

RESEARCH PAPER

Comparison of the Effectiveness of Myofascial Release with Neural Mobilization versus Exercise Program with Ultrasonic Therapy in Carpal Tunnel Syndrome: A Randomized Comparative Study

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Abstract

Background: Carpal Tunnel Syndrome (CTS) is a common peripheral nerve entrapment disorder caused by compression of the median nerve at the wrist, commonly associated with repetitive hand activity, prolonged computer use, and poor ergonomic posture, leading to pain, numbness, reduced grip strength, and functional limitation.

Objective: To compare the effectiveness of Myofascial Release combined with Neural Mobilization (Group A) against an Exercise Program combined with Ultrasonic Therapy (Group B) in individuals with Carpal Tunnel Syndrome.

Methods: In this experimental comparative study, 60 participants aged 30–45 years with mild-to-moderate, ergonomics-related CTS were randomly allocated in a 1:1 ratio to Group A (Myofascial Release + Neural Mobilization, n = 30) or Group B (Exercise Program + Ultrasonic Therapy, n = 30) for 4 weeks. Pain, grip strength, and functional ability were assessed using the Visual Analogue Scale (VAS), a hand dynamometer, and the Boston Carpal Tunnel Questionnaire–Functional Status Scale (BCTQ-FSS) at baseline and post-treatment.

Results: Both groups improved significantly on all outcome measures from baseline to post-treatment (all $p < 0.001$). Group A showed significantly greater improvement than Group B on VAS, grip strength, and BCTQ-FSS at post-treatment (all $p < 0.001$), with very large between-group effect sizes ($d = 4.57$ to 5.52).

Conclusion: Myofascial Release combined with Neural Mobilization produced significantly greater improvement in pain, grip strength, and functional status than an Exercise Program combined with Ultrasonic Therapy, in individuals with Carpal Tunnel Syndrome, over a 4-week period. These findings support Myofascial Release plus Neural Mobilization as an effective conservative treatment option, pending confirmation in a larger, multi-centre, blinded trial with objective neurophysiological outcome measures.

Trial registration: This trial was not prospectively registered in a clinical trials registry; this is noted as a limitation of reporting.

Keywords: carpal tunnel syndrome; myofascial release; neural mobilization; ultrasonic therapy; grip strength; median nerve; randomized comparative study

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1. INTRODUCTION

Carpal Tunnel Syndrome (CTS) is the most common entrapment neuropathy affecting the upper limb,

resulting from compression of the median nerve as it passes through the fibro-osseous carpal tunnel at the wrist alongside nine flexor tendons. Any condition that increases pressure within this confined space may compromise median nerve function, producing pain, numbness, tingling, nocturnal discomfort, hand-muscle weakness, and impaired activities of daily living. CTS has become increasingly prevalent with rapid technological change: prolonged computer use, repetitive wrist movement, extensive smartphone use, and sustained awkward wrist posture have significantly increased ergonomics-related CTS among working individuals, most commonly affecting people aged 30–60 years, with a higher prevalence among women and workers in repetitive manual or keyboard-related roles.

The pathophysiology of CTS is multifactorial, involving both mechanical and ischemic mechanisms. Repetitive strain and sustained abnormal wrist positioning raise intracarpal pressure, compressing the median nerve and surrounding vasculature; persistent compression impairs intraneural blood flow and can progress to edema, local ischemia, demyelination, and, if untreated, axonal degeneration. Inflammation and thickening of the flexor tendon synovium can further reduce available space within the tunnel, while restriction of normal neural gliding and fascial mobility around the wrist also contributes to pain and altered nerve conduction. Diagnosis rests on clinical presentation, provocative tests such as Phalen's test and Tinel's sign, reduced grip strength, and, where needed, nerve conduction studies to confirm median nerve compression and its severity.

