

EFFECTIVENESS OF PHYSICAL THERAPY AS PRIMARY TREATMENT FOR NECK PAIN AND CERVICAL RADICULOPATHY: CLINICAL CHARACTERISTICS OF PATIENTS WITH SYMPTOM RECURRENCE

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ABSTRACT

Background/Objectives: Existing literature substantiates non-operative management, particularly physical therapy, and adjunctive modalities, as the primary approach for treating cervical radiculopathy (CR). However, there is a subset of patients who do not improve with primary physical therapy, hence requiring additional procedures. This study evaluates the short-term efficacy of physical therapy interventions in individuals diagnosed with CR and describing the clinical characteristics of patients who experienced symptom recurrence during follow-up.

Methods: In this prospective cohort study of 60 patients (18–60 years) diagnosed with CR by a medical practitioner and fulfilling inclusion criteria were evaluated using tests and scales for pain, disability, quality of life, strength, and dexterity. Individualized physical-therapy protocols were designed with evaluations at admission, discharge and up to 6 months. Patients' improvements were documented, and the clinical characteristics of patients with symptom recurrence were described.

Results: The mean numerical pain rating scale, neck disability index and CR impact scale scores at entry and discharge were (6.9±1.4 and 1.1±1.1), (25.1±7.1 and 3.7±3.3) and (48.6±21.3 and 84.7±8.2), respectively. The scores were significantly different with a Z-score of -6.7359. At p<0.0001, t-Score -21.146 at p<0.0001 and t-Score 12.86 at p<0.0001, the Grip strength was lower on the affected side (50.5±12.8 vs. 59.9±14.2, p<0.0001). 10 participants reported improved quality of life, and all the patients reported excellent relief from symptoms, which was consistent at 3 and 6-month follow-ups. During continued clinical follow-up beyond the study period, eight patients reported recurrence of symptoms.

Conclusion: The results from our study support physical therapy intervention as the primary treatment modality for neck pain and CR. There is a certain subset of patients in whom the results worsen over time who end up requiring additional procedures, including surgery. Six of the eight patients who experienced symptom recurrence were subsequently diagnosed with early-stage cervical myelopathy, indicating that for a subset of patients initially diagnosed with radiculopathy, the underlying pathology may be more complex and involve the spinal cord. This highlights the importance of vigilant monitoring for myelopathic signs during follow-up to facilitate timely surgical referral.

Keywords: Neck pain, Cervical radiculopathy, Cervical spondylosis, Physical therapy.

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INTRODUCTION

Neck pain is among the most common musculoskeletal complaints worldwide. It remains a major contributor to years lived with disability across adult populations [1]. Population-level estimates consistently place neck pain among the leading causes of functional limitation, work absenteeism, and health-care utilization. It is responsible for substantial socioeconomic consequences attributable to reduced productivity and recurrent care-seeking. Beyond direct costs related to treatment indirect costs – such as lost wages and caregiver burden – amplify the public health impact on patients [2]. The condition is multifactorial, influenced by biological determinants (ageing, sex, degenerative changes, neuromuscular dysfunction, and comorbid systemic disease) as well as psychosocial contributors including stress, sleep disturbance, anxiety, and maladaptive coping behaviors. In routine clinical practice, the burden of neck pain is particularly apparent in working-age adults in whom recurrent symptoms can impair daily activities. It may also limit participation in employment and negatively affect the overall quality of life of individuals [3].

The cervical spine is anatomically and biomechanically specialized to balance stability and mobility; however, it is vulnerable to degenerative and mechanical overload. It comprises of seven cervical vertebrae

(C1–C7) and intervertebral discs interposed between vertebral bodies [4]. Eight paired cervical nerve roots emerge from the cervical spinal cord and traverse neural foramina and innervate the upper extremities, shoulder girdle, neck and thorax. This relationship between osseo-ligamentous structures, discs and nerve roots means that degenerative disc disease and postural loading can readily translate into neural irritation. Clinically, the transition from non-specific axial neck pain to radicular features may often reflect progressive compromise at the foraminal level, where even small reductions in foraminal diameter may cause symptoms in susceptible individuals [5].

Cervical radiculopathy (CR) represents a clinically important subset within the broader spectrum of neck pain disorders. It is characterized by pain and/or neurological symptoms, which can be attributed to compression or inflammation of a cervical nerve root. Common etiologies include spondylotic foraminal stenosis and disc herniation. Less frequent causes include trauma, instability, inflammatory lesions or neoplastic diseases. In cases of CR Patients typically report neck pain that radiates to the shoulder, scapular region, arm or hand [6]. It is often accompanied by sensory symptoms (paraesthesia, numbness), motor weakness, or reflex changes in a dermatomal pattern. Because symptom patterns may overlap with shoulder pathology, peripheral

entrapment neuropathies, and even non-musculoskeletal conditions, CR remains a diagnostic challenge in some cases and demands careful clinical reasoning. Importantly, although many patients experience favorable natural history with conservative care, a clinically meaningful subgroup demonstrates persistent pain and disability, or experiences progression to more concerning neurological involvement, thereby requiring escalation of management [7].

Accurate identification of CR and stratification of severity rely on a combination of history, physical examination, and selective investigations. Provocative and neurodynamic tests – including Spurling's manoeuvre, cervical distraction/compression testing, shoulder abduction relief sign and upper limb tension tests (ULTT) are commonly used to reproduce symptoms in cases of CR. Imaging modalities such as cervical X-rays, computed tomography, and magnetic resonance imaging can help characterize degenerative changes and foraminal compromise. Electrophysiologic testing electromyography (EMG)/nerve conduction velocity (NCV) may be used when diagnostic uncertainty persists or when differentiating radiculopathy from peripheral neuropathy. From a treatment standpoint, current practice generally favors non-operative management as first-line care for most patients without progressive neurological deficit or red-flag features. Conservative strategies include education, administration of analgesics, activity modification and physical therapy. Interventions such as exercise therapy. Refractory cases not responding to conservative therapy may need surgical intervention [8].

The present study is designed to evaluate the short-term effectiveness of physical therapy as a primary treatment for neck pain with CR using standardized measures of pain, disability, functional impact, strength, dexterity, and quality of life, while describing the clinical characteristics of patients who experienced symptom recurrence during follow-up.

