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IMPACT OF DRY NEEDLING WITH MYOFASCIAL RELEASE; A SYNERGISTIC APPROACH FOR PAIN, MOBILITY AND DYNAMIC BALANCE IN CERVICAL MYOFASCIAL PAIN SYNDROME: A RANDOMIZED CONTROLLED TRIAL

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Abstract

Background: Cervical myofascial pain syndrome (MPS) causes severe pain, impairs range of motion (ROM), and dynamic balance.

Objective: Compare impact of Dry Needling combined with Myofascial Release (DN+MFR) versus Conventional Physiotherapy cervical pain, range of motion (ROM) and dynamic balance among patients diagnosed with cervical myofascial pain syndrome (MPS).

Methods: A two-arm randomized controlled trial (N = 50; 25 per group) was conducted over 4 weeks, with assessments at pre-, mid-, and post-intervention stages. Group A (Interventional group) received Dry Needling with Myofascial Release while Group B (Control group) received conventional physiotherapy management of MPS; which comprised of TENS, Therapeutic Ultrasound and ROM exercises. Outcomes included pain (NPRS), dynamic balance (Y-Balance Test), and cervical ROM (CROM Deluxe). Data were analyzed using GLM repeated-measures ANOVA with sphericity checks and Greenhouse–Geisser corrections applied where necessary.

Results: Large time effects for all outcomes ($p<.001$; $\eta^2= .91–.97$). There were marked Time×Group interactions favoring DN+MFR for pain ($F(1.90,91.22)=136.84$, $p<.001$, $\eta^2=.740$) and for ROM; flexion ($F(1.75,84.02)=137.46$, $p<.001$, $\eta^2=.741$), extension ($F(2,96)=133.26$, $p<.001$, $\eta^2=.735$), rotation left ($F(1.74,83.43)=130.40$, $p<.001$, $\eta^2=.731$), and rotation right ($F(1.75,83.84)=143.27$, $p<.001$, $\eta^2=.749$). Post means (±SE): NPRS DN+MFR 0.48±0.16 vs Control 5.64±0.16. Between-group effects also favored DN+MFR for pain and several ROM planes (all $p<.001$). Y-Balance improved strongly over time in both groups; Left composite showed no interaction ($p=.864$) and no between-group difference ($p=.107$), while Right composite showed a small interaction ($F(1.25,59.99)=5.37$, $p=.017$, $\eta^2=.101$) with higher Post means in DN+MFR.

Conclusion: Dry Needling combined with Myofascial Release produced substantially greater pain reduction and ROM gains than conventional physiotherapy; balance improved in both groups, with only modest between-group differences.

INTRODUCTION

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INTRODUCTION

Neck pain constitutes one of the most prevalent musculoskeletal disorders globally, with studies indicating a lifetime prevalence ranging broadly (for example, mean ~48.5% in adults) and annual prevalence often exceeding 30% or higher in many populations. Its socioeconomic impact is substantial, stemming from lost productivity, health-care utilization, and disability (Fejer et al,.2006; Kazeminasab et al,.2022). Among the various underlying etiologies of chronic mechanical neck pain, cervical myofascial pain syndrome (MPS) remains a significant contributor, particularly in young to middle-aged adults. Myofascial pain syndrome is characterized by the presence of myofascial trigger points (MTrPs), hyper-irritable foci situated within taut bands of skeletal muscle, which may provoke local and referred pain, motor dysfunction (such as reduced range of motion and weakness), and associated autonomic phenomena (Jafri et al,.2014). The pathophysiology of MPS involves sustained contracture of sarcomeres due to abnormal motor end-plate activity, local ischemia, and metabolic crisis leading to nociceptive sensitization within the muscle spindle (Shah et al., 2015). These physiological changes produce muscular stiffness, restricted Cervical Range of Motion (CROM), altered postural control, and impaired dynamic balance due to the disruption of neuromuscular coordination (Farasyn & Meeusen, 2021; Sciotti et al., 2001). Chronic activation of nociceptive afferents from MTrPs may also contribute to central sensitization, amplifying pain perception and prolonging disability (Dommerholt et al., 2020).

