Research Paper

Mesotherapy vs Transcutaneous Electrical Nerve Stimulation for Chronic Low Back Pain in Patients With Radiculopathy

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ABSTRACT

Objectives: Chronic low back pain (CLBP) with radiculopathy is a disabling condition, and conventional treatments often provide limited relief. Transcutaneous electrical nerve stimulation (TENS) and mesotherapy are promising modalities; however, their comparative efficacy is not well established. This study aimed to compare the effects of mesotherapy versus TENS on pain and functional disability in patients with magnetic resonance imaging-confirmed lumbar radiculopathy.

Methods: This open-label randomized clinical trial included 60 patients with CLBP. Patients were allocated to either a TENS group (10 sessions of 100 Hz stimulation) or a mesotherapy group (six sessions of subcutaneous piroxicam and lidocaine injections). Pain intensity was measured using the visual analog scale (VAS) and functional disability with the Roland-Morris disability questionnaire (RMDQ) at baseline, immediately post-treatment, and at one- and two-month follow-ups.

Results: Both TENS ($P<0.001$) and mesotherapy ($P<0.001$) groups showed significant improvements in VAS and RMDQ scores compared to their respective baselines. Immediately following the interventions, patients in the mesotherapy group demonstrated a significantly greater reduction in both pain VAS and RMDQ scores than those in the TENS group. This superiority was maintained at the one- and two-month follow-up assessments, where the mesotherapy group continued to show significantly better outcomes. The therapeutic effect of TENS was transient, with scores at one and two months not being significantly different from baseline.

Discussion: Mesotherapy provides a more potent and durable reduction in pain and disability compared to TENS for patients with CLBP. The sustained benefit of mesotherapy suggests it is a more robust therapeutic option for this condition, potentially creating a meaningful therapeutic window that allows patients to more effectively engage in active rehabilitation programs.

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Highlights

- Mesotherapy led to a sustained reduction in pain and disability in patients with chronic radicular low back pain.
- TENS showed short-term benefits, but its effects diminished after one month.
- Mesotherapy involved subcutaneous injections at acupuncture points, enhancing its therapeutic impact.
- No adverse effects were reported in either treatment group.
- Mesotherapy may offer a therapeutic window for initiating active rehabilitation programs.

Plain Language Summary

This study compares two treatment methods for chronic low back pain (CLBP) with radiculopathy: transcutaneous electrical nerve stimulation (TENS) and mesotherapy. Sixty patients with magnetic resonance imaging-confirmed herniated discs participated in the trial. Both treatments reduced pain and disability, but mesotherapy showed a stronger and longer-lasting effect. While TENS provided short-term relief, mesotherapy maintained its benefits for up to two months. These findings suggest that mesotherapy may be a more effective option for managing CLBP.

Introduction

Low back pain (LBP) is a pervasive and disabling global health condition, representing a major socioeconomic challenge due to its high associated healthcare costs and impact on work disability [1, 2]. Its lifetime prevalence in the adult population is estimated to be as high as 80%, with many individuals transitioning to chronic low back pain (CLBP), defined as pain persisting beyond 12 weeks [3, 4]. Although most cases are nonspecific, a substantial portion arises from specific spinal pathologies [4]. Lumbar radiculopathy due to nerve root compression is a common presentation of specific LBP, most frequently caused by a herniated intervertebral disc or spinal stenosis [4, 5]. Risk factors for LBP are multifactorial and include age, occupational exposures, such as heavy lifting, and various psychosocial factors [2, 5].

The management of CLBP with radiculopathy is centered on a multimodal, conservative-first paradigm that combines patient education, physical therapy, and pharmacologic interventions [3, 5]. Clinical practice guidelines commonly endorse non-pharmacologic strategies such as supervised exercise and manual therapy as foundational treatments, alongside education on maintaining activity and a favorable prognosis [4, 6]. These are often supplemented with pharmacologic agents, including nonsteroidal anti-inflammatory drugs, and, for neuropathic components, medications, such as gabapentin. For refractory symptoms, interventional procedures such as epidural steroid injections are frequently employed, though their efficacy is often temporary [3, 7]. Despite this array of options, many interventions have failed to consistently provide lasting pain relief, with numerous modalities supported by low-certainty evidence, rendering their outcomes unpredictable for a significant subset of patients [1, 4].