METHODS

This was a prospective cohort study conducted in the Physiotherapy outpatient department (OPD) of a tertiary care teaching hospital (SDM Medical College and Hospital). Patients were recruited consecutively over a 12-month period, with outcome assessments conducted at enrolment, discharge, 3 months, and 6 months after enrolment. Ethical approval was obtained from the Institutional Ethics Committee, and all eligible participants provided written informed consent before enrolment. Consecutive patients diagnosed with CR by a medical practitioner and referred for physiotherapy were screened for eligibility and recruited using convenience sampling. Patients referred for physiotherapy with a medical practitioner diagnosis of CR (n=81) were screened against predefined inclusion (age 18–60 years; unilateral/bilateral upper-limb pain with sensory/motor symptoms) and exclusion criteria. A total of 69 participants met eligibility and were enrolled. Follow-up losses were 4 at 3 months and 5 at 6 months (total dropouts=9), resulting in a final analyzed sample of 60 participants (Fig. 1).

At enrolment, demographic and clinical details of all cases were recorded. It was followed by a standardized physical therapy assessment. Assessment of pain intensity was done by using the numerical pain rating scale (NPRS). Inclinator (microFET) was used to measure the cervical range of motion. Handgrip strength was measured using the Jamar dynamometer. Standard provocative and neurodynamic tests, including Spurling's test, ULTT, cervical compression and distraction test, were performed to support clinical diagnosis and document baseline findings.

Functional and patient-reported outcomes were assessed at baseline using the neck disability index (NDI), World Health organization quality of life–BREF (WHOQOL-BREF), CR impact scale (CRIS), and upper-limb dexterity using the nine-hole peg test (NHPT). The treating team documented the diagnostic approach used by the referring physician and the baseline examination findings. Treatment was delivered as an individualized physical therapy program, finalized in consultation with senior physical therapy faculty; the components and progression of

the protocol were recorded. Participants who could attend regularly received supervised OPD-based therapy, while others were provided a structured home-based protocol with follow-up monitoring. All outcome measures were re-assessed at discharge, and again at 3 months and 6 months after enrolment.

Statistical analysis was performed using SPSS. Normality of continuous variables was evaluated using the Kolmogorov–Smirnov test. Changes in repeated outcome measures across time points (enrolment, discharge, 3 months, 6 months) were analyzed using repeated-measures analysis of variance (ANOVA), with *post hoc* pairwise comparisons performed using paired-samples t-tests with Bonferroni correction where applicable. A two-sided $p < 0.05$ was considered statistically significant (adjusted where relevant for multiple comparisons).

Inclusion criteria

- Age 18–60 years (any gender)
- Clinically diagnosed CR by a medical practitioner (with or without herniated disc, cervical spondylosis, and/or degenerative disc disease)
- Referred for physiotherapy management
- Unilateral or bilateral upper-limb pain with associated sensory and/or motor symptoms.

Exclusion criteria

- Diagnosed cervical myelopathy or clinical evidence suggestive of myelopathy
- Coexisting shoulder disorders (e.g., periarticular/frozen shoulder, reflex sympathetic dystrophy/complex regional pain syndrome of upper limb), shoulder dislocation, or acute fractures
- Active treatment for malignancy, rheumatoid arthritis, ankylosing spondylitis, systemic infections, or polyneuropathy
- Prior cervical spine surgery or other spinal surgery within the preceding 6 months

RESULTS

The results were analyzed using SPSS software version 23.0. Kolmogorov–Smirnov test was used for analyzing distribution of data. ANOVA for repeated measure was used NPRS, NDI, grip strength, NHPT, WHO-QOL BREF and CRIS.

Detailed results of all outcome measures across the 4 time points (enrolment, discharge, 3 months, and 6 months) are presented in the *post hoc* pairwise comparison tables and figures below.

A repeated-measures ANOVA was performed for all the dependent variable with one within-subject factor (Time: Enrolment, discharge, 3 months, and 6 months).

Post hoc pairwise comparisons were later conducted using paired-samples t-tests with Bonferroni correction ($\alpha = 0.05/6 = 0.0083$). Effect sizes were reported as partial η^2 for ANOVA and Cohen's d for pair-wise tests.

NPRS (pain intensity)

A repeated-measures ANOVA showed a clear and significant effect of time on pain intensity, $F(3,177) = 584.14$, $p < 0.001$, $\eta^2_p = 0.91$, reflecting a very large effect size. Participants experienced marked reductions in pain from enrolment to discharge, with further improvement observed at both 3- and 6-month follow-ups. *Post hoc* analyses indicated that each time point differed significantly from the next (all $p < 0.0083$). Overall, pain levels declined steadily across the study period, highlighting strong and lasting benefits of the intervention (Table 1 and Fig. 2).

NDI

The analysis of neck-related disability showed a significant effect of time, $F(3,177) = 479.16$, $p < 0.001$, $\eta^2_p = 0.89$, indicating a large effect size. *Post hoc* tests revealed significant improvements between all assessment points (all $p < 0.0083$). Disability scores steadily declined