Management of cervical MPS is multidisciplinary, with physiotherapy interventions forming the cornerstone of conservative care. Traditional modalities such as Therapeutic Ultrasound, Transcutaneous Electrical Nerve Stimulation (TENS), and Range-of-Motion (ROM) exercises have long been employed to relieve pain, enhance circulation, and restore movement. Ultrasound therapy promotes tissue healing by increasing local temperature and perfusion, facilitating collagen extensibility (Koçak et al., 2019). Similarly, TENS acts via segmental inhibition and activation of descending inhibitory pathways to reduce pain perception (Paolucci et al., 2021). Despite their popularity, systematic reviews report inconsistent long-term efficacy for these modalities in chronic MPS (Huang et al., 2021; Dundar et al., 2023). In contrast, minimally invasive and manual therapy techniques, notably Dry Needling (DN) and Myofascial Release (MFR), have shown emerging evidence of superiority for pain reduction and functional improvement in cervical MPS (Navarro-Santana et al., 2020; Liu et al., 2022). DN targets MTrPs directly by inserting sterile filiform needles into taut bands, provoking a local twitch response (LTR) that normalizes end-plate potentials, increases perfusion, and reduces nociceptive input (Tekin et al., 2013; Turo et al., 2015). Studies indicate that DN may provide greater immediate and short-term pain relief compared to stretching, ultrasound, or sham interventions (Kietrys et al., 2013; Boyraz et al., 2021). Complementary to DN, Myofascial Release (MFR) aims to restore soft-tissue mobility through gentle, sustained manual pressure on fascial restrictions, improving viscoelastic properties and reducing muscle tension (Ajimsha et al., 2015). MFR enhances proprioception, decreases sympathetic tone, and may improve muscle extensibility and joint mobility when applied to the upper trapezius and cervical fascia (Cagnie et al., 2020 ; Chaitow & De Lany, 2018). Recent randomized trials demonstrate that combining DN with MFR results in greater pain reduction, improved cervical ROM, and enhanced quality of life compared with DN alone or conventional electrotherapy (Tasoglu et al., 2017; Gildir et al., 2019)

Although both conventional physiotherapy (Ultrasound + TENS + ROM) and manual/minimally invasive therapies (DN + MFR) are widely used in clinical practice, comparative evidence assessing their relative effectiveness, particularly for dynamic balance and functional symmetry, remains scarce. Previous research has focused predominantly on pain and ROM outcomes, often neglecting neuromotor performance and postural stability, which are clinically relevant for patients resuming daily activities or occupational tasks (Shaffer et al., 2013; Plisky et al., 2006). Moreover, most available trials have been conducted in Western or East Asian populations, with minimal representation from South Asian clinical settings, where ergonomic and sociocultural factors differ substantially. Hence, this randomized controlled trial was conducted in South Punjab, Pakistan, to evaluate the comparative effectiveness of Dry Needling combined with Myofascial Release versus Ultrasound, TENS, and ROM exercises on pain (NPRS), cervical range of motion (CROM Deluxe), and dynamic balance (Y-Balance Test) among individuals with cervical MPS. Conducting this study in the local population is particularly significant given the high prevalence of mechanical neck disorders among computer users, healthcare workers, and manual laborers in Pakistan's southern regions (Ahmad et al., 2021). This trial seeks to generate evidence to guide physiotherapists toward evidence-based and cost-effective protocols, bridging the translational gap between advanced manual therapy techniques and traditional electrotherapy approaches.

METHODOLOGY

Study Design

This study was designed as a randomized controlled trial (RCT).Participants diagnosed with Cervical Myofascial Pain Syndrome (MPS) were recruited and allocated to intervention and control groups. The study followed CONSORT guidelines for non-pharmacological trials to ensure methodological transparency and reproducibility.