Among conservative modalities for managing CLBP, transcutaneous electrical nerve stimulation (TENS) is a widely employed, non-invasive, and safe method with a low side-effect profile [8]. TENS involves the pulsatile stimulation of sensory fibers and is primarily theorized to reduce pain via the 'gate control' mechanism, where the stimulation of large-diameter A-β sensory afferents inhibits the transmission of nociceptive signals from smaller A-δ and C fibers [8, 9]. However, despite its frequent use, evidence for the efficacy of TENS is conflicting, with some studies showing only slight reductions in pain and no effect on functional disability [9]. Separately, mesotherapy, which involves intradermal micro-injections of therapeutic agents, has emerged as another promising treatment for localized musculoskeletal pain [10, 11]. This technique facilitates slower drug diffusion, allowing for a localized therapeutic effect with a lower risk of systemic complications [11]. Reviews suggest it is a well-tolerated and effective option for reducing both acute and chronic musculoskeletal vertebral pain [10]. In this study, mesotherapy was injected using a new combination of acupuncture points to investigate the effectiveness of the new injection point compared to previous studies.

Despite the promise of symptomatic resolution with newly incorporated non-invasive therapeutic modalities such as TENS and mesotherapy, quality evidence is lacking to formulate robust recommendations. Accordingly, this study aimed to compare TENS and mesotherapy in a cohort of patients with CLBP due to magnetic resonance imaging (MRI)-confirmed herniated disc in an open-label randomized trial.

Materials and Methods

Study design and patient enrollment

Our study was designed as an open-label randomized clinical trial containing two treatment arms with blinded outcome evaluation. Patients who presented to the physical medicine and rehabilitation outpatient clinics affiliated with Isfahan University of Medical Sciences during 2023-2024 were assessed according to the eligibility criteria and enrolled in the study accordingly.

Eligibility criteria

The inclusion criteria were aged >18 years, a diagnosis of radicular CLBP due to disc herniation confirmed in an MRI study examined by a physical medicine specialist, and moderate to severe pain intensity (i.e. six and above on the visual analog scale [VAS]). Patients with a history of surgery within the preceding three months, rheumatological disease, neurological disease (e.g. multiple sclerosis, central or peripheral neuropathy), other systemic diseases (e.g., diabetes mellitus, chronic kidney disease), structural spinal pathologies (e.g. spondylolysis, spondylolisthesis, vertebral fracture, scoliosis), metabolic diseases of bone (e.g. Paget's disease), coagulopathy including primary (e.g. hemophilia) or secondary (e.g. warfarin use) conditions, illicit drug abuse, infection at the site of planned mesotherapy injection, sacroiliac inflammation detected in physical examination, use of complementary treatment modalities, including acupuncture, herbal medication, TENS, or mesotherapy, within the preceding 4 weeks, or allergy to mesotherapy medications, including lidocaine and piroxicam, or neoplastic disorders were excluded from the study.

Patient randomization and allocation

Eligible patients were randomly allocated to either the TENS group or mesotherapy group in a 1:1 ratio. A computer-generated random number sequence was used, employing a permuted block randomization design with randomly varying block sizes of 4 and 6, including six of 4 (24 patients) and six blocks of 6 (36 patients). This method ensures that the number of participants in each treatment arm remains closely balanced throughout the enrollment period.

The randomization list was generated using The R Project for Statistical Computing by a study statistician with no clinical involvement in the trial. To ensure allocation concealment, the treatment arms were placed in sequentially numbered, sealed, opaque envelopes. After a participant was enrolled, the next available envelope in the sequence was opened by a study coordinator to reveal the group assignment. Given the nature of the therapeutic procedures, patients and the treating therapists could not be blinded.

Treatment arms

The two treatment arms of our study included the mesotherapy and TENS groups. All patients, regardless of their allocated treatment group, received baseline treatment comprising baclofen (10 mg daily) and Williams Flexion Exercises [12] for five sets three times daily.

Mesotherapy group

The mesotherapy solution comprised 1 mL of 2% lidocaine and 1 mL of 20 mg/mL piroxicam. Patients in the mesotherapy group received subcutaneous mesotherapy injection at 10 acupuncture points associated with LBP, including BL22, BL23, BL24, BL25, BL51, BL52, BL40, BL36, GB30, and K3. Mesotherapy treatment was conducted twice weekly for three consecutive weeks, for a total of six sessions.

TENS group

Patients in the TENS group received an electrical current of 100 Hz with a pulse width of 200-300 microseconds for 20 minutes through four electrodes every other day for a total of 10 sessions. TENS currents were produced using a Novin Multi Stim 735X (Novin Medical Engineering Company, No. 510, Parsian Complex, Charbagh Bala, Isfahan, Iran) device. The TENS pads were placed paraspinally over the lumbar region, targeting the areas of pain in the lower back.