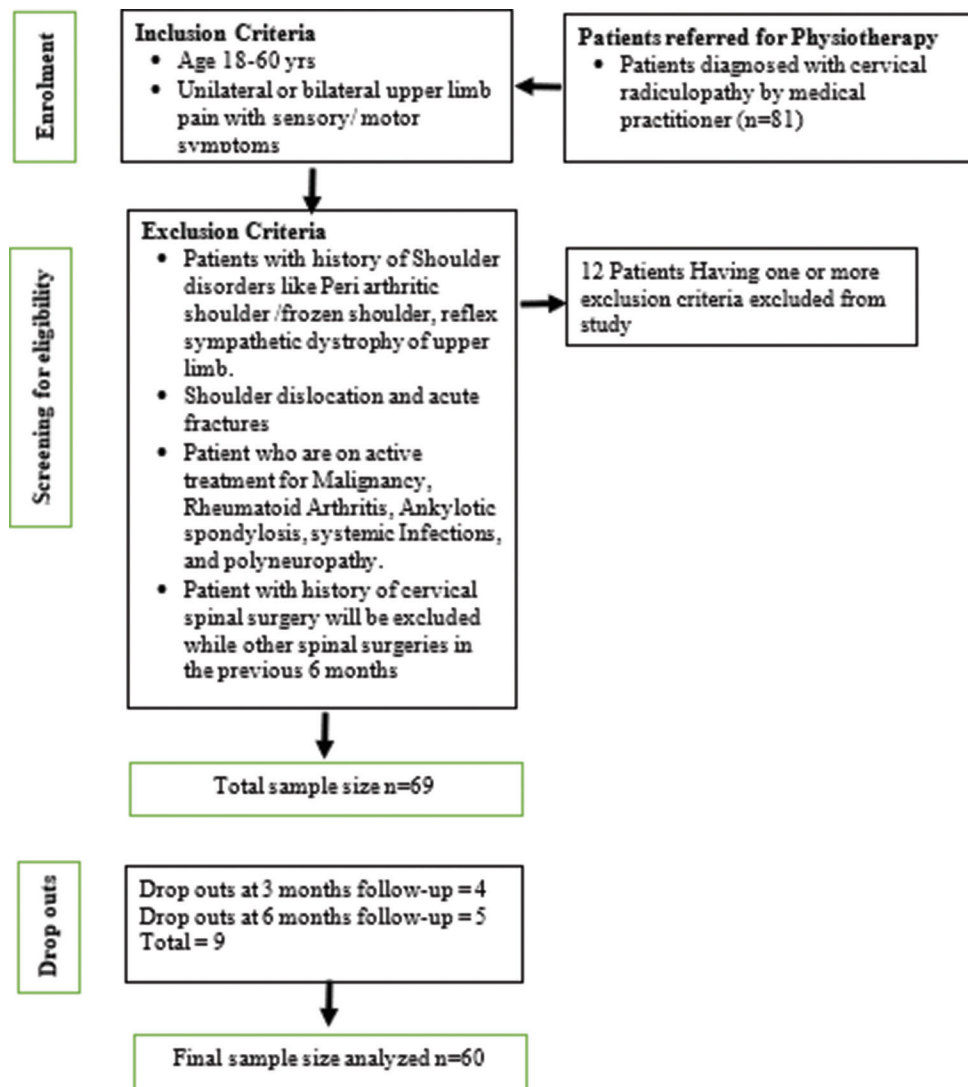


Fig. 1: Participant recruitment and follow-up flow diagram

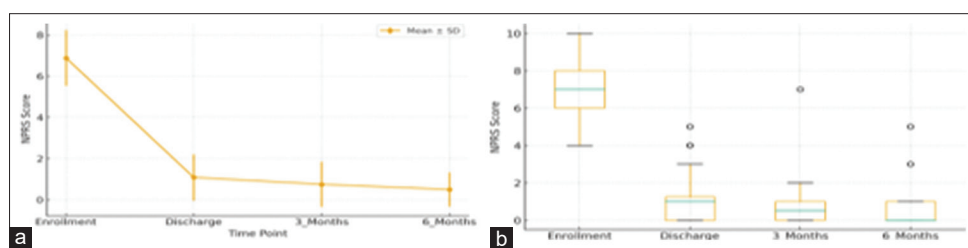


Fig. 2: Numerical pain rating scale (NPRS) over time: (a) Mean±standard deviation NPRS scores at enrolment, discharge, 3 months, and 6 months. (b) Boxplot showing median and interquartile range of NPRS across the same time points, with outliers plotted as points

Table 1: Post hoc pairwise comparisons for numerical pain rating scale (repeated measures analysis of variance with Bonferroni correction)

Comparison	Mean diff	t	df	p	p_adj (Bonf)	Cohen's d
Enrolment versus Discharge	-5.80	24.63	59	<0.001	<0.001	3.18
Enrolment versus 3 months	-6.13	26.01	59	<0.001	<0.001	3.35
Enrolment versus 6 months	-6.38	28.24	59	<0.001	<0.001	3.63
Discharge versus 3 months	-0.33	2.89	59	0.005	0.030	0.37
Discharge versus 6 months	-0.58	4.77	59	<0.001	0.006	0.61
3 months versus 6 months	-0.25	1.45	59	0.152	0.912	0.18

throughout the rehabilitation period and continued to improve during follow-up. This pattern suggests that participants experienced rapid and lasting gains in functional ability and performance of daily activities over the 6 months (Table 2 and Fig. 3).

Grip strength (affected)

For grip strength on the affected side, the effect of time was not statistically significant, $F(3,177)=3.60$, $p=0.015$, $\eta^2_p=0.06$. Although there was a slight numerical increase over time, this change did not remain significant after Bonferroni correction, suggesting a small effect size and minimal functional improvement in this domain. Overall, while participants showed notable gains in pain and disability measures, grip strength appeared to remain largely stable throughout the follow-up period (Table 3 and Fig. 4).

NHPT-affected

The analysis of fine motor coordination, measured by the NHPT, showed no significant effect of time, $F(3,177)=2.14$, $p=0.097$, $\eta^2_p=0.04$. This indicates that dexterity in the affected limb remained largely unchanged across the intervention and follow-up periods (Table 4 and Fig. 5).

WHOQOL-BREF (quality of life)

Analysis of the WHOQOL-BREF revealed a significant main effect of time, $F(3,177)=69.82$, $p<0.001$, $\eta^2_p=0.54$, reflecting a large and clinically meaningful improvement in perceived quality of life. Participants reported steady gains from enrolment through discharge, with further enhancement or maintenance of these improvements at 3- and 6-month follow-ups. These findings underscore the substantial psychosocial benefits associated with the intervention, extending beyond physical recovery (Table 5 and Fig. 6).

CRIS (community reintegration)

Community reintegration showed a significant effect of time, $F(3,177)=180.02$, $p<0.001$, $\eta^2_p=0.75$, indicating a very large effect size. *Post hoc* analyses revealed significant improvements across all assessment points (all $p<0.0083$), reflecting notable gains in community participation and social engagement following rehabilitation. These enhancements were not only statistically significant but also well maintained at the 6-month follow-up, highlighting meaningful and lasting functional recovery (Table 6 and Fig. 7).

