013e318214eaaf] [PMID]

[12] Abdolrazaghi HA, Khansari M, Mirshahi M, Ahmadi Pishkuhi M. Effectiveness of tendon and nerve gliding exercises in the treatment of patients with mild idiopathic carpal tunnel syndrome: A randomized controlled trial. Hand. 2023; 18(2):222-9. [DOI:10.1177/15589447211006857] [PMID] [PMCID]

[13] Wulandari R, Ariyanto A. Giving nerve and tendon gliding exercises to reduce pain in carpal tunnel syndrome. Physical Therapy Journal of Indonesia. 2024; 5(1):29-31. [DOI:10.51559/ptji.v5i1.173]

[14] Wagemakers SH, Van Der Velden JM, Gerlich AS, Hindriks-Keegstra AW, van Dijk J, Verhoeff J. A systematic review of devices and techniques that objectively measure patients' pain. Pain Physician. 2019; 22(1):1-13. [DOI:10.36076/ppj/2019.22.1]

[15] Boonstra AM, Preuper HR, Reneman MF, Posthumus JB, Stewart RE. Reliability and validity of the visual analogue scale for disability in patients with chronic musculoskeletal pain. International Journal of Rehabilitation Research. 2008; 31(2):165-9. [DOI:10.1097/MRR.0b013e3282fc0f93]

[16] Vaishya R, Misra A, Vaish A, Ursino N, D'Ambrosi R. Hand grip strength as a proposed new vital sign of health: A narrative review of evidences. Journal of Health, Population, and Nutrition. 2024; 43(1):7. [DOI:10.1186/s41043-024-00500-y] [PMID] [PMCID]

[17] Atya AM, Mansour WT. Laser versus nerve and tendon gliding exercise in treating carpal tunnel syndrome. Life Science Journal. 2011; 8(2):413-20. [Link]

[18] Shetty KD, Basu AR, Nuckols TK; Multi-Society Working Group for Electrodiagnosis Quality Measures in CTS. Refining quality measures for electrodiagnostic testing in suspected carpal tunnel syndrome to account for acceptable variations in practice: Expert review process. Muscle Nerve. 2024; 70(3):316-24. [DOI:10.1002/mus.28176] [PMID]

[19] Dumitru D, Nandedkar SD, Netherton B. Neurophysiology and instrumentation. Paper presented at: AANEM 57th Annual Meeting. 1 October 2010; Québec, Canada. [Link]

[20] Brininger TL, Rogers JC, Holm MB, Baker NA, Li ZM, Goitz RJ. Efficacy of a fabricated customized splint and tendon and nerve gliding exercises for the treatment of carpal tunnel syndrome: A randomized controlled trial. Archives of Physical Medicine and Rehabilitation. 2007; 88(11):1429-35. [DOI:10.1016/j.apmr.2007.07.019] [PMID]

[21] Alfonso C, Jann S, Massa R, Torreggiani A. Diagnosis, treatment and follow-up of the carpal tunnel syndrome: A review. Neurological Sciences. 2010; 31(3):243-52. [DOI:10.1007/s10072-009-0213-9] [PMID]

[22] Pimentel IS, Pimentel VS, Faloppa F, Belloti JC, Tamaoki MJ, Pimentel BF. Usefulness of the phalen test and the tinel sign in the prognosis and the impact on quality of life of patients with carpal tunnel syndrome undergoing classical open carpal tunnel release. Revista Brasileira de Ortopedia. 2024; 59(1):54-9. [DOI:10.1055/s-0044-1779318]

[23] Bland JD. Treatment of carpal tunnel syndrome. Muscle & Nerve. 2007; 36(2):167-71. [DOI:10.1002/mus.20802] [PMID]

[24] Bartkowiak Z, Eliks M, Zgorzalewicz-Stachowiak M, Romanowski L. The effects of nerve and tendon gliding exercises combined with low-level laser or ultrasound therapy in carpal tunnel syndrome. Indian Journal of Orthopaedics. 2019; 53(2):347-52. [DOI:10.4103/ortho.IJOrtho_45_17] [PMID] [PMCID]

[25] Pinar L, Enhos A, Ada S, Güngör N. Can we use nerve gliding exercises in women with carpal tunnel syndrome? Advances in Therapy. 2005; 22(5):467-75. [DOI:10.1007/BF02849867] [PMID]

[26] Bakhtiary AH, Rashidy-Pour A. Ultrasound and laser therapy in the treatment of carpal tunnel syndrome. The Australian Journal of Physiotherapy. 2004; 50(3):147-51. [DOI:10.1016/S0004-9514(14)60152-5] [PMID]

[27] Kisner C, Colby LA, Borstad J. Therapeutic exercise: Foundations and techniques. Philadelphia: Fa Davis; 2017. [Link]