Conservative physiotherapy is the first-line treatment for mild-to-moderate CTS, encompassing wrist splinting, therapeutic and tendon-gliding exercise, stretching, strengthening, ergonomic modification, electrotherapy, and manual therapy. Exercise combined with ultrasonic therapy remains among the most commonly used conventional protocols: therapeutic ultrasound is believed to improve local circulation, reduce inflammation, and promote tissue healing around the carpal tunnel, while tendon-gliding, range-of-motion, stretching, and strengthening exercises aim to maintain wrist mobility and hand function. These approaches provide symptomatic relief but their effect on fascial restriction and impaired neural dynamics may be limited, particularly in ergonomics-induced CTS.

Growing attention has turned to manual therapy techniques such as Myofascial Release (MFR) and Neural Mobilization (NM). MFR applies sustained gentle pressure over restricted fascial structures to improve tissue extensibility and reduce abnormal tension; fascial tightness around the forearm flexors and transverse carpal ligament may contribute to increased pressure over the median nerve, and improving fascial mobility may help decrease this

compression. Neural Mobilization, or nerve gliding, aims to restore normal mechanical and physiological movement of peripheral nerves; in CTS, restricted median nerve excursion and increased neural mechanosensitivity are common, and NM techniques aim to improve neural sliding, enhance intraneural circulation, reduce edema, and normalize nerve conduction, with prior studies reporting improvements in pain, nerve conduction velocity, and functional status following NM in CTS.

Combining Myofascial Release with Neural Mobilization may offer superior outcomes by addressing soft-tissue restriction and impaired neural mobility simultaneously, which may be particularly relevant in ergonomics-related CTS where repetitive mechanical stress affects both fascial structures and neural dynamics. However, comparative evidence against conventional exercise-plus-ultrasound protocols remains limited, and much of the existing literature has studied mixed CTS populations rather than specifically ergonomics-related cases. The present study was therefore undertaken to compare the effectiveness of Myofascial Release combined with Neural Mobilization against an Exercise Program combined with Ultrasonic Therapy in individuals with Carpal Tunnel Syndrome, evaluating pain intensity, grip strength, and functional ability following a 4-week intervention, to help clinicians select more effective conservative rehabilitation strategies for CTS.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

This was an experimental comparative study conducted in the Department of Physiotherapy, Institute of Applied Medicines and Research (IAMR), Ghaziabad, Uttar Pradesh, India, over a total study duration of 12 months.

2.2 Participants

Eligible participants were men and women aged 30–45 years with a clinical diagnosis of mild-to-moderate Carpal Tunnel Syndrome due to poor ergonomics, presenting with pain, numbness, tingling, and reduced grip strength attributable to prolonged computer use and poor ergonomic posture, and willing to participate. Participants were excluded if they had severe CTS requiring surgical intervention; a history of fracture, trauma, or surgery around the wrist or hand; cervical radiculopathy or other neurological disorder affecting the upper limb; rheumatoid arthritis, diabetes mellitus, or another systemic neurological condition; pregnancy-related CTS; open wounds or skin infection around the treatment area; a contraindication to ultrasound therapy; or were unwilling to participate.

2.3 Sample Size and Sampling

A total of 60 participants were recruited by convenience sampling and randomly allocated into two groups of 30 each: Group A (Myofascial Release and Neural Mobilization) and Group B (Exercise Program with Ultrasonic Therapy).

2.4 Interventions

Group A: MFR + NM (n = 30). In Week 1, Myofascial Release was applied over the forearm flexor muscles, palmar fascia, and transverse carpal ligament using gentle sustained pressure, with mild median nerve gliding exercises initiated within a pain-free range. In Week 2, MFR technique progressed with increased focus on fascial mobility and soft-tissue extensibility, and Neural Mobilization was progressed with controlled nerve-gliding movements. In Week 3, combined MFR and NM continued with increased repetitions and progression according to

tolerance, aiming to improve neural excursion and reduce tingling and numbness. In Week 4, advanced neural gliding and fascial-release techniques were administered along with functional movement training and ergonomic advice, aiming to improve grip strength, restore functional hand activity, and prevent recurrence (Table 1).