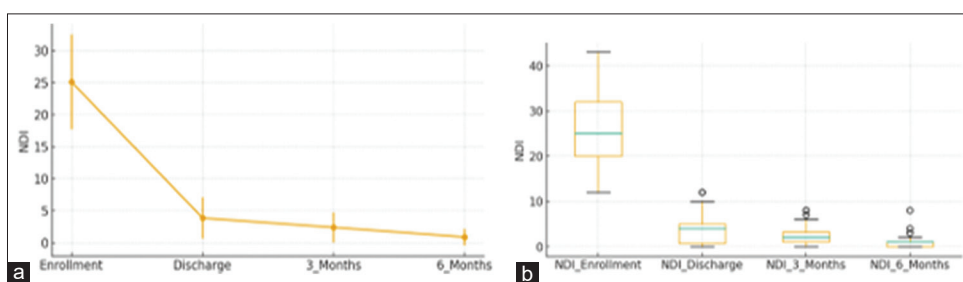


Fig. 3: Neck disability index (NDI) over time: (a) Mean±standard deviation NDI scores at enrolment, discharge, 3 months, and 6 months. (b) Boxplot showing median and interquartile range of NDI across the same time points, with outliers plotted as points

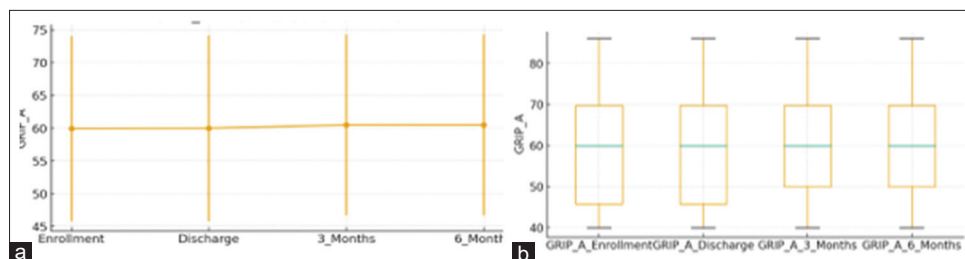


Fig. 4: Grip strength (a) over time: (a) Mean±standard deviation grip strength (Jamar dynamometer) at enrolment, discharge, 3 months, and 6 months. (b) Boxplot showing median and interquartile range of grip strength across the same time points, with outliers plotted as points

Table 2: Post hoc pairwise comparisons for neck disability index-repeated measures analysis of variance with Bonferroni correction

Comparison	Mean diff	t	Df	p	p_adj (Bonf)	Cohen's d
Enrollment versus Discharge	-21.21	22.89	59	<0.001	<0.001	2.95
Enrolment versus 3 months	-22.60	23.65	59	<0.001	<0.001	3.04
Enrolment versus 6 months	-24.08	24.82	59	<0.001	<0.001	3.20
Discharge versus 3 months	-1.39	3.82	59	<0.001	0.006	0.49
Discharge versus 6 months	-2.87	4.99	59	<0.001	0.006	0.64
3 months versus 6 months	-1.48	1.29	59	0.201	1.000	0.17

Table 3: Post hoc pairwise comparisons for grip strength (affected)-repeated measures analysis of variance with Bonferroni correction

Comparison	Mean diff	t	df	p	p_adj (Bonf)	Cohen's d
Enrolment versus Discharge	-0.05	0.56	59	0.580	1.000	0.07
Enrolment versus 3 months	-0.59	1.24	59	0.219	1.000	0.16
Enrolment versus 6 months	-0.59	1.25	59	0.216	1.000	0.16
Discharge versus 3 months	-0.54	1.31	59	0.196	1.000	0.17
Discharge versus 6 months	-0.54	1.32	59	0.192	1.000	0.17
3 months versus 6 months	0.00	0.02	59	0.982	1.000	0.00

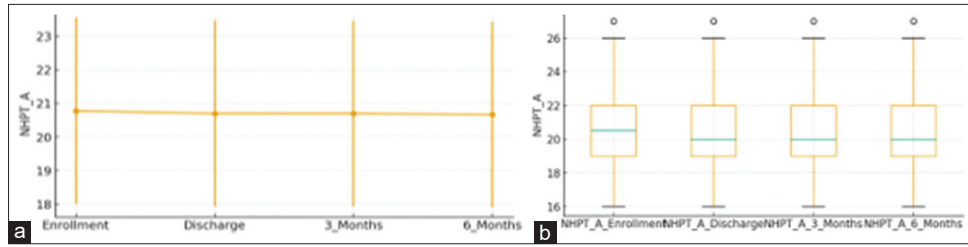


Fig. 5: Nine-hole peg test (NHPT) time (a) over time: (a) Mean±standard deviation NHPT completion time at enrolment, discharge, 3 months, and 6 months. (b) Boxplot showing median and interquartile range of NHPT times across the same time points, with outliers plotted as points

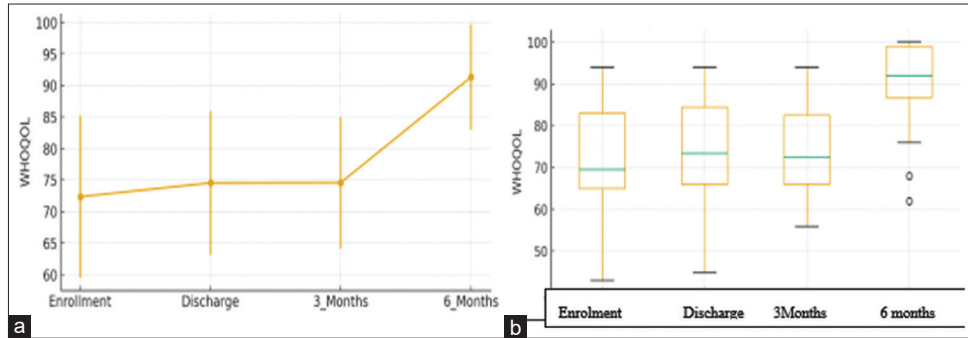


Fig. 6: The World Health Organisation quality of life (WHOQOL)-BREF over time: (a) Mean±standard deviation WHOQOL-BREF scores at enrolment, discharge, 3 months, and 6 months. (b) Boxplot showing median and interquartile range of WHOQOL-BREF scores across the same time points, with outliers plotted as points

Table 4: Post hoc pairwise comparisons for nine-hole peg test repeated measures analysis of variance with Bonferroni correction

Comparison	Mean diff	t	Df	p	p_adj (Bonf)	Cohen's d
Enrollment versus Discharge	0.08	0.87	59	0.390	1.000	0.11
Enrollment versus 3 months	0.08	0.89	59	0.379	1.000	0.11
Enrollment versus 6 months	0.11	0.93	59	0.355	1.000	0.12
Discharge versus 3 months	0.00	0.00	59	0.999	1.000	0.00
Discharge versus 6 months	0.03	0.41	59	0.685	1.000	0.05
3 months versus 6 months	0.03	0.41	59	0.683	1.000	0.05