[28] Totten PA, Hunter JM. Therapeutic techniques to enhance nerve gliding in thoracic outlet syndrome and carpal tunnel syndrome. Hand Clinics. 1991; 7(3):505-20. [DOI:10.1016/S0749-0712(21)01102-1] [PMID]

[29] Nasution N, Fitriadi D. Boston carpal tunnel syndrome questionnaire clinical function assessment outcomes of carpal tunnel injection for carpal tunnel syndrome. International Surgery Journal. 2024; 11(5):753-8. [DOI:10.18203/2349-2902.isj20240959]

[30] Collins SL, Moore RA, McQuay HJ. The visual analogue pain intensity scale: What is moderate pain in millimetres? Pain. 1997; 72(1-2):95-7. [DOI:10.1016/S0304-3959(97)00005-5] [PMID]

[31] Jablecki CK, Andary MT, So YT, Wilkins DE, Williams FH. Literature review of the usefulness of nerve conduction studies and electromyography for the evaluation of patients with carpal tunnel syndrome. AAEM Quality Assurance Committee. Muscle & Nerve. 1993; 16(12):1392-414. [DOI:10.1002/mus.880161220] [PMID]

[32] Jenkins DB. Hollinshead's functional anatomy of the limbs and back. Edinburgh: Elsevier Health Sciences; 2008. [Link]

[33] Sekaringtyas D, Susilo TE, Prihati E. Combination TENdon and nerve gliding exercise with neurodynamic mobilization to improve hand function in carpal tunnel syndrome patient: a case report. Paper presented at: Academic Physiotherapy Conference Proceeding. 2022 January 22; Surakarta, Indonesia. [Link]

[34] Kurniawti IR, Hasbia H. Comparison on effectiveness of nerve mobilization and Kinesio Taping toward changes in Carpal Tunnel syndrome. Journal of Physics. 2020; 1529:032034. [DOI:10.1088/1742-6596/1529/3/032034]

[35] Tal-Akabi A, Rushton A. An investigation to compare the effectiveness of carpal bone mobilisation and neurodynamic mobilisation as methods of treatment for carpal tunnel syndrome. Manual Therapy. 2000; 5(4):214-22. [DOI:10.1054/math.2000.0355] [PMID]

[36] Akalin E, El O, Peker O, Senocak O, Tamci S, Gülbahar S, Cakmur R, et al. Treatment of carpal tunnel syndrome with nerve and tendon gliding exercises. American Journal of Physical Medicine & Rehabilitation. 2002; 81(2):108-13. [DOI:10.1097/00002060-200202000-00006] [PMID]

[37] Alam M, Khan M, Ahmed SI, Ali SS. Effectiveness of neural mobilization and ultrasound therapy on pain severity in carpal tunnel syndrome. Biomedical Research and Therapy. 2018; 5(4):2187-93. [DOI:10.15419/bmrat.v5i4.432]

[38] Núñez de Arenas-Arroyo S, Cavero-Redondo I, Torres-Costoso A, Reina-Gutiérrez S, Álvarez-Bueno C, Martínez-Vizcaíno V. Short-term effects of neurodynamic techniques for treating carpal tunnel syndrome: A systematic review with meta-analysis. The Journal of Orthopaedic and Sports Physical Therapy. 2021; 51(12):566-80. [DOI:10.2519/jospt.2021.10533] [PMID]

[39] Bardak AN, Alp M, Erhan B, Paker N, Kaya B, Onal AE. Evaluation of the clinical efficacy of conservative treatment in the management of carpal tunnel syndrome. Advances in Therapy. 2009; 26(1):107-16. [DOI:10.1007/s12325-008-0134-7] [PMID]

[40] Mohamed FI, Hassan AA, Abdel-Magied RA, Wageh RN. Manual therapy intervention in the treatment of patients with carpal tunnel syndrome: Median nerve mobilization versus medical treatment. Egyptian Rheumatology and Rehabilitation. 2016; 43:27-34. [DOI:10.4103/1110-161X.177424]

[41] Eftekharsadat B, Babaei-Ghazani A, Habibzadeh A. The Efficacy of 100 and 300 mg Gabapentin in the Treatment of Carpal Tunnel Syndrome. Iranian Journal of Pharmaceutical Research. 2015; 14(4):1275-80. [PMID]

[42] Hui AC, Wong SM, Leung HW, Man BL, Yu E, Wong LK. Gabapentin for the treatment of carpal tunnel syndrome: a randomized controlled trial. European Journal of Neurology. 2011; 18(5):726-30. [DOI:10.1111/j.1468-1331.2010.03261.x] [PMID]

This Page Intentionally Left Blank