Sampling Technique

A consecutive non-probability sampling technique was employed to recruit participants from the Department of Rehabilitation, National Orthopedic and General Hospital Bahawalpur, Punjab, Pakistan. Eligible participants were randomly assigned to one of the treatment groups using systematic randomization to minimize selection bias.

Sample Size Calculation

Sample size analysis was conducted in G*Power 3.1. Assuming a medium effect size ($f = 0.45$), $\alpha = 0.05$, power ($1–\beta$) = 0.80, correlation among repeated measures ($r = 0.50$), and non-sphericity correction ($\varepsilon = 1.0$), the minimum required total sample was approximately 46 participants. To ensure adequate power and allow for modest attrition, the final target sample was set at 50 participants, allocated 25 per group. This sample size provides ≥80% power to detect clinically meaningful group × time effects in pain, dynamic balance, and cervical ROM outcomes (Faul, Erdfelder, Buchner, & Lang, 2009).

Study Setting

The research was conducted in the Physiotherapy and Rehabilitation Department of National Orthopedic and General Hospital, Bahawalpur. The environment provided standardized treatment cubicles, therapeutic modalities, and instrumented setups for objective measurement of range of motion and balance.

Sample Selection Procedure

Inclusion Criteria

Participants were considered eligible for inclusion if they met specific clinical and demographic criteria. Individuals aged between 20 and 40 years, of either gender, were included in the study. All participants were required to have a clinically confirmed diagnosis of Myofascial Pain Syndrome (MPS) affecting the cervical region, characterized by the presence of taut bands, palpable trigger points, and an altered craniovertebral angle, as identified by a qualified physiotherapist or physician according to standard diagnostic criteria (Nasir et al., 2025). Only those with mild to moderate MPS, with or without referred pain or cervical radiculopathy, were included to ensure homogeneity of symptom severity. Written informed consent was obtained from each participant after a comprehensive explanation of the study's objectives, intervention procedures, potential risks, and expected benefits.

Exclusion Criteria

Participants were excluded from the study if they presented with any condition that could compromise safety or interfere with treatment outcomes. Similarly, patients with severe comorbidities such as cervical myelopathy, vertebral compression, or vertigo; a history of previous cervical or cranial surgery; and pregnancy were excluded. Individuals with contraindications to dry needling or electrotherapy, such as bleeding disorders, the presence of a cardiac pacemaker, or open wounds, were also excluded. Additional exclusion factors included an inability to attend scheduled treatment sessions, significant cognitive impairment or communication, participation in concurrent physiotherapy or interventional research trials, and any history of malignancy or trauma involving the cervical spine or head. These exclusion parameters were implemented to ensure participant safety, minimize potential confounding variables, and strengthen the internal validity of the research findings.

Randomization and Group Allocation

Eligible participants who met the inclusion criteria were randomly assigned to two parallel treatment groups using a systematic allocation method to ensure equal distribution and reduce selection bias. Participants were assigned sequentially (1st participant to Group A, 2nd to Group B, and the sequence repeated accordingly). Allocation concealment was maintained through the use of sealed opaque envelopes, which were prepared by an independent researcher and opened only after baseline assessments were completed.

Group A: Dry Needling + Myofascial Release (Interventional Group)

Participants received Dry Needling (DN) targeting identified myofascial trigger points in the upper trapezius and cervical paraspinal muscles. Sterile acupuncture needles (0.25 × 25 mm, Hua Long) were inserted perpendicularly at a 30° angle into the taut bands, immobilized between the thumb and index finger to elicit a local twitch response (LTR). Each needle was left in situ for 20 minutes, rotated at the 10th minute, and then removed (Tekin et al., 2013; Tasoglu et al., 2017).

This was followed by Myofascial Release (MFR), a low-load, sustained manual stretch applied to the fascial layer until a palpable tissue release was achieved, typically lasting 90–120 seconds per segment. The session duration was ~30 minutes, twice weekly for 4 weeks.