Table 5: Post hoc pairwise comparisons for World Health organization quality of life -BREF (Bonferroni-adjusted)

Comparison	Mean diff	t	df	p	p_adj (Bonf)	Cohen's d
Enrolment versus discharge	-2.18	3.52	59	0.001	0.006	0.45
Enrolment versus 3 months	-2.23	3.47	59	0.001	0.006	0.45
Enrolment versus 6 months	-18.96	10.92	59	<0.001	<0.001	1.41
Discharge versus 3 months	-0.05	0.09	59	0.926	1.000	0.01
Discharge versus 6 months	-16.78	9.91	59	<0.001	<0.001	1.28
3 months versus 6 months	-16.73	9.91	59	<0.001	<0.001	1.28

Repeated-measures ANOVA showed a very large and highly significant time effect for pain (NPRS) and disability (NDI), indicating marked improvement across follow-up (partial $\eta^2 \approx 0.91$ and 0.89 ; $p < 10^{-84}$). CRIS also demonstrated a very large significant change over time (partial $\eta^2 = 0.753$; $p \approx 10^{-53}$), reflecting a substantial reduction in radiculopathy impact. Quality of life (WHOQOL-BREF) improved significantly with a moderate-to-large time effect (partial $\eta^2 = 0.542$; $p \approx 10^{-30}$). Grip strength showed a small but statistically significant time effect (partial $\eta^2 = 0.058$; $p = 0.0147$), suggesting modest functional gains. In contrast, NHPT did not show a significant change over time ($p = 0.097$), indicating no clear improvement in fine motor dexterity across the measured time points. During continued clinical follow-up beyond the 6-month study period, 8 (13.3%) patients reported recurrence of symptoms. On clinical

reassessment, 6 of these patients demonstrated signs suggestive of early cervical myelopathy (Table 7).

In the present study, participants demonstrated clinically meaningful improvements in both pain intensity and functional disability over the follow-up period. The mean NPRS scores decreased substantially from baseline (6.9 ± 1.4) to discharge (1.1 ± 1.1) and remained lower at the 3-month (0.8 ± 1.1) and 6-month (0.5 ± 0.8) assessments. Similarly, NDI scores showed a notable reduction from (25.1 ± 7.4) at enrolment to (3.9 ± 3.2) at discharge, with improvements largely sustained at 3 months (2.4 ± 2.3) and 6 months (0.9 ± 1.3). The reductions in NPRS and NDI at discharge remained within the established MCID threshold's ($1.1-6.3$ for NPRS and 11.75 for NDI), indicating that the changes were

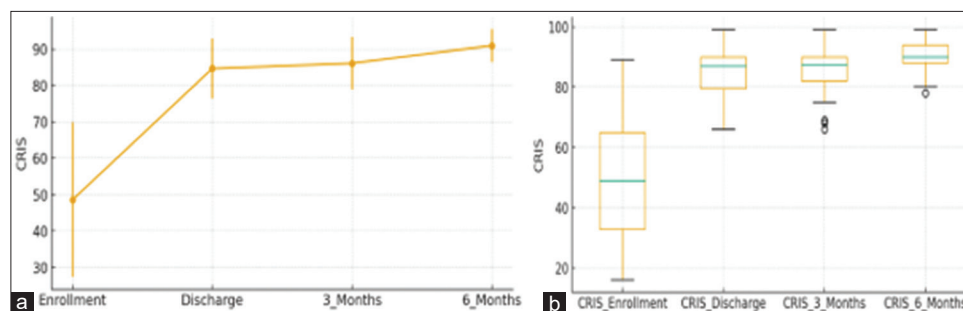


Fig. 7: Cervical radiculopathy impact scale (CRIS) over time: (a) Mean±standard deviation CRIS scores at enrolment, discharge, 3 months, and 6 months. (b) Boxplot showing median and interquartile range of CRIS across the same time points, with outliers plotted as points

Table 6: Post hoc pairwise comparisons for cervical radiculopathy impact scale (Bonferroni-adjusted)

Comparison	Mean diff	t	df	p	p_adj (Bonf)	Cohen's d
Enrolment versus Discharge	-36.10	14.83	59	<0.001	<0.001	1.91
Enrolment versus 3 months	-37.54	15.10	59	<0.001	<0.001	1.95
Enrolment versus 6 months	-42.40	17.16	59	<0.001	<0.001	2.22
Discharge versus 3 months	-1.44	2.44	59	0.018	0.108	0.31
Discharge versus 6 months	-6.30	5.77	59	<0.001	0.006	0.74
3 months versus 6 months	-4.86	4.48	59	<0.001	0.012	0.58

Table 7: Summary of analysis of variance analysis across all the measures

Measure	F (df ₁ , df ₂)	p-value	Partial η ²	Interpretation
Numerical pain rating scale	F (3, 177)=584.141	1.557×10 ⁻⁹¹	0.9083	Very large time effect
Neck disability index	F (3, 177)=479.161	1.09×10 ⁻⁸⁴	0.8904	Very large time effect
Grip strength (A)	F (3, 177)=3.598	0.0147	0.0575	Small effect
Nine-hole peg test (A)	F (3, 177)=2.138	0.0971	0.0350	Not significant
World Health organization quality of life-BREF	F (3, 177)=69.820	7.651×10 ⁻³⁰	0.5420	Moderate-large effect
Cervical radiculopathy impact scale	F (3, 177)=180.018	1.571×10 ⁻⁵³	0.7532	Very large time effect

not only statistically evident but also clinically relevant. Although slight further reductions in the scores were observed during the follow-up periods. These findings suggest that the intervention had a meaningful and persistent effect on alleviating pain and improving functional outcomes, supporting its potential effectiveness in the conservative management of the condition.

DISCUSSION

Cervical degenerative disc disease (Cervical Spondylosis) can result in four clinical entities (1) Discogenic neck pain (axial) pain, (2) Radiculopathy (root compromise) (3) Myelopathy (cord compression) or (4) Myeloradiculopathy (Combination of spinal cord and root compromise) [9]. The majority of patients with axial neck pain with radiculopathy and early stages of myelopathy are recommended physical therapy as a part of non-operative management protocol. This has been validated and recommended by various other authors and associations specializing in spinal diseases [10,11]. The onset of cervical degeneration is progressive once clinical symptoms appear and has been well documented by various studies [12]. This progression in cervical degeneration with ageing forms the basis for patient education and preventive strategies to be adapted.