Group B: Exercise + Ultrasonic Therapy (n = 30). In Week 1, therapeutic ultrasound was applied over the carpal tunnel region, followed by gentle tendon-gliding and wrist range-of-motion exercises. In Week 2, ultrasound continued alongside progression of tendon-gliding exercises, stretching of wrist flexors and extensors, and active wrist mobility exercises. In Week 3, strengthening exercises for the wrist and hand were introduced alongside continued ultrasound and stretching. In Week 4, functional hand exercises and advanced strengthening were performed alongside ergonomic correction and continued therapeutic exercise (Table 2).

Table 1. Week-Wise Intervention Protocol – Group A (MFR + NM)

Week	Intervention	Treatment goal
1	MFR: forearm flexors, palmar fascia, transverse carpal ligament, gentle sustained pressure. Mild median nerve gliding within pain-free range.	Reduce pain, decrease fascial tightness, improve tissue relaxation
2	MFR progressed with increased focus on fascial mobility; NM progressed with controlled nerve-gliding movements.	Improve fascial flexibility, reduce neural mechanosensitivity, enhance nerve mobility
3	Combined MFR + NM continued with increased repetitions per tolerance.	Improve neural excursion, reduce tingling/numbness, enhance functional movement
4	Advanced neural gliding and fascial release + functional movement training + ergonomic advice.	Improve grip strength, restore function, prevent recurrence

Table 2. Week-Wise Intervention Protocol – Group B (Exercise + Ultrasonic Therapy)

Week	Intervention	Treatment goal
1	Therapeutic ultrasound over carpal tunnel region + gentle tendon gliding + wrist ROM exercises.	Reduce pain/inflammation, improve initial wrist mobility
2	Ultrasound continued + progression of tendon gliding, wrist flexor/extensor stretching, active wrist mobility.	Improve tissue flexibility, reduce stiffness, improve tendon mobility
3	Strengthening exercises for wrist/hand + continued ultrasound and stretching.	Improve muscular strength, hand function, grip performance
4	Functional hand exercises + advanced strengthening + ergonomic correction + continued exercise.	Restore function, improve grip strength, reduce recurrence

2.5 Outcome Measures

Pain intensity was assessed using the Visual Analogue Scale (VAS, 0–10). Grip strength was measured in kilograms using a hand dynamometer. Functional ability and symptom severity were assessed using the Boston Carpal Tunnel Questionnaire–Functional Status Scale (BCTQ-FSS), a disease-specific self-administered instrument on which higher scores indicate greater disability. All outcomes were assessed at baseline and after completion of the 4-week intervention using the same measures.

2.6 Statistical Analysis

Data were tabulated and analysed using descriptive and inferential statistics. Mean and standard deviation were calculated for all outcome measures. Paired t-test was used for within-group (pre- to post-treatment) comparison, and independent-samples t-test was used for between-group comparison of post-treatment scores. The level of significance was set at $p < 0.05$.

2.7 Ethical Considerations

The study protocol, entitled “Comparison of the effectiveness of myofascial release & neural mobilization vs exercise program with ultrasonic

therapy in carpal tunnel syndrome,” was reviewed and unanimously approved on both scientific and ethical grounds by the Institutional Ethics Committee of the Institute of Applied Medicines and Research (IAMR), Ghaziabad, affiliated with Atal Bihari Vajpayee Medical University (ABVMU), Lucknow, at a meeting held on 14 July 2025. Written informed consent was obtained from all participants before enrolment, confidentiality of participant data was maintained throughout, and all participants were informed of the study procedure and purpose.