Group B: Control Group (Electrotherapy + ROM Exercises)

Control participants received Therapeutic Ultrasound (1 MHz, 1.5 W/cm², 8 minutes) and TENS (80 Hz, 100 μs, 20 minutes) applied to the cervical region, followed by active ROM exercises for flexion, extension, rotation, and lateral flexion. Sessions were conducted twice weekly for 4 weeks. This regimen represents conventional physiotherapy care for MPS (Kumar et al., 2020).

Outcome Measures

Pain intensity was measured using the Numeric Pain Rating Scale (NPRS), a validated 11-point self-report scale where 0 = no pain and 10 = worst pain imaginable. It is widely used for musculoskeletal conditions and demonstrates high test-retest reliability (ICC = 0.95) (Jensen et al., 1993; Rodriguez et al., 2001). Cervical ROM was quantified for flexion, extension, right/left lateral flexion, and right/left rotation using the CROM Deluxe (Baseline®), a validated,

instrumented goniometer incorporating gravity and magnetic inclinometers for accurate multi-planar motion capture. (Audette et al., 2010; Tousignant-Laflamme et al., 2005). Dynamic balance was evaluated using the Y-Balance Test (YBT), a reliable and valid measure assessing neuromuscular control through reach distances in three directions, anterior, posteromedial, and posterolateral. The composite YBT score was calculated as per standard formula of the three reach distances, reflecting overall dynamic balance ability (Shaffer et al., 2013; Plisky et al., 2006).

Statistical Analysis

Data were analyzed using SPSS v25.0. The General Linear Model (GLM) Repeated-Measures ANOVA was applied to determine within-group (time effect), between-group (group effect), and interaction (time × group) differences for all dependent variables (pain, ROM, and balance). Mauchly's test assessed sphericity; when violated, Greenhouse–Geisser corrections were applied. Post-hoc analyses used Bonferroni or Tukey HSD adjustments for multiple comparisons. A p-value < 0.05 was considered statistically significant, and partial eta squared (η^2) values were reported for effect size interpretation.

RESULTS

Baseline Characteristics

Groups were comparable for age and gender (ns). BMI was higher in controls (p=.003), which can blunt mobility gains; consider a sensitivity/ANCOVA adjusting for BMI. This baseline check supports internal validity before attributing changes to treatment. (Table-1)

Table-1. Baseline Demographic Characteristics

Variable	Group A (DN + MFR) Mean ± SD (n=25)	Group B (Control) Mean ± SD (n=25)	p-value
Age (years)	29.04 ± 5.48	30.16 ± 5.26	0.464
BMI (kg/m²)	26.93 ± 5.57	31.43 ± 4.76	0.003
Gender (M/F)	11 / 14	15 / 10	0.258

Normality

Both Kolmogorov–Smirnov (KS) and Shapiro–Wilk (SW) tests yielded significant p values ($p < 0.05$), indicating minor deviations from perfect normality. The Skewness and Kurtosis values (–0.572 to –0.194 and 0.030 to –1.433) fall well within the acceptable normality range (–1.0 to +1.0) for skewness and (–2.0 to +2.0) for kurtosis (Kim, 2013; Blanca et al., 2017). Thus, both variables, NPRS_Pre (pain) and Right Composite-Pre (Y-Balance), can be treated as approximately normally distributed, validating the use of parametric GLM repeated-measures ANOVA for further inferential testing. (Table-2) The Normal Q–Q plots for NPRS and Y Balance Test illustrate that most observed data points align closely with the diagonal reference line, approximate a normal distribution, satisfying the assumption of normality required for GLM repeated-measures ANOVA. (Figure-1)

Table-2. Tests of Normality with Skewness and Kurtosis

Variable	KSS*	KS Sig.	SWS*	SW Sig.	Skewness	Kurtosis
NPRS_Pre	0.237	0.000	0.880	0.000	-0.572	0.030
Right Composite-Pre	0.147	0.009	0.909	0.001	-0.194	-1.433

