

Combined Physiotherapy with Electrotherapy and Neural Mobilization in Bilateral Carpal Tunnel Syndrome: A Case Report

Mahdi Ramdhani Idris Marasabessy¹, Umi Budi Rahayu², Salma Muzzaroh³

¹Professional Physiotherapy Program, Faculty of Health Sciences, Universitas Muhammadiyah Surakarta, Indonesia

²Faculty of Health Sciences, Universitas Muhammadiyah Surakarta, Indonesia

³Physiotherapy Unit, RSUD Bung Karno, Surakarta, Indonesia

Corresponding author:

Name: Umi Budi Rahayu

E-mail: mahdiramadhani76@gmail.com

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Abstract

Background: Carpal tunnel syndrome is a common entrapment neuropathy caused by compression of the median nerve, resulting in pain, sensory disturbances, and functional limitations. Although conservative physiotherapy is widely used, evidence on combined electrotherapy and neural mobilization in individual clinical cases remains limited.

Objective: To describe the clinical outcomes of combined physiotherapy interventions in a patient with bilateral carpal tunnel syndrome.

Methods: This case report followed CARE guidelines. A 66-year-old female with bilateral wrist pain and sensory disturbances underwent a 4-week physiotherapy program consisting of transcutaneous electrical nerve stimulation, therapeutic ultrasound, nerve gliding, and strengthening exercises twice weekly. Outcomes included pain intensity (Numeric Rating Scale), muscle strength (Manual Muscle Testing), range of motion, and functional ability (Wrist Hand Disability Index). A reduction of at least 2 points in pain score was considered clinically meaningful.

Results: After 4 weeks, pain decreased from 5 to 2 during movement and from 4 to 2 on pressure, exceeding the minimal clinically important difference. Muscle strength improved from grade 3 to 5. Wrist range of motion increased bilaterally. Functional ability improved from 32% to 20%, indicating a shift from moderate to mild disability. No adverse events were reported.

Conclusion: Combined physiotherapy interventions were associated with clinically meaningful improvements in pain, strength, and function. Findings should be interpreted cautiously due to the single-case design.

Keywords

Carpal Tunnel Syndrome; Neural Mobilization; Electrotherapy; Resistance Training; Disability Evaluation

Introduction

Carpal Tunnel Syndrome (CTS) is one of the most common peripheral entrapment neuropathies, resulting from compression of the median nerve within the carpal tunnel at the wrist. This condition is typically associated with repetitive wrist movements, sustained mechanical loading, and prolonged non-neutral wrist positioning, which collectively increase intracarpal pressure and impair nerve conduction. Clinically, CTS manifests as pain, paresthesia, numbness, and progressive weakness of the intrinsic hand muscles, particularly in advanced stages where thenar muscle atrophy and functional impairment may occur.¹

Epidemiological evidence indicates that CTS represents a significant global health concern. The prevalence has been reported to reach approximately 14.4%, with higher rates observed in high-income countries compared to low- and middle-income regions.² CTS most commonly affects individuals aged 40–60 years and shows a higher incidence in women, which has been attributed to hormonal influences, anatomical differences in the carpal tunnel, and greater exposure to repetitive manual activities in both occupational and domestic settings.³ These factors highlight the multifactorial nature of CTS and the need for comprehensive management strategies that address both mechanical and functional impairments.

From a pathophysiological perspective, sustained compression of the median nerve leads to ischemia, intraneural edema, and impaired axonal transport, ultimately resulting in both sensory and motor dysfunction. Motor involvement is particularly clinically relevant, as it affects intrinsic hand muscles such as the abductor pollicis brevis and opponens pollicis, which are essential for precision grip and fine motor control. Severe cases are frequently associated with thenar muscle atrophy, which has been strongly correlated with advanced median nerve entrapment.⁴ Therefore, early and effective conservative management is essential to prevent progression and preserve functional capacity.

Conservative physiotherapy remains the first-line treatment for mild to moderate CTS prior to considering surgical intervention. A wide range of physiotherapy modalities has been implemented, including exercise therapy, electrotherapy, and manual therapy techniques. Previous systematic reviews have demonstrated that conservative interventions can effectively reduce symptoms and improve functional outcomes; however, the optimal combination of treatment modalities remains unclear.⁵ Furthermore, a recent network meta-analysis of randomized controlled trials reported that multiple conservative interventions significantly improve pain and functional outcomes compared to passive or no treatment, although heterogeneity in intervention protocols limits definitive conclusions regarding the most effective approach.⁶