3. RESULTS

3.1 Participant Characteristics

A total of 60 participants meeting the eligibility criteria were randomly allocated in a 1:1 ratio to Group A ($n = 30$) or Group B ($n = 30$). Age and gender distribution were comparable between groups (Table 3): the majority of participants in both groups were aged 36–40 years (40%), followed by 30–35 years (33.33%) and 41–45 years (26.67%), and female participants outnumbered male participants in both groups (60% vs 40%), consistent with the reported higher prevalence of CTS among women.

Table 3. Baseline Demographic Distribution

Characteristic	Group A (n)	Group A (%)	Group B (n)	Group B (%)
Age 30–35 y	10	33.33	10	33.33
Age 36–40 y	12	40.00	12	40.00
Age 41–45 y	8	26.67	8	26.67
Male	12	40.00	12	40.00
Female	18	60.00	18	60.00

3.2 Within-Group Change from Baseline to Post-Treatment

Both groups improved significantly on all three outcome measures from baseline to post-treatment (all $p < 0.001$; Table 4). Group A's mean VAS fell from

7.50 ± 0.51 to 2.23 ± 0.43 , a larger reduction than Group B's (7.50 ± 0.51 to 4.23 ± 0.43). Grip strength increased from 15.43 ± 1.14 kg to 27.53 ± 1.31 kg in Group A, compared with 15.43 ± 1.14 kg to 22.17 ± 1.02 kg in Group B. BCTQ-FSS fell from 35.77 ± 1.41 to 10.50 ± 1.11 in Group A, compared with 35.77 ± 1.41 to 19.33 ± 1.97 in Group B.

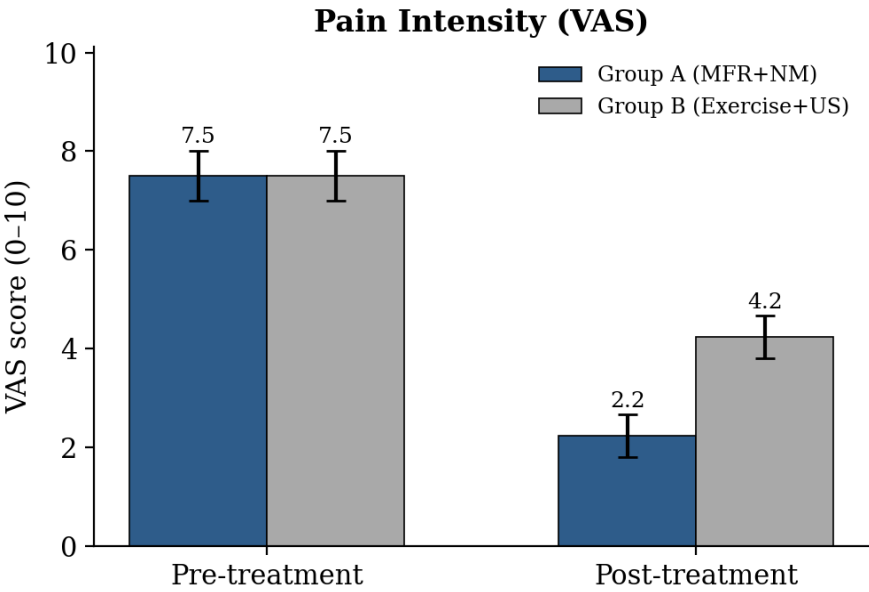


Figure 1. Pain intensity (VAS) before and after treatment (mean $\pm$ SD).