*KSS: Kolmogorov–Smirnov Statistic; SWS: Shapiro–Wilk Statistic

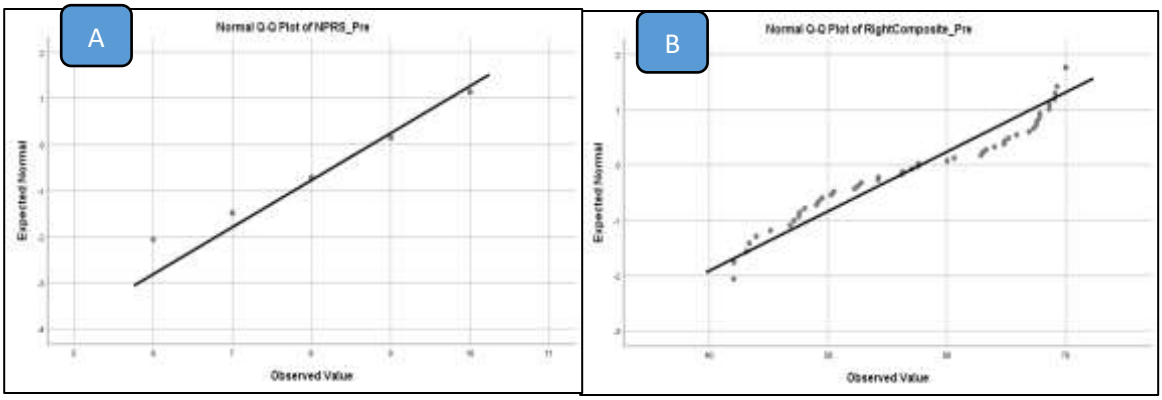

Figure-1: Q-Q Plots for NPRS (A) and Y Balance Test (B) Composite Scores

Impact on Pain (NPRS)

At baseline, both groups exhibited comparable pain levels (mean NPRS ≈ 8.48 ± 1.12 in the DN + MFR group vs 9.04 ± 0.74 in the control group). Following the 4-week intervention, pain scores declined markedly to 0.48 ± 0.82 in the intervention group and to 5.64 ± 0.81 in the control group, reflecting greater improvement in the experimental arm. The main effect of Time was highly significant ($F(2, 47) = 831.12$, $p < .001$, $\eta^2 = .945$), demonstrating substantial pain reduction across the treatment period in both groups. The Group × Time interaction was also significant ($F(2, 47) = 136.84$, $p < .001$, $\eta^2 = .740$), confirming that the DN + MFR group exhibited a steeper decline in pain intensity than the control group. A significant between-group effect ($F(1, 48) = 222.59$, $p < .001$, $\eta^2 = .823$) further established that post-treatment pain was substantially lower in participants receiving Dry Needling combined with Myofascial Release. (Table-3,4)

Table-3. Comparative NPRS Scores (Pain Intensity) Between Groups Across Time Points

Group	Pre (M ± SD)	Mid (M ± SD)	Post (M ± SD)
Intervention	8.48 ± 1.12	4.56 ± 1.04	0.48 ± 0.82
Control	9.04 ± 0.74	7.92 ± 0.91	5.64 ± 0.81

Table-4. Repeated-Measures GLM Results for NPRS

Effect	df	F	p	Partial η^2	Ob. Power
Time	2, 47	831.12	< .001	.945	1.000
Time × Group	2, 47	136.84	< .001	.740	1.000
Group	1, 48	222.59	< .001	.823	1.000

Impact on Balance (Y-Balance Test)

Both groups showed substantial time-dependent improvement in dynamic balance on both limbs, confirming that progressive physiotherapy interventions enhanced functional stability. The absence of significant group effects for the left composite and the small interaction on the right composite ($\eta^2 \approx .10$) indicate that improvements were largely symmetrical and not treatment-specific. (Table-5) Pain reduction and cervical mobility gains likely mediated the observed balance recovery through enhanced proprioceptive feedback and reduced neuromuscular inhibition rather than direct balance training effects.

