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# Influence of TECAR Therapy on Proprioception Functions in Cervical Radiculopathy

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## ABSTRACT:

**Objectives:** This study examined whether combined TECAR therapy into a cervical proprioception protocol enhances pain and function in cervical radiculopathy secondary to disc bulge.

**Methods:** 60 participants aged from 30 to 40 years old with cervical radiculopathy secondary to disc bulge. They were recruited and randomly allocated to two equal groups. The active TECAR group received radiofrequency TECAR therapy plus designed cervical proprioception protocol, while the sham TECAR group underwent sham TECAR p;us the same designed proprioception protocol. Interventions were conducted three sessions per week for 4 weeks. All outcomes were assessed at start and after completion of the treatment period, included cervical joint position error (JPE), cervical range of motion (ROM), pressure pain threshold (PPT), and Neck Disability Index (NDI) scores.

**Results:** In both groups, outcome measures improved significantly over the 4-week intervention period,. However, more favorable enhancement in the active TECAR group, with statistically significant larger decreases in cervical JPE and NDI scores and more ncreases in PPT and ROM compared with the sham TECAR group ($p < 0.05$).

**Conclusion:** TECAR therapy plus designed cervical proprioception protocol produced greater enhancement in cervical pain and function in Cervical radiculopathy secondary to disc bulge.

## 1. INTRODUCTION

Cervical spine musculoskeletal disorders are among the most prevalent presentations in modern clinical practice and are often linked to significant limitations in daily activities, reduced occupational capacity, and a general decline in quality of life [1]. Cervical radiculopathy is a particular neurological condition that results from irritation or compression of a cervical nerve root [2]. It is typically characterized by muscle weakness, hyporeflexia, and sensory abnormalities limited to the dermatome that corresponds to the affected root level. A subset of patients may develop more severe neurological deficits that require more intensive and all-encompassing therapeutic approaches [3].

Proprioception denotes afferent sensory information originating from muscles, joints, and deep tissues that provides the central nervous system with continuous feedback on body segment position and movement.. In the cervical spine, this proprioceptive feedback is crucial for precise control of head and neck orientation and for the coordination of cervical motion with trunk movement and the external environment [4]. Altered proprioceptive input and impaired sensorimotor integration are believed to be key contributors to the initiation and maintenance of symptoms in cervical spondylosis and other chronic cervical disorders [5]. Impaired cervical proprioception often results in maladaptive postural strategies, which muscle length–tension balance. This imbalance, characterized by shortening and hyperactivity of some muscles and elongation with reduced activation of others, further aggravates postural misalignment and related clinical manifestations [6].

In disc-related cervical radiculopathy, spinal nerve root compression, ongoing nociceptive drive, and hyporflexia markedly disturb afferent input from deep cervical tissues. This altered