Physical therapy as the primary intervention modality is recommended by various studies to halt the progression of disease, improve pain, and disability. Various studies have reported improvement in functional scores and relief of symptoms ranging from 75% to 90% after 6 weeks of conservative management and physical therapy [13-16]. In our study, the results were similar with significant improvement in the majority

of the patients based on pain by NPRS, Disability by NDI, Quality of life by WHO-QOL BREF, and functional outcome by CRIS. There was no significant change in the recovery of fine motor skill by NHPT and Grip strength. Xu X, Ling Y, in their systematic review and network meta-analysis in involving 632 participants with CR with a mean age range of 40-47 years, concluded that manual therapy alone should be considered the first-line conservative treatment for CR, and the role of traction required further investigation. The improvement based on NDI alone was (68.1%) which is comparable to our study [17].

The evidence from various studies supporting conservative management, particularly physical therapy as the primary interventional modality in patients presenting with CR has been well documented with improvement in pain and quality of life (Table 8).

Patients who experience symptom recurrence after initial improvement with physical therapy for CR warrant close monitoring to reduce the duration of morbidity and suffering. In our study, 8 (13.3%) patients reported recurrence of symptoms during continued clinical follow-up beyond the formal 6-month study period. These patients' demographic details and initial clinical findings were reassessed. Six of the eight patients who experienced symptom recurrence were subsequently diagnosed with early-stage cervical myelopathy after a combined thorough clinical examination and investigations with the referring medical practitioner. These six patients were above 45 years of age. This indicates that for a subset of patients initially diagnosed with radiculopathy, the underlying pathology may be more complex and involve the spinal cord, and the benefits of physical therapy may be limited in such cases. Early myelopathy changes were identified in

Table 8: Comparison of various studies analyzing effectiveness of physical therapy as the primary interventional modality in patients presenting with cervical radiculopathy

Authors and study	Type	Number of patients or studies	Conclusions
García-Juez <i>et al.</i> [18]	Systemic review and Meta-analysis	777 STUDIES	Combined articular (joint) +neural mobilization produced the largest short-term pain and disability improvements.
López-Pardo <i>et al.</i> [19]	Systemic review and Meta-analysis	285 patients	Routine physical therapy accompanied by neural mobilization is superior for improving mobility in comparison with routine physical therapy alone in patients with musculoskeletal neck disorders and cervical radiculopathy.
Xu and Ling [17]	Systemic review and Meta-analysis	632 patients	Manual therapy is an effective intervention for improving neck pain and disability in patients with Cervical radiculopathy
Savva <i>et al.</i> [20]	A randomized, double-blinded, placebo-controlled clinical trial.	66	At 4-week follow-up, Cervical Traction in combination with neural mobilization resulted in improved outcomes in pain, function and disability in patients with Cervical radiculopathy

these 6 patients in the form of small muscles wasting of hand and involvement of long tract signs (clonus, Hoffman sign, Babinski sign, or inverted radial reflexes). These clinical signs of involvement of long tracts, indicative of the onset of myelopathic changes, have been well documented by various authors [21-24]. There were no clinical or radiological signs of myelopathy in the other two patients. These findings in our study highlight the need for accurate clinical examination not only at the initial contact, but also during subsequent visits to identify early onset of myelopathy changes in patients under treatment for CR and chronic pain. Their symptom trajectory highlights the importance of vigilant monitoring for myelopathic signs during follow-up to facilitate timely surgical referral.

Significant decreases in NDI and pain intensity (NPRS) were noted, demonstrating significant time effects ($\eta^2_p > 0.85$). Such findings align with previous research reporting strong responsiveness of pain and disability to comprehensive rehabilitation models integrating physical therapy, patient education, and graded activity exposure [25,26]. The progressive decline in pain across all time points indicates that treatment effects were not transient but sustained over 6 months, suggesting that participants developed adaptive strategies and improved self-management skills that maintained therapeutic benefits [27].

Similarly, improvements in quality of life (WHOQOL-BREF) and community reintegration (CRIS) were substantial, indicating broad psychosocial benefits beyond physical recovery. This corresponds with existing literature highlighting how biopsychosocial rehabilitation frameworks foster enhanced coping mechanisms, social participation, and a sense of self-efficacy [28,29]. The observed gains in these domains suggest that participants experienced holistic recovery encompassing emotional well-being, social connectedness, and reintegration into meaningful life roles. These outcomes are particularly noteworthy, as long-term quality-of-life improvements are often difficult to achieve in populations with persistent pain or disability [30].

In contrast, motor function measures – grip strength and dexterity (NHPT) – did not show statistically significant change over time. Although small numerical gains were noted, they did not survive Bonferroni correction, implying limited motor adaptation across the follow-up period. This outcome aligns with prior studies suggesting that motor recovery often plateaus earlier than sensory or psychosocial improvements, particularly when neuroplastic or muscular limitations predominate [31,32]. These findings suggest that while the intervention was effective in mitigating pain and disability, its motor components may require augmentation to elicit measurable gains in fine motor control and strength. Incorporating task-oriented or technology-assisted motor retraining might enhance neuroplasticity and engagement in future programs [33].

A clinically important finding of this study was the identification of patients who experienced symptom recurrence after initial treatment success. The identification of symptoms suggestive of cord involvement or myelopathy changes by frequent clinical examinations in these patients is of utmost importance, as these patients need urgent referral for more aggressive treatment modalities such as surgical intervention if the cord involvement symptoms persist or worsen. These clinical signs after the onset of myelopathy changes and the long-term prognosis with and without surgical intervention have been well documented [34-37].

The results of this study demonstrate significant and long-lasting improvements in pain, disability, quality of life, and community reintegration following the rehabilitation program, with large effect sizes across all psychosocial and functional measures. These findings provide compelling evidence for the long-term efficacy of multimodal rehabilitation in facilitating both physical and psychosocial recovery after neurological or musculoskeletal impairment.