Harms monitoring

Patients were actively monitored during each treatment session and at all follow-up visits for adverse events, including hematoma, infection, allergic reactions, neurological symptoms, and TENS-related skin irritation or burns. Participants were also instructed to report any delayed adverse effects by telephone. No adverse events were identified during active surveillance.

Treatment fidelity

All mesotherapy injections and TENS applications were administered by a board-certified physical medicine and rehabilitation specialist with >10 years of clinical experience. The intervention protocol was standardized, and the treating physicians adhered to a predefined procedural checklist to ensure fidelity across participants.

Outcome measures

The outcomes of our study were assessed using a VAS on a discrete scale of 0 (no pain) to 10 (worst possible pain), classified as mild (1-3), moderate (4-7), and severe (8-10), and the Roland-Morris disability questionnaire (RMDQ) [13]. Both outcome measures were assessed before the treatment initiation, immediately after completion of the treatment courses, and one month and two months after treatment termination. The researcher in charge of patient handling during the acquisition of outcome measures was blinded to the allocated treatment groups.

Statistical analysis

Categorical and continuous variables were described as frequency (percentage of relative frequency) and Mean±SD. Independent samples t-test and chi-square or Fisher's exact test were used to assess differences in continuous and categorical variables, respectively, among the two groups. Analysis of covariance (ANCOVA) was used to adjust for baseline VAS and RMDQ because it improves precision by accounting for initial differences. Repeated-measures ANCOVA was used to compare outcomes while adjusting for baseline values. This approach provided unbiased estimates of treatment effects when baseline imbalance exists.

Results

Table 1 presents the results of the comparison of demographic characteristics, pain scores, and RMDQ scores in the two groups: TENS and mesotherapy (MESO).

The results indicated no significant difference in the frequency distribution of gender, education level, and disk location, or the average age between the two study groups (P>0.05). However, the pain score and RMDQ score at baseline showed significant differences between the two groups (P<0.05) (Table 1).

Table 2 presents the results of the comparison of the average pain and RMDQ scores over time (before, immediately after, one month later, and two months after the intervention).

The results obtained from the independent t-test indicated a statistically significant difference between the average pain scores in the two groups, TENS and MESO, at the time before the intervention (P=0.006), immediately after the intervention (P<0.001), one month after the intervention (P<0.001), and two months after the intervention (P<0.001) (Table 1).

The results obtained from the independent t-test indicated a statistically significant difference between the average RMDQ scores in the two groups, TENS and MESO, at the time before the intervention (P=0.047), immediately after the intervention (P<0.001), one month after the intervention (P<0.001), and two months after the intervention (P<0.001) (Table 1).

The results obtained from the repeated-measures ANCOVA, controlling for the baseline pain score, showed that the main effect of the group on pain score was significant (P<0.001). In other words, a significant difference in pain scores was observed between the two groups, TENS and MESO. Additionally, the main effect of the interaction between time and group was significant on the average pain score (P<0.001). In other words, a significant difference in pain scores was observed between the two groups, TENS and MESO, at different time points.

The main effect of time on pain score was not significant (P=0.633); in other words, no significant difference was observed in pain scores across different time levels.

The results obtained from the repeated-measures ANCOVA, controlling for the baseline RMDQ score, indicated that the main effect of the group on the RMDQ score was significant (P<0.001). In other words, a significant difference in RMDQ scores was observed between the two groups, TENS and MESO. Additionally, the main effect of the interaction of time and group was significant on the average RMDQ score (P<0.001). In other words, a significant difference in RMDQ scores was observed between the two groups, TENS and MESO, at different time points.

The main effect of time on the RMDQ score was not significant (P=0.138); in other words, no significant difference in RMDQ scores was observed across different time levels.

Table 1. Comparison of baseline characteristics between TENS and MESO groups

Variables		No. (%)/Mean±SD		P
		TENS Group (n=30)	MESO Group (n=30)	
Sex	Male	7(23.3)	7(23.3)	>0.999
	Female	23(76.7)	23(76.7)	
Age		56.90±10.12	56.07±9.28	0.741
Education	Illiterate	8(26.7)	8(26.7)	0.985
	Primary	8(26.7)	9(30.0)	
	Diploma	6(20.0)	5(16.7)	
	Bachelor	8(26.7)	8(26.7)	
Disk location	L3-L4	1(3.3)	0	0.167
	L4-L5	7(23.3)	7(23.3)	
	L5-S1	16(53.3)	10(33.3)	
	L3-L4, L4-L5	0	3(10.0)	
	L4-L5, L5-S1	6(20.0)	10(33.3)	
VAS score		8.7±1.05	9.37±0.71	0.006*
RMDQ score		19.47±1.96	18.17±2.91	0.047*

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Abbreviations: TENS: Transcutaneous electrical nerve stimulation; VAS: Visual analog scale; RMDQ: Roland-morris disability questionnaire; MESO: Mesotherapy.