Table-5. Comparative Y-Balance Composite Scores (Left & Right) Between Groups Across Time Points

Group	Left Pre	Left Mid	Left Post	Right Pre	Right Mid	Right Post
Intervention	61.50 ± 8.76	72.87 ± 7.40	87.71 ± 7.71	57.37 ± 9.31	69.44 ± 9.36	86.08 ± 8.02
Control	58.22 ± 9.47	69.89 ± 5.92	84.20 ± 4.98	58.22 ± 9.47	69.89 ± 5.92	82.73 ± 3.41

Cervical ROM

All cervical movement planes exhibited highly significant time effects ($p < .001$) and large partial η^2 values (.91 – .95), demonstrating that both treatments improved mobility over time. However, the time × group interactions were consistently large (.73 – .75), indicating a superior trajectory of improvement in the Intervention group. The enhanced motion can be attributed to pain modulation, release of taut bands, and fascial extensibility restoration achieved through DN-induced local twitch responses combined with MFR's sustained fascial loading. These mechanisms facilitate normalized motor end-plate function, reduced muscle guarding, and improved proprioceptive feedback (Fernández-de-Las-Peñas & Dommerholt, 2018; Shah et al., 2015). The use of CROM Deluxe instrumentation adds reliability and validity to these finding, previous clinimetric studies have established its excellent test-retest reliability (ICC > 0.90) for all cervical planes (Audette et al., 2010; Williams et al., 2010). (Table-6)

Table-6. Comparative Cervical ROM (°) Across All Movement Planes Between Groups Over Time

Movement Plane	Group	Pre (M ± SD)	Mid (M ± SD)	Post (M ± SD)
Flexion	Intervention	52.12 ± 5.81	65.36 ± 6.01	84.56 ± 3.45
	Control	50.72 ± 4.84	57.12 ± 4.70	64.64 ± 3.04
Extension	Intervention	35.80 ± 3.14	47.48 ± 2.76	67.20 ± 2.18
	Control	35.76 ± 5.27	41.16 ± 4.48	49.80 ± 4.88
Rotation – Left	Intervention	47.84 ± 10.41	66.40 ± 9.03	84.52 ± 7.54
	Control	45.60 ± 6.56	50.88 ± 6.56	57.48 ± 6.10
Rotation – Right	Intervention	47.44 ± 10.50	66.44 ± 9.07	84.24 ± 7.40
	Control	45.20 ± 6.60	50.92 ± 6.05	57.20 ± 5.74

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Furthermore, all Time × Group interactions were highly significant ($p < .001$, $\eta^2 = .731–.749$), suggesting that the rate and magnitude of improvement differed between groups, with the intervention group showing greater improvement compared to the control. The Between-Group effects were also significant across all movements ($p < .001$, $\eta^2 = .528–.602$), reinforcing the superior effectiveness of the DN + MFR intervention in enhancing cervical mobility compared to electrotherapy and exercise alone. (Figure-2)