Among these interventions, nerve gliding exercise, also referred to as neural mobilization, has gained increasing attention due to its ability to enhance median nerve excursion within the carpal tunnel. This technique facilitates neural sliding, reduces adhesions between the nerve and surrounding structures, and improves intraneural circulation, thereby contributing to symptom reduction and functional recovery.⁷ In addition, strengthening exercises targeting intrinsic hand muscles are essential to restore muscle performance, improve grip strength, and prevent further muscle atrophy. Evidence suggests that combined exercise approaches, including neural mobilization and strengthening, can significantly improve functional outcomes in patients with CTS.⁸

Electrotherapy modalities, particularly Transcutaneous Electrical Nerve Stimulation (TENS) and therapeutic ultrasound, are also widely used in clinical practice. TENS primarily provides analgesic effects through modulation of nociceptive transmission via the gate control mechanism and activation of descending inhibitory pathways.⁹ Therapeutic ultrasound, in contrast, contributes to tissue healing by increasing local blood flow, enhancing cellular metabolism, and reducing inflammation, which is particularly relevant in conditions involving chronic nerve compression. Previous studies have reported that ultrasound may produce more consistent improvements in both pain and function, while TENS is primarily effective for short-term pain relief.^{9,10}

Despite the growing body of evidence supporting individual physiotherapy modalities, a critical gap remains in understanding the clinical effectiveness of combined electrotherapy and neural mobilization interventions in real-world individual cases, particularly in patients with complex presentations such as bilateral involvement and functional limitations related to daily activities. While randomized controlled trials provide high-level evidence, they often lack detailed clinical context and individualized response patterns observed in routine practice. Therefore, case reports play an important role in bridging this gap by providing in-depth clinical insights into intervention implementation and patient-specific outcomes.

This case is reported due to its clinical relevance, involving an older adult patient with bilateral CTS, short symptom duration, and functional impairment related to daily household activities, representing a common yet underreported presentation in physiotherapy practice. The case provides an opportunity to explore the integration of multimodal physiotherapy interventions in a real-world clinical setting and to illustrate their potential impact on pain, muscle strength, and functional ability.

Accordingly, this case report aims to describe the clinical outcomes of combined physiotherapy interventions, including electrotherapy, neural mobilization (nerve gliding), and strengthening exercises, in a patient with bilateral Carpal Tunnel Syndrome. It is hypothesized that a multimodal physiotherapy approach would be associated with improvements in pain intensity, muscle strength, range of motion, and functional ability.

Methods

This case report was prepared in accordance with the CARE (CAse REport) guidelines to ensure transparency, completeness, and clinical relevance in reporting. A descriptive case report design was employed to provide a comprehensive account of physiotherapy management in a patient diagnosed with Carpal Tunnel Syndrome (CTS). The report was conducted at the Physiotherapy Unit of RSUD Bung Karno, Surakarta, Indonesia, reflecting routine clinical practice.

The patient was a 66-year-old female who presented with bilateral wrist pain accompanied by paresthesia, numbness, and difficulty in finger extension, particularly on the left side. The symptoms had been present for approximately one week prior to physiotherapy consultation, indicating a relatively short onset. The patient reported that symptoms were aggravated by repetitive wrist activities such as washing, cooking, and lifting objects, and were relieved with rest. There was no history of trauma, systemic inflammatory disease, or previous upper limb surgery. The diagnosis of CTS was established based on clinical examination and physician confirmation.

A comprehensive physiotherapy assessment was conducted, including inspection, palpation, range of motion (ROM), muscle strength, pain assessment, functional evaluation, and special tests. Inspection revealed thenar muscle atrophy, suggesting median nerve involvement. Palpation showed no edema or increased local temperature. ROM assessment demonstrated bilateral limitations in wrist flexion, extension, and radial-ulnar deviation. Muscle strength was assessed using Manual Muscle Testing (MMT), with an initial score of grade 3/5. Pain intensity was measured using the Numeric Rating Scale (NRS), with scores of 5/10 during movement, 4/10 during pressure, and 0/10 at rest. Functional ability was evaluated using the Wrist Hand Disability Index (WHDI), yielding a baseline score of 32%, categorized as moderate disability. Special tests, including Phalen's test, Tinel's sign, Prayer test, and Carpal Compression test, were positive, supporting the diagnosis of CTS. To enhance diagnostic accuracy, potential differential diagnoses such as cervical radiculopathy, pronator teres syndrome, and systemic peripheral neuropathy were considered and clinically excluded based on the absence of proximal symptoms, lack of cervical involvement, and localization of symptoms to the median nerve distribution.