The limitations of this study include the use of convenience sampling, which may introduce potential selection bias and limit the generalizability of the findings for the broader population of patients having CR. The relatively small sample size of 60 patients, with only eight experiencing symptom recurrence, precludes the use of predictive modeling techniques such as logistic regression to identify baseline factors associated with poor outcome; hence, the findings regarding symptom recurrence are descriptive in nature. The observation of symptom recurrence in eight patients was noted during continued clinical follow-up beyond the formal 6-month study period and was not part of the prospectively planned statistical analysis. Future studies with larger sample sizes and probability-based sampling methods are warranted to confirm these findings and enable formal predictive analyses.

CONCLUSION

The study results collectively indicate that the rehabilitation protocol implemented led to lasting and clinically significant enhancements in both subjective and objective measures, with the most substantial effects seen in pain, disability, and quality of life. The characterization of patients who experienced symptom recurrence is clinically important, as six of the eight such patients were subsequently diagnosed with early-stage cervical myelopathy, suggesting that the underlying pathology in these patients was more complex than initially appreciated and may require more invasive procedures, including surgery. The lack of notable motor improvements highlights the need for tailored, domain-specific strategies in rehabilitation, suggesting that different therapeutic mechanisms may be responsible for recovery in sensory, functional, and motor areas. Further studies should investigate focused

motor interventions within wider rehabilitative frameworks and assess the long-term viability of all functional domains.

AUTHORS' CONTRIBUTIONS

Sriram K: Conceptualization, methodology, investigation, Data curation, Formal analysis, Writing – original draft. Jyoti S. Jeevannavar: Conceptualization, methodology, supervision, validation, Writing – review & editing. Santosh Jeevannavar: Clinical evaluation and diagnosis, supervision, Writing – review & editing. All authors have read and approved the final version of the manuscript.

CONFLICTS OF INTEREST

None.