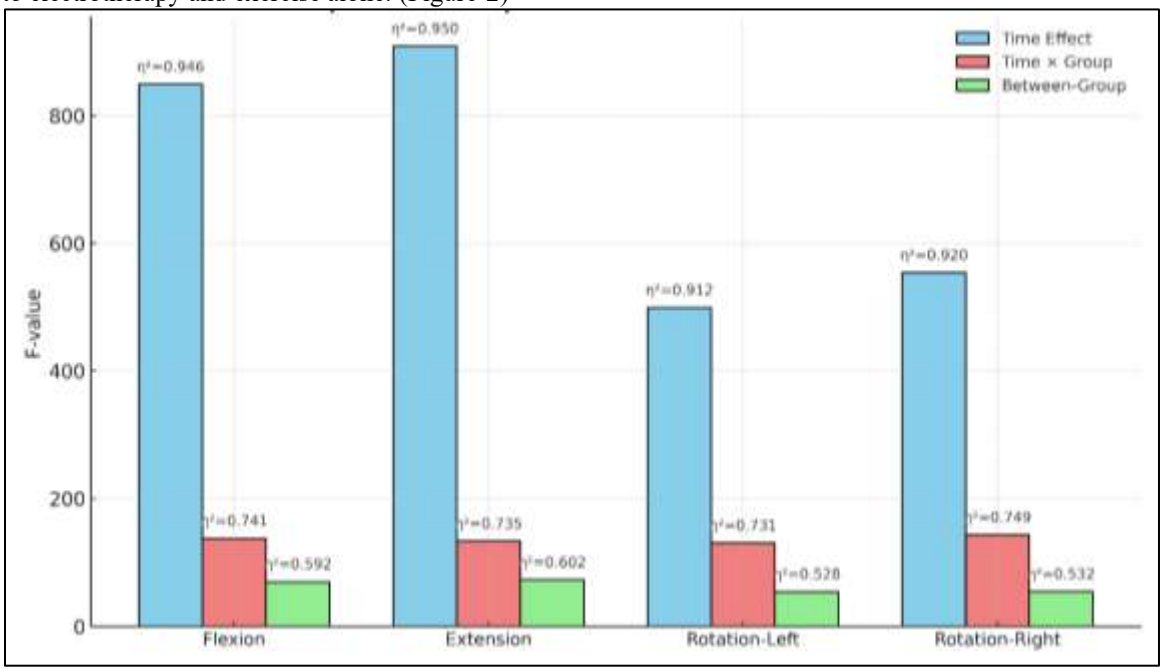

Figure-2: Group x time Comparisons for Cervical ROM Outcomes

DISCUSSION

The present randomized controlled trial examined the comparative effectiveness of DN with MFR versus a conventional physiotherapy package (therapeutic ultrasound, TENS and ROM exercises) over three time points (pre, mid, post) in adults with cervical myofascial pain syndrome (MPS). Our results demonstrated substantial reductions in pain, large gains in cervical range of motion (ROM) across flexion/extension/rotations, and improvements in dynamic balance, with consistently superior outcomes in the intervention group for pain and ROM, and more modest between-group differences in balance. The intervention group achieved a reduction in NPRS from ~8.48 to ~0.48, whereas the control group improved to ~5.64. The large time × group interaction ($\eta^2 = .740$) indicates that the combination treatment produced markedly greater analgesia. This aligns with systematic reviews reporting that dry needling applied to myofascial trigger points (MTrPs) can reduce pain in neck pain populations (Hernández-Secorún et al., 2023). Specifically, a meta-analysis found that DN improved pain and functional capacity at short and mid-term intervals (SMDs ~ −0.87) in chronic neck pain (Hernández-Secorún et al.,2023). Our results extend this evidence in a South-Punjab Pakistani cohort, and with a combined manual therapy protocol (MFR + DN) rather than DN alone.

Significant interaction effects in all measured ranges of motion ($\eta^2 = .528–.749$) favor the experimental arm. These findings suggest that beyond analgesia, the combined intervention may have corrected soft-tissue/neuromuscular restrictions more effectively. Although earlier reviews on DN alone found mixed evidence for ROM improvements (Cagnie et al., 2017), our findings support the notion that adding a myofascial release component may enhance movement restoration. This may be explained by improved tissue extensibility, fascial glide, reduction of taut bands, and restoration of motor control, all of which are physiologically plausible in MPS (Shah et al., 2015). Both groups improved markedly (large time-effects: $\eta^2 \sim .94$) in balance score. However, the between-group difference was negligible for the left composite ($\eta^2=.002$) and small for the right composite ($\eta^2=.101$). This suggests that while DN with MFR accelerated improvements in pain and ROM, balance may reflect more global neuromuscular re-adaptation influenced by both interventions (e.g., reduced pain, increased movement) rather than being highly intervention-specific. The Y-Balance Test is a validated tool in musculoskeletal research, and rapid improvements likely reflect reduced central inhibition and improved proprioceptive/motor output (Plisky et al., 2009).