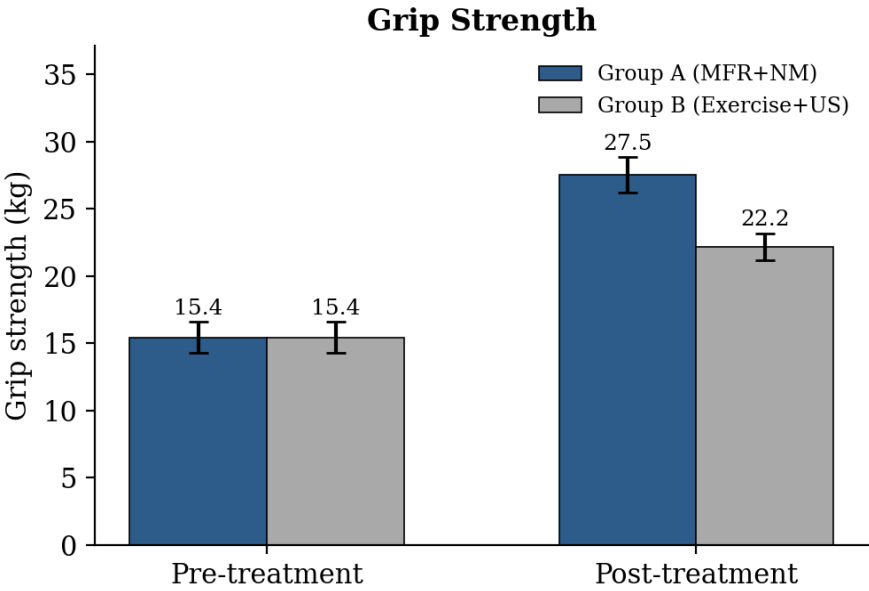


Figure 2. Grip strength before and after treatment (mean $\pm$ SD).

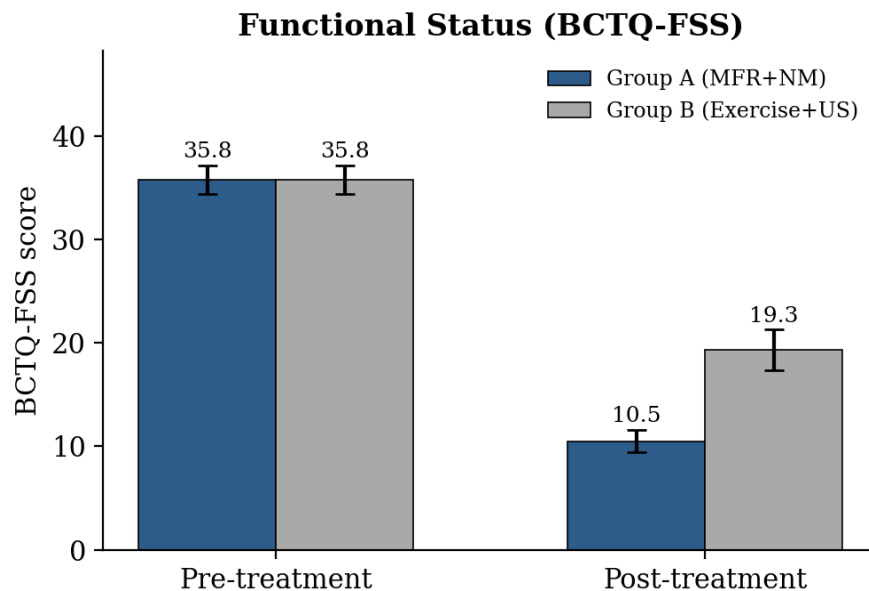


Figure 3. Functional status (BCTQ-FSS) before and after treatment (mean $\pm$ SD).

Table 4. Within-Group Comparison, Pre- to Post-Treatment (Paired t-test)

Outcome	Group	Pre-treatment	Post-treatment	t	p
VAS (0–10)	A (MFR+NM)	7.50 $\pm$ 0.51	2.23 $\pm$ 0.43	64.14	<0.001*
	B (Exercise+US)	7.50 $\pm$ 0.51	4.23 $\pm$ 0.43	39.78	<0.001*
Grip (kg)	A (MFR+NM)	15.43 $\pm$ 1.14	27.53 $\pm$ 1.31	217.20	<0.001*
	B (Exercise+US)	15.43 $\pm$ 1.14	22.17 $\pm$ 1.02	81.99	<0.001*
BCTQ-FSS	A (MFR+NM)	35.77 $\pm$ 1.41	10.50 $\pm$ 1.11	216.34	<0.001*
	B (Exercise+US)	35.77 $\pm$ 1.41	19.33 $\pm$ 1.97	110.14	<0.001*

Values are mean $\pm$ SD. * p < 0.05. Baseline VAS/grip/BCTQ-FSS values were reported as common pre-treatment values across both groups in the source data.