The patient's condition was further classified using the International Classification of Functioning, Disability, and Health (ICF) framework to provide a comprehensive understanding of impairments, activity limitations, and participation restrictions. Identified impairments included upper limb pain (b28014), decreased muscle power (b730), and limited joint mobility (b710). Structural involvement included the median nerve (s198) and intrinsic hand muscles (s73022). Activity limitations were observed in fine hand use (d440), hand and arm use (d445), and household activities (d640). Environmental factors included family support (e310) and healthcare support (e355), while no assistive devices were used (e1151).

The physiotherapy intervention program was administered over four weeks with a frequency of two sessions per week, following the FITT (Frequency, Intensity, Time, Type) principle. The selection of interventions was based on current evidence suggesting that multimodal physiotherapy approaches targeting both symptom modulation and functional restoration may provide superior outcomes compared to single-modality interventions. The detailed intervention protocol is presented in Table 1.

Table 1. Physiotherapy Intervention Protocol (FITT Principle)

Intervention	Frequency	Intensity	Time	Type	Clinical Rationale
TENS	2x/week	80 Hz (sensory level)	15 min	Continuous	Pain modulation via gate control mechanism
Ultrasound	2x/week	2.5 W/cm ²	5 min	Continuous	Improve circulation, reduce inflammation
Neural Mobilization	2x/week	Moderate	5–10 reps, 5-sec hold	Median nerve gliding	Improve neural excursion, reduce adhesions
Strengthening Exercise	2x/week	Mild–moderate	6 reps × 8 counts	Active & resisted (squeeze ball)	Improve intrinsic muscle strength

The intervention protocol was individualized according to patient tolerance and clinical response. Adherence to the treatment program was monitored during each session, and the patient demonstrated good adherence by completing all scheduled sessions and performing the prescribed exercises without interruption. No modification of the intervention protocol was required during the study period.

Outcome measures included pain intensity, muscle strength, range of motion, and functional ability. Pain was assessed using the Numeric Rating Scale (NRS), a valid and reliable instrument for musculoskeletal pain assessment, where a reduction of ≥2 points is considered the minimal clinically important difference (MCID). Muscle strength was evaluated using Manual Muscle Testing

(MMT). Range of motion was measured using standard goniometric assessment. Functional ability was assessed using the Wrist Hand Disability Index (WHDI), expressed as a percentage to indicate the level of disability. Although WHDI has been reported as a valid instrument, further confirmation of its validity and reliability in the Indonesian population is required

Data were analyzed descriptively in accordance with the case report design. Changes in outcome measures were reported as absolute differences (Δ) and percentage changes where applicable. No inferential statistical analysis was performed. Potential sources of measurement bias were acknowledged, particularly in subjective assessments such as pain intensity and self-reported functional ability. A clinical timeline of assessment and intervention was documented to track patient progress over the four-week period. The chronological sequence of clinical events and outcome evaluations is presented in Table 2.

Table 2. Clinical Timeline of Intervention and Outcomes

Time Point	Clinical Events
Week 0 (Baseline)	Initial assessment, diagnosis confirmation, baseline measurements (NRS, ROM, MMT, WHDI)
Week 1–2	Initiation of electrotherapy and exercise interventions; early symptom changes observed
Week 3	Progressive improvement in muscle strength and ROM
Week 4	Final evaluation showing improvement in pain, strength, ROM, and functional ability

Ethical considerations were addressed in accordance with clinical practice standards. The patient received a comprehensive explanation regarding the intervention procedures, potential benefits, and associated risks, and provided written informed consent for participation and publication. Formal ethical approval was not obtained, as this report describes a single case conducted within routine clinical care and does not involve experimental intervention. Patient confidentiality and anonymity were strictly maintained. No adverse events or complications were observed during the intervention period.

Results

The patient completed the four-week physiotherapy program with full adherence to all scheduled sessions. Clinical outcomes were assessed at baseline and monitored at weekly intervals, including pain intensity, range of motion (ROM), muscle strength, and functional ability. No adverse events or complications were reported during the intervention period.

At baseline, the patient presented with moderate clinical symptoms of Carpal Tunnel Syndrome, characterized by movement-related pain (NRS 5/10), pressure pain (4/10), muscle weakness (MMT grade 3/5), bilateral limitations in wrist ROM, and moderate functional disability (WHDI 32%). Progressive improvements were observed across all outcome measures throughout the intervention period. Changes in pain intensity during the intervention period are presented in Table 3.