Our findings are consistent with recent meta-analyses confirming the efficacy of dry needling for neck and shoulder MPS (Navarro-Santana et al., 2020; Hernández-Secorún et al., 2023) and support earlier randomized trials where MFR-based programs improved pain and function in chronic neck pain (Gauns et al., 2018). In contrast, while TENS and ultrasound remain standard modalities for short-term symptom control (Paolucci et al., 2021; Zhang et al., 2024),

their long-term functional impact appears modest, aligning with our control-group outcomes. From a clinical standpoint, DN + MFR offers a safe, cost-effective, and rapidly effective strategy for reducing pain and restoring cervical mobility in young to middle-aged adults with MPS. Its integration into physiotherapy practice is particularly relevant for resource-limited settings such as South Punjab, Pakistan, where rapid functional recovery is essential to minimize work absenteeism and healthcare costs.

The control group's improvements are consistent with literature showing that therapeutic ultrasound may reduce pain in MPS/neck pain (SMD ~ −1.04) but evidence for functional/ROM improvements is less robust (Zhang et al., 2024). TENS has also been shown to produce short-term analgesia in MPS (Pain & Therapy review). However, the magnitude of change in our control group, though clinically meaningful, was substantially less than in intervention group. This suggests that a multimodal intervention targeting trigger points plus adjunct myofascial release may be more efficacious for cervical MPS.

CONCLUSION

The present randomized controlled trial provides robust evidence that the combination of Dry Needling and Myofascial Release (DN + MFR) is markedly more effective than conventional physiotherapy comprising ultrasound, TENS, and range-of-motion (ROM) exercises for the management of cervical myofascial pain syndrome (MPS). Participants treated with DN + MFR exhibited significant reductions in pain intensity, greater increases in cervical flexion, extension, and rotation ROM, and clinically meaningful functional improvements over a four-week period, whereas the control group achieved comparatively little gains.

In conclusion, Dry Needling combined with Myofascial Release significantly outperforms conventional physiotherapy in alleviating pain and improving cervical ROM in cervical MPS, offering physiotherapists a more effective evidence-based intervention for optimizing patient recovery and quality of life.

Limitations

Several limitations should be acknowledged. First, our sample size (n=50) is appropriate for medium effect size detection yet limits generalizability. Second, though we randomized and concealed allocation, blinding of participants and therapists was not feasible; placebo effects cannot be excluded. Third, baseline BMI difference (control higher BMI) may have influenced mobility/functional recovery; future analysis should adjust for this. Fourth, the follow-up was limited to immediate post-treatment; long-term durability (3-6 months) remains untested, previous reviews highlight limited long-term data for DN (Hernández-Secorún et al., 2023). Fifth, the generalizability to older adults or those with multi-level cervical pathology may be limited. Finally, investigating biomechanical and neurophysiological biomarkers (e.g., EMG mapping, pressure-pain thresholds, shear-wave elastography) would further elucidate the mechanisms underlying observed improvements.

Recommendations

Future trials should incorporate long-term follow-up (6-12 months), include cost-effectiveness analyses (relevant in low-resource settings), and explore dose-response relationships (needle number, pressure release time, MFR duration). Comparative effectiveness with other advanced manual therapies (instrument-assisted soft tissue mobilisation, high-velocity thrusts) would also be valuable. Given the small effect size for balance improvement differentials, future work might explore targeted neuromotor training adjuncts to trigger-point interventions.

Trials Registration and Ethical Consideration

Ethical approval was obtained from the Institutional Review Board (Ref. No. NOGH/ERC/0125/006).The main study clinical trial has already been registered at PRS clinical trial registry USA (ID: NCT07098754)

Conflict of Interest: The authors declare no conflicts of interest related to the authorship or publication of this research.

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