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REFERENCES

- Bono CM, Ghiselli G, Gilbert TJ, Kreiner DS, Reitman C, Summers JT. An evidence-based clinical guideline for the diagnosis and treatment of cervical radiculopathy from degenerative disorders. *Spine J*. 2011 Jan;11(1):64-72. doi: 10.1016/j.spinee.2010.10.023, PMID 21168100
- Davies BM, Phillips R, Clarke D, Furlan JC, Demetriades AK, Milligan J. Establishing the socio-economic impact of degenerative cervical myelopathy is fundamental to improving outcomes [AO spine RECODE-DCM research priority number 8]. *Glob Spine J*. 2022 Feb;12(1 Suppl):122S-9. doi: 10.1177/21925682211039835, PMID 35174730, PMCID PMC8859704
- Oh T, Lafage R, Lafage V, Protopsaltis T, Challier V, Shaffrey C. Comparing quality of life in cervical spondylotic myelopathy with other chronic debilitating diseases using the short form survey 36-health survey. *World Neurosurg*. 2017 Oct;106:699-706. doi: 10.1016/j.wneu.2016.12.124, PMID 28065875
- Holck P. Cervikalcolumnas anatomi. *Tidsskr Nor Laegeforen*. 2010 Jan 14;130(1):29-32. doi: 10.4045/tidsskr.09.0296, PMID 20094120
- Ray WZ, Akbari S, Shah LM, Bisson E. Correlation of foraminal area and response to cervical nerve root injections. *Cureus*. 2015 Jul 20;7(7):e286. doi: 10.7759/cureus.286, PMID 26203404, PMCID PMC4509621
- Iyer S, Kim HJ. Cervical radiculopathy. *Curr Rev Musculoskelet Med*. 2016 Sep;9(3):272-80. doi: 10.1007/s12178-016-9349-4, PMID 27250042, PMCID PMC4958381
- Singh R, Khan S, Ambade RE, Kanani K, Agrawal V, Patel SK. Revolutionizing relief: Cervical radiculopathy with neurological deficits rescued by cervical disc replacement. *Cureus*. 2024 May 8;16(5):e59923. doi: 10.7759/cureus.59923, PMID 38854171, PMCID PMC11161573.
- Almasi A, Jafari S, Solouki L, Darvishi N. The best surgical treatment for cervical radiculopathy: A systematic review and network meta-analysis. *Adv Biomed Res*. 2023 Jul 25;12:191. doi: 10.4103/abr.abr_251_22, PMID 37694261, PMCID PMC10492624
- Miller MD, Thompson SR. *Spine*. In: Miller's Review of Orthopaedics. 9th ed. Philadelphia, PA: Elsevier Health Sciences; 2020. p. 690-5.
- Azar FM, Beaty JH. *Spine*. In: Campbell's Operative Orthopaedics. 14th ed. Philadelphia, PA: Elsevier; 2021. p. 1610-34.
- Grauer JN. *Orthopedic Knowledge Update*. Vol. 12. Illinois: American Academy of Orthopaedic Surgeons; 2017. p. 563-72.
- Okada E, Matsumoto M, Ichihara D, Chiba K, Toyama Y, Fujiwara H. Aging of the cervical spine in healthy volunteers: A 10-year longitudinal magnetic resonance imaging study. *Spine (Phila Pa 1976)*. 2009 Apr 1;34(7):706-12. doi: 10.1097/BRS.0b013e31819c2003, PMID 19333104.
- Roh JS, Teng AL, Yoo JU, Davis J, Furey C, Bohlman HH. Degenerative disorders of the lumbar and cervical spine. *Orthop Clin North Am*. 2005 Jul;36(3):255-62. doi: 10.1016/j.ocl.2005.01.007, PMID 15950685
- Woods BI, Hilibrand AS. Cervical radiculopathy: Epidemiology, etiology, diagnosis, and treatment. *J Spinal Disord Tech*. 2015 Jun;28(5):E251-9. doi: 10.1097/bsd.0000000000000284, PMID 25985461
- Childress MA, Becker BA. Nonoperative management of cervical radiculopathy. *Am Fam Physician*. 2016 May 1;93(9):746-54. PMID 27175952.
- Borrelli-Andrés S, Marqués-García I, Lucha-López MO, Fanlo-Mazas P, Hernández-Secorún M, Pérez-Bellmunt A. Manual therapy as a management of cervical radiculopathy: A systematic review. *BioMed Res Int*. 2021 Jun 3;2021:9936981. doi: 10.1155/2021/9936981, PMID 34189141, PMCID PMC8195637
- Xu X, Ling Y. Manual therapy for cervical radiculopathy: Effects on neck disability and pain - a systematic review and network meta-analysis. *J Pain Res*. 2025 Apr 14;18:2035-45. doi: 10.2147/jpr.s513428, PMID 40255362, PMCID PMC12008560
- García-Juez S, Navarro-Santana MJ, Valera-Calero JA, Albert-Lucena D, Varas-De-la-Fuente AB, Plaza-Manzano G. Effectiveness of articular and neural mobilization for managing cervical radicular pain: A systematic review with network meta-analysis. *J Orthop Sports Phys Ther*. 2025 Jul;55(7):1-14. doi: 10.2519/jospt.2025.12757, PMID 40576779
- López-Pardo MJ, Calvache-Mateo A, Martín-Núñez J, Heredia-Ciuró A, López-López L, Valenza MC. Routine physical therapy with and without neural mobilization in chronic musculoskeletal neck disorders with nerve-related symptoms: Systematic review and meta-analysis. *Healthcare (Basel)*. 2024;12(12):1225. doi: 10.3390/healthcare12121225, PMID 38921339
- Savva C, Korakakis V, Efsthathiou M, Karagiannis C. Cervical traction combined with neural mobilization for patients with cervical radiculopathy: A randomized controlled trial. *J Bodyw Mov Ther*. 2021 Apr;26:279-89. doi: 10.1016/j.jbmt.2020.08.019, PMID 33992259
- Joghataei MT, Arab AM, Khaksar H. The effect of cervical traction combined with conventional therapy on grip strength on patients with cervical radiculopathy. *Clin Rehabil*. 2004 Dec;18(8):879-87. doi: 10.1191/0269215504cr828oa, PMID 15609843
- ZirkI G, Schaumburger J, Gehentges M, Kaiser M. Increase in strength after multimodal pain management concept in patients with cervical radiculopathy-A non-randomized, uncontrolled clinical trial. *Medicina (Kaunas)*. 2024 Nov 28;60(12):1961. doi: 10.3390/medicina60121961, PMID 39768842, PMCID PMC11676987
- Peolsson A, Söderlund A, Engquist M, Lind B, Löfgren H, Vavruch L. Physical function outcome in cervical radiculopathy patients after physiotherapy alone compared with anterior surgery followed by physiotherapy: A prospective randomized study with a 2-year follow-up. *Spine (Phila Pa 1976)*. 2013 Feb 15;38(4):300-7. doi: 10.1097/BRS.0b013e31826d2cbb, PMID 23407407
- Seddio AE, Katsnelson BM, Gouzoulis MJ, Jabbouri SS, Jonnalagadda A, Day W. Cervical radiculopathy management with physical, chiropractic, and acupuncture therapy: Factors associated with different therapy utilization patterns. *N Am Spine Soc J*. 2025;22:100610. doi: 10.1016/j.xnsj.2025.100610, PMID 40636516
- Kamper SJ, Apeldoorn AT, Chiarotto A, Smeets RJ, Ostelo RW, Guzman J. Multidisciplinary biopsychosocial rehabilitation for chronic low back pain. *Cochrane Database Syst Rev*. 2014;2014(9):CD000963. doi: 10.1002/14651858.CD000963.pub3, PMID 25180773
- Gross A, Langevin P, Burnie SJ, Bédard-Brochu MS, Empey B, Dugas E. Manipulation and mobilisation for neck pain contrasted against an inactive control or another active treatment. *Cochrane Database Syst Rev*. 2015;2015(9):CD004249. doi: 10.1002/14651858.CD004249.pub4, PMID 26397370
- Nicholas M, Molloy A, Tonkin L. Cognitive-behavioral interventions for chronic pain and disability: Current perspectives and future directions. *Pain Manag*. 2020;10(2):145-57.
- Schipper K, Bakker M, Abma TA. Empowerment in rehabilitation: The development of a new model. *Patient Educ Couns*. 2019;102(9):1657-64.
- Saltychev M, Eskola M, Laimi K. Effectiveness of rehabilitation interventions on quality of life after musculoskeletal injuries: A systematic review. *Disabil Rehabil*. 2021;43(18):2624-33.
- McCracken LM, Morley S. The psychological flexibility model: A basis for integration and progress in psychological approaches to chronic pain management. *J Pain*. 2014;15(3):221-34. doi: 10.1016/j.jpain.2013.10.014, PMID 24581630
- Kwakkel G, Winters C, Van Wegen EE, Nijland RH, Van Kuijk AA, Visser-Meily A, et al. Effects of unilateral upper limb training in two distinct prognostic groups early after stroke: The explicit-stroke randomized clinical trial. *Neurorehabil Neural Repair*. 2016;30(9):804-16. doi: 10.1177/1545968315624784.
- Langhorne P, Coupar F, Pollock A. Motor recovery after stroke: A systematic review. *Lancet Neurol*. 2009 Aug 1;8(8):741-54.

- doi: 10.1016/S1474-4422(09)70150-4, PMID 19608100
33. Teasell R, Hussein N, Foley N. Physical rehabilitation approaches to improve motor function after stroke. *J Stroke Cerebrovasc Dis.* 2020;29(9):105132.
 34. Williams J, D'Amore P, Redlich N, Darlow M, Suwak P, Sarkovich S. Degenerative cervical myelopathy: Evaluation and management. *Orthop Clin North Am.* 2022;53(4):509-21. doi: 10.1016/j.ocl.2022.05.007, PMID 36208893
 35. Harrop JS, Naroji S, Maltenfort M, Anderson DG, Albert T, Ratliff JK. Cervical myelopathy: A clinical and radiographic evaluation and correlation to cervical spondylotic myelopathy. *Spine (Phila Pa 1976)* 2010 Mar 15;35(6):620-4. doi: 10.1097/BRS.0b013e3181b723af, PMID 20150835
 36. Nemani VM, Kim HJ, Piyaskulkaew C, Nguyen JT, Riew KD. Correlation of cord signal change with physical examination findings in patients with cervical myelopathy. *Spine (Phila Pa 1976)* 2015 Jan 1;40(1):6-10. doi: 10.1097/brs.0000000000000659, PMID 25341986
 37. Muthukumar N. Surgical management of cervical spondylotic myelopathy. *Neurol India.* 2012 Mar-Apr;60(2):201-9. doi: 10.4103/0028-3886.96402, PMID 22626705

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