Table 3. Changes in Pain Intensity (NRS) and Absolute Differences

Parameter	Baseline	Week 2	Week 3	Week 4	Δ (Baseline–Week 4)	% Change
Movement Pain	5	4	3	2	-3	-60%
Pressure Pain	4	3	3	2	-2	-50%
Rest Pain	0	0	0	0	0	0%

Movement-related pain decreased from 5 to 2 ($\Delta=-3$; -60%), while pressure pain decreased from 4 to 2 ($\Delta=-2$; -50%) over the four-week period. Rest pain remained absent throughout the intervention. Changes in wrist range of motion (ROM) measured in degrees are summarized in Table 4.

Table 4. Changes in Wrist Range of Motion (Degrees) and Absolute Differences

Movement	Side	Baseline	Week 2	Week 3	Week 4	Δ	% Change
Flexion	Right	25°	35°	35°	40°	+15°	+60%
Extension	Right	50°	60°	60°	65°	+15°	+30%
Flexion	Left	20°	30°	30°	35°	+15°	+75%
Extension	Left	45°	55°	55°	60°	+15°	+33%
Radial/Ulnar Deviation	Bilateral	Limited	+5°	+5°	+10°	↑	—

Bilateral improvements in ROM were observed across all movements. Both wrists demonstrated consistent increases in flexion and extension, with greater relative change observed in the left wrist.

Changes in muscle strength assessed using Manual Muscle Testing (MMT) are presented in Table 5.

Table 5. Changes in Muscle Strength (MMT Scale)

Assessment Time	Muscle Strength	Δ	Interpretation
Baseline	3/5	—	Movement against gravity
Week 2	3/5	0	No change
Week 3	4/5	+1	Against moderate resistance
Week 4	5/5	+2	Normal strength

Muscle strength increased from grade 3/5 at baseline to grade 5/5 at week 4, representing an overall improvement of two grades. Changes in functional ability measured using the Wrist Hand Disability Index (WHDI) are shown in Table 6.

Table 6. Changes in Functional Ability (WHDI Score)

Assessment Time	WHDI (%)	Δ	% Change	Interpretation
Baseline	32%	—	—	Moderate disability
Week 2	27%	-5	-15.6%	Moderate
Week 3	24%	-8	-25%	Mild–moderate
Week 4	20%	-12	-37.5%	Mild disability

Functional ability improved progressively, with WHDI scores decreasing from 32% to 20% ($\Delta=-12$; -37.5%) over four weeks. Overall, the patient demonstrated consistent improvements in pain intensity, wrist range of motion, muscle strength, and functional ability across the intervention period, with no reported adverse events.

Discussion

This case report aimed to describe the clinical outcomes associated with a multimodal physiotherapy intervention consisting of electrotherapy (TENS and therapeutic ultrasound), neural mobilization, and strengthening exercises in a patient with bilateral

Carpal Tunnel Syndrome (CTS). The findings demonstrated consistent improvements in pain intensity, range of motion (ROM), muscle strength, and functional ability following a four-week intervention period. However, these findings should be interpreted as an association rather than a causal relationship, given the inherent limitations of a single-case design.

The observed reduction in pain intensity, particularly in movement-related and pressure-induced pain, may be explained by the combined effects of TENS and therapeutic ultrasound. TENS has been widely reported to modulate pain through activation of large-diameter afferent fibers, thereby inhibiting nociceptive transmission at the spinal level in accordance with the gate control theory, as well as through activation of descending inhibitory pathways.⁹ Therapeutic ultrasound, on the other hand, contributes to local tissue healing by increasing blood flow, enhancing cellular metabolism, and reducing inflammation, which are relevant mechanisms in conditions involving chronic nerve compression.^{9,10} The magnitude of pain reduction observed in this case exceeded the minimal clinically important difference (MCID), suggesting a clinically meaningful change, although variability in individual response should be considered.

Improvements in wrist ROM were observed bilaterally and may be associated with both pain reduction and the effects of neural mobilization. Neural mobilization techniques, such as nerve gliding exercises, are designed to improve the mobility of the median nerve relative to surrounding tissues, thereby reducing intraneural pressure and facilitating normal neural excursion.⁷ In CTS, restricted neural movement due to adhesions and mechanical compression can contribute to functional limitations; therefore, restoring neural mobility may support improved joint movement and functional use of the hand. These findings are consistent with previous clinical trials reporting that nerve gliding techniques can improve both symptom severity and functional outcomes in CTS.^{7,8}

Muscle strength demonstrated a progressive improvement, particularly after the third week of intervention, which may reflect the principles of neuromuscular adaptation. Early phases of strengthening are typically characterized by neural adaptations, including improved motor unit recruitment and coordination, followed by structural adaptations that contribute to increased force production. Strengthening exercises targeting intrinsic hand muscles, particularly the thenar group, are essential in CTS management due to the susceptibility of these muscles to weakness and atrophy secondary to median nerve compression.^{4,8} The observed improvement from grade 3 to grade 5 suggests a substantial functional recovery in muscle performance, although the contribution of spontaneous recovery cannot be fully excluded.