*<0.05 considered statistically significant, An independent samples t-test was used for statistical analysis of age, VAS score, and RMDQ score, χ^2 test was used for sex and education, and Fisher's exact test was used for disk location.

Based on the results of the Bonferroni post hoc test, the average pain score in the MESO groups showed a significant reduction at the times immediately after, one month after, and two months after the intervention compared to the baseline, while no statistically significant differences were observed between other time points.

However, in the TENS group, only the pain score obtained immediately after treatment was significantly different from the baseline score (P<0.001), while one (P=0.478) and two months (P=0.802) after, pain scores did not significantly differ from the initial pain score. Additionally, pain scores at one month and two months after the treatment did not show any significant difference (P=0.738).

Based on the results of the Bonferroni post hoc test, the average RMDQ score in the MESO group showed a significant reduction at the times immediately after, one month after, and two months after the intervention compared to the baseline, while no statistically significant differences were observed between other time points.

However, in the TENS group, only the RMDQ score obtained immediately after treatment was significantly different from the baseline score (P<0.001), while one month (P=0.711) and two months (P=0.804) after, RMDQ scores did not significantly differ from the initial RMDQ score. Additionally, RMDQ scores at one month and two months after the treatment did not show any significant difference (P=0.605).

Discussion

This open-label randomized clinical trial was designed to compare the efficacy of TENS versus mesotherapy in patients with CLBP secondary to MRI-confirmed radiculopathy. The primary findings demonstrated that while both treatment modalities led to a significant improvement in pain and functional disability compared to their respective baselines, mesotherapy resulted in statistically superior outcomes at all post-treatment time points. Specifically, the mesotherapy group experienced a significant and sustained reduction in both VAS and

Table 2. Repeated-measures ANCOVA (controlling for baseline VAS score and RMDQ score) comparing changes in VAS score and RMDQ score outcome measures from immediately after to two months later in the TENS and MESO groups

Variables	Group	Mean±SD				P		
		Time				RM-ANCOVA		
		Before	Immediately After	One Month Later	Two Months Later	Group	Time	Time×Group
VAS score	TENS	8.92±0.86	6.40±1.29	8.80±0.58	8.96±1.06	<0.001*	0.633	< 0.001
	MESO	9.37±0.71	4.47±1.33	4.73±1.28	5.20±1.29			
	Between groups, P	0.006*	<0.001*	<0.001*	<0.001*			
RMDQ score	TENS	19.41±1.97	15.28±2.30	19.62±2.78	16.31±2.49	<0.001*	0.138	<0.001
	MESO	18.17±2.91	10.23±3.25	10.60±3.04	11.23±3.15			
	Between groups, P	0.047*	<0.001*	<0.001*	<0.001*			

Abbreviations: TENS: Transcutaneous electrical nerve stimulation; VAS: Visual analog scale; RMDQ: Roland-Morris disability questionnaire; ANCOVA: Analysis of covariance; MESO: Mesotherapy.

*<0.05 is statistically significant.

RMDQ scores that persisted through the two-month follow-up. In stark contrast, the therapeutic benefit in the TENS group was transient, with pain and disability scores returning to levels not significantly different from baseline by the one-month mark. These results contribute to the ongoing search for effective, minimally invasive treatments for a condition that often responds poorly to conventional therapies [15, 16].

The robust and sustained effect observed in our mesotherapy group aligns with its proposed mechanism of action, which involves the injection of active substances into the superficial layers of the skin to achieve a high local concentration and prolonged therapeutic effect [17]. This technique aims to maximize the local pharmacological effect—in our case, the anti-inflammatory action of piroxicam and the anesthetic effect of lidocaine—while minimizing systemic exposure and associated adverse events [18]. Our findings are consistent with multiple reviews and trials that have established mesotherapy as a well-tolerated and effective option for reducing both acute and chronic musculoskeletal pain [17, 19]. The choice of injection site may also be a critical factor; a study by Di Cesare et al. found that injecting into acupuncture points, as was done in our study, yielded more effective pain relief for CLBP than injections into trigger points [20], suggesting a potential synergistic effect between the pharmacological action and the stimulation of specific neurovascular nodes.