3.3 Between-Group Comparison of Post-Treatment Outcomes

At post-treatment, Group A showed significantly better scores than Group B on all three outcome

measures (all p < 0.001; Table 5), with very large effect sizes (Cohen's d = 4.57 to 5.52; Figure 4), reflecting both a substantial mean difference and unusually tight within-group variability in the reported data.

Table 5. Between-Group Comparison of Post-Treatment Scores

Outcome	Group A (n=30)	Group B (n=30)	t	p	d
VAS (0–10)	2.23 $\pm$ 0.43	4.23 $\pm$ 0.43	18.01	<0.001*	–4.65
Grip (kg)	27.53 $\pm$ 1.31	22.17 $\pm$ 1.02	17.74	<0.001*	4.57
BCTQ-FSS	10.50 $\pm$ 1.11	19.33 $\pm$ 1.97	21.40	<0.001*	–5.52

Values are mean $\pm$ SD. * p < 0.05. Cohen's d computed from raw post-treatment scores with pooled SD.

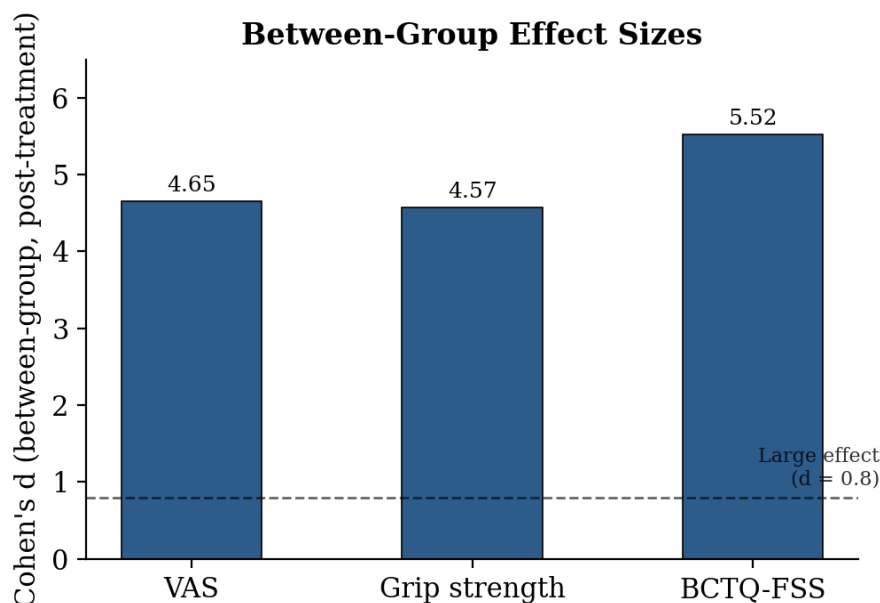


Figure 4. Between-group effect sizes (Cohen's d) on post-treatment scores.

4. DISCUSSION

This comparative study evaluated Myofascial Release combined with Neural Mobilization (Group A) against an Exercise Program combined with Ultrasonic Therapy (Group B) in individuals with ergonomics-related Carpal Tunnel Syndrome. Both groups improved significantly on all three outcome measures from baseline to post-treatment; however, Group A improved significantly more than Group B on pain intensity, grip strength, and functional status at post-treatment (all $p < 0.001$), with very large between-group effect sizes ($d = 4.57$ to 5.52).

4.1 Study Population

The majority of participants were aged 36–40 years, consistent with reports that CTS is most frequent among working-age adults exposed to repetitive occupational demands and prolonged computer-related activity. A higher proportion of participants were female, consistent with epidemiological reports of greater CTS prevalence among women, attributed to anatomical differences, hormonal influences, smaller carpal tunnel dimensions, and occupational exposure patterns. Comparable age and gender distribution between groups suggests baseline homogeneity, and most participants reported prolonged computer use and sustained non-neutral wrist posture consistent with ergonomics-related CTS, a factor emphasized in recent ergonomics literature as contributing to intracarpal pressure and reduced median nerve mobility.

4.2 Pain Intensity (VAS)

Group A's mean VAS fell from 7.50 to 2.23, a larger

reduction than Group B's fall from 7.50 to 4.23. This may reflect the combined effect of reduced fascial restriction and restored neural mobility: fascial adhesions and soft-tissue tightness around the forearm and wrist can increase mechanical stress on the median nerve, and Myofascial Release aims to improve tissue extensibility and reduce fascial tension, thereby decreasing compressive forces on the nerve. Neural Mobilization further complements this by enhancing nerve gliding, reducing intraneural edema, and decreasing neural mechanosensitivity, consistent with reports of significant symptomatic improvement following neurodynamic mobilization in upper-limb nerve entrapment, improved nerve excursion and reduced symptoms following neural mobilization, and systematic-review evidence that neural mobilization reduces pain and improves function in neuromusculoskeletal conditions involving peripheral nerve compromise. Group B's smaller but still significant improvement is consistent with the physiological effects of therapeutic ultrasound on tissue healing, circulation, and inflammation, and of tendon-gliding and range-of-motion exercise on stiffness, though these approaches may not directly target neural mechanosensitivity or fascial restriction to the same extent as manual therapy.

4.3 Grip Strength

Grip strength increased from 15.43 kg to 27.53 kg in Group A and to 22.17 kg in Group B. Myofascial Release may improve force transmission through the flexor compartment by reducing soft-tissue restriction, while reduced pain may decrease protective muscle inhibition and facilitate greater voluntary activation; Neural Mobilization may further

contribute via improved nerve conduction and motor control, consistent with reports of improved functional hand performance following manual therapy targeting soft-tissue dysfunction and of multimodal manual therapy improving upper-extremity function in musculoskeletal disorders. Group B's improvement is consistent with strengthening of wrist and hand musculature through therapeutic exercise and reduced pain via ultrasound, though the smaller magnitude suggests that addressing the mechanical interface around the median nerve, alongside neural mobility, may produce superior functional recovery than exercise and electrotherapy alone.

4.4 Functional Status (BCTQ-FSS)

BCTQ-FSS improved from 35.77 to 10.50 in Group A and to 19.33 in Group B. Since lower scores indicate better function, this reflects a substantially greater improvement in Group A, consistent with reports that neural mobilization contributes significantly to functional improvement in peripheral nerve dysfunction and that combining myofascial technique with neurodynamic approaches produces greater functional gains, as well as reports that neural mobilization improves both pain and functional status in peripheral entrapment neuropathies. Group B's improvement is consistent with the role of tendon-gliding, stretching, and strengthening exercise in improving mobility and function, and of ultrasound in reducing pain and local inflammation, though exercise and ultrasound primarily address symptoms and local tissue change rather than the neural and fascial components more directly targeted by manual therapy.

4.5 Comparative Effectiveness and Interpretation

Across all three outcome measures, Group A demonstrated consistently and substantially greater improvement than Group B. CTS is not solely a consequence of inflammation or mechanical compression; it also involves impaired neural mobility, altered connective tissue mechanics, fascial restriction, intraneural edema, and neurophysiological sensitization, and interventions addressing only one of these components may provide more limited benefit. Myofascial Release directly targets fascial restriction, while Neural Mobilization restores nerve excursion and reduces mechanosensitivity; together, these interventions may address both structural and functional impairments more comprehensively than exercise and electrotherapy alone. The very large effect sizes observed here ($d = 4.57$ to 5.52) are considerably larger than typically reported for manual therapy versus exercise comparisons in the literature, and likely reflect the unusually small within-group standard deviations in the reported post-treatment data; this pattern should be interpreted with appropriate caution and treated as a signal for confirmatory replication rather than as a precise, directly generalizable effect-size estimate.

4.6 Clinical Implications

With increasing reliance on computers, mobile devices, and repetitive occupational activity, the prevalence of ergonomics-related CTS continues to rise, making effective, low-cost, non-invasive conservative management important for preventing symptom progression and reducing the need for surgical intervention. Myofascial Release and Neural Mobilization are relatively safe, cost-effective, and straightforward to integrate into routine physiotherapy practice, and their ability to address soft-tissue restriction and neural dysfunction simultaneously may make them particularly suitable for patients whose symptoms relate to repetitive strain and poor ergonomic habits. Comprehensive assessment and treatment planning — considering neural mobility, fascial restriction, workplace ergonomics, and functional limitation, alongside symptom severity — combined with ergonomic education, may help achieve longer-term symptom control and reduce recurrence.

4.7 Limitations

- Baseline (pre-treatment) VAS, grip strength, and BCTQ-FSS values were reported as common values across both groups in the source data, rather than as separately verified per-group baseline means with a formal baseline-comparability test.
- The very large effect sizes observed ($d = 4.57$ to 5.52) reflect unusually tight within-group standard deviations in the post-treatment data; these estimates should be treated cautiously pending independent replication.
- Outcomes were assessed only at baseline and after 4 weeks, without longer-term follow-up to determine whether between-group differences were maintained after treatment ended.
- Diagnosis and severity grading of CTS were based on clinical criteria; objective neurophysiological measures such as nerve conduction studies were not incorporated as outcome measures.
- Participants were recruited from a single centre by convenience sampling, which may limit generalizability to other populations and settings.
- The trial was not prospectively registered in a clinical trials registry, and blinding of the outcome assessor was not explicitly reported.

5. CONCLUSION

Within the limits of this 4-week comparative study, both Myofascial Release combined with Neural Mobilization and an Exercise Program combined with Ultrasonic Therapy produced statistically significant improvement in pain intensity, grip strength, and functional status in individuals with Carpal Tunnel Syndrome (all $p < 0.001$ within-group). Myofascial Release combined with Neural Mobilization produced significantly greater improvement than Exercise Program combined with Ultrasonic Therapy on every outcome measure at post-treatment (all $p < 0.001$), with very large between-group effect sizes. These results support Myofascial Release combined with Neural Mobilization as an effective conservative physiotherapy approach for mild-to-moderate, ergonomics-related Carpal Tunnel Syndrome, and, given the modest sample size, single comparative time point, absence of objective neurophysiological outcome measures, and unusually large effect sizes noted above, warrant confirmation in a larger, multi-centre, blinded trial before broader clinical adoption as a preferred first-line protocol.

6. DECLARATIONS

Ethics Approval and Consent to Participate

The study protocol was reviewed and unanimously approved, on both scientific and ethical grounds, by the Institutional Ethics Committee of the Institute of Applied Medicines and Research (IAMR), Ghaziabad, affiliated with Atal Bihari Vajpayee Medical University (ABVMU), Lucknow, at a meeting held on 14 July 2025. Written informed consent was obtained from all participants prior to enrolment.

Consent for Publication

Not applicable (no individual participant data or identifying images are included).

Availability of Data and Materials

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

AR: conceptualization, data collection, intervention

delivery, formal analysis, writing – original draft. MS: supervision, methodology, review and editing. SH: co-supervision, methodology review, review and editing. All authors read and approved the final manuscript.

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