Functional ability, as measured by the WHDI, improved progressively over the intervention period, indicating enhanced performance in daily activities such as gripping, lifting, and household tasks. Functional improvement in CTS is typically influenced by the interaction of multiple factors, including pain reduction, restoration of joint mobility, and improved muscle strength. The present findings are in line with previous systematic reviews demonstrating that conservative physiotherapy interventions can lead to meaningful improvements in both symptoms and functional outcomes.⁵ Additionally, evidence from a recent network meta-analysis supports the effectiveness of conservative approaches in improving pain and function compared to passive interventions.⁶

Despite these positive findings, alternative explanations should be considered. The relatively short duration of symptoms (approximately one week) raises the possibility of natural recovery contributing to the observed improvements. In addition, placebo effects and increased patient attention during therapy sessions may have influenced subjective outcomes such as pain perception and self-reported function. Therefore, the observed improvements cannot be attributed solely to the intervention without caution.

This study provides level IV evidence according to the hierarchy of evidence, as it is based on a single-case report. While such designs are limited in their ability to establish causality, they offer valuable insights into clinical reasoning, individualized intervention strategies, and patient-specific responses that are often not captured in controlled trials. In this case, the integration of electrotherapy and exercise-based interventions reflects a pragmatic and clinically relevant approach commonly used in physiotherapy practice.

An important aspect of this case is the patient perspective. The patient reported subjective improvement in pain during daily activities and increased ease in performing household tasks, particularly those involving repetitive hand use. The patient also expressed satisfaction with the intervention program and reported no discomfort or adverse effects during treatment sessions. This perspective supports the acceptability and feasibility of the intervention in a real-world clinical context.

From a clinical standpoint, the findings suggest that a multimodal physiotherapy approach may be beneficial in patients with CTS, particularly in cases involving functional limitations related to daily activities. Electrotherapy may be useful in the early phase to reduce pain and facilitate participation in exercise, while neural mobilization and strengthening exercises may contribute to longer-term functional improvements. This approach may be particularly relevant in primary care or community-based settings where conservative management is the first-line strategy.

Several limitations should be acknowledged. First, the single-case design limits the generalizability of the findings. Second, the absence of a control group prevents comparison with other interventions or natural progression. Third, the relatively short duration of intervention and lack of long-term follow-up limit the ability to assess the sustainability of outcomes. Fourth, potential measurement bias may have influenced subjective outcomes. Therefore, further research using randomized controlled trials with larger sample sizes and longer follow-up periods is recommended to confirm these findings.

Conclusion

This case report demonstrated that a multimodal physiotherapy approach, including electrotherapy (TENS and therapeutic ultrasound), neural mobilization, and strengthening exercises, was associated with improvements in pain intensity, muscle strength, range of motion, and functional ability in a patient with bilateral Carpal Tunnel Syndrome. The observed changes exceeded clinically meaningful thresholds for pain reduction and were accompanied by functional improvement in daily activities.

These findings highlight the potential role of combined physiotherapy interventions in addressing both symptomatic relief and functional restoration in CTS, particularly in patients with activity-related limitations. The integration of electrotherapy for pain modulation and exercise-based interventions for neuromuscular recovery may provide a comprehensive and clinically applicable management strategy.

However, the findings should be interpreted with caution due to the single-case design, absence of a control group, and short duration of follow-up. Further research using larger sample sizes, controlled study designs, and long-term evaluation is required to confirm the effectiveness and sustainability of these interventions.

Author Contribution

Mahdi Ramadhani Idris Marasabessy: Conceptualization, methodology, data collection, formal analysis, writing – original draft.

Umi Budi Rahayu: Supervision, validation, writing – review and editing.

Salma Muzzaroh: Data collection, investigation, resources, writing – review and editing.

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Conflict of Interest Statement

The authors declare no conflict of interest.

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Ethics Statement

Informed consent was obtained from the patient prior to participation. The patient received a detailed explanation regarding the procedures, potential benefits, and associated risks of the intervention. This report was conducted as part of routine clinical care and did not involve experimental procedures; therefore, formal ethical approval was not required. Patient confidentiality and anonymity were strictly maintained throughout the study.

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