The performance of the TENS group in our study accurately reflected the complex and often conflicting evidence base for this modality. We observed a statistically significant improvement in pain and disability immediately after treatment, which is consistent with the 'gate control theory' of pain, in which electrical stimulation of large-diameter afferent nerve fibers is thought to inhibit the transmission of pain signals from smaller nociceptive fibers [21, 22]. However, the evidence for TENS remains contested. The meta-analysis by Resende et al. found that TENS was superior to placebo only during therapy, with the effect disappearing at follow-up, a pattern that mirrors our findings precisely [23]. The initial benefit in our TENS group waned significantly at one and two months. This transient effect is a well-documented limitation, with other studies on radiculopathy also reporting a lack of sustained benefit [24, 25]. Furthermore, the wide variability in TENS protocols across studies—including differences in frequency, pulse width, and electrode placement—contributes to the heterogeneous results in the literature, making definitive conclusions about its efficacy challenging [26, 27].

The sustained superiority of mesotherapy over TENS in our trial is a key finding. We attribute this significant difference primarily to the distinct therapeutic mechanisms and the specific pathology of our patient cohort. Chronic radiculopathy secondary to a herniated disc is characterized by both mechanical nerve root compression and significant chemical irritation from inflammatory mediators released by the nucleus pulposus [5].

Mesotherapy, with its direct delivery of an anti-inflammatory agent (piroxicam), directly addresses this underlying inflammatory pathophysiology. TENS, in contrast, provides only symptomatic neuromodulation of pain perception without altering the local inflammatory environment [23]. Therefore, it is logical that the direct pharmacological intervention of mesotherapy produced a more profound and, crucially, more durable effect than the symptomatic modulation of TENS.

From a clinical perspective, these findings suggest that for patients with moderate-to-severe chronic radicular pain from a herniated disc, mesotherapy may be a more robust treatment option than TENS. The ability of mesotherapy to provide significant and lasting relief for at least two months could be instrumental in breaking the cycle of pain and inactivity, thereby creating a "therapeutic window" for patients to engage more fully in the active components of rehabilitation, such as the prescribed Williams Flexion Exercises. This aligns with the consensus that CLBP is a heterogeneous condition that is best managed with a multimodal approach, where passive treatments facilitate active participation [16]. Clinical practice guidelines consistently endorse a combination of education, exercise, and manual therapies, with pharmacology as an adjunct [28, 29]. Our findings suggest mesotherapy may be a particularly effective adjunct for this patient population.

Several limitations of our study must be acknowledged. First, the open-label design means that patient and therapist expectations could have influenced the results. Although the outcome assessor was blinded, performance bias cannot be fully excluded. Second, our trial began with a statistically significant difference in baseline VAS and RMDQ scores between the groups. We adjusted for this covariable in our statistical analysis (ANCOVA), which is the appropriate method to account for such differences; however, this initial imbalance remains a limitation. Third, our sample size of 60 patients, while sufficient to detect the large differences observed, may have been underpowered to detect smaller but still clinically relevant differences at longer follow-up intervals. Finally, our study population was highly specific, and the findings may not be generalizable to patients with nonspecific LBP or radiculopathy from other causes, such as spinal stenosis.

In this study, none of the patients experienced treatment complications, including hematoma, injection site ulcers, allergies, drug side effects, or burns from TENS.

Conclusion

In conclusion, this study demonstrates that while both mesotherapy and TENS are effective in the short term for chronic radicular LBP, mesotherapy provides a significantly greater and more durable reduction in both pain and disability that is sustained for at least two months. In contrast, the effect of TENS was transient. Based on these results, mesotherapy appears to be a more effective therapeutic option for this specific condition. Future research should focus on larger, sham-controlled trials with longer follow-up periods to confirm these findings and to explore the long-term role of mesotherapy within a comprehensive rehabilitation program for patients with chronic radiculopathy.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Isfahan University of Medical Sciences, Isfahan, Iran (Code: IR.MUI.MED.REC.1402.263), was explained to eligible patients, and written informed consent was obtained before patient allocation.

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Authors' contributions

All authors contributed equally to the conception and design of the study, data collection and analysis, interpretation of the results, and drafting of the manuscript. Each author approved the final version of the manuscript for submission.

Conflict of interest

The authors declared no conflicts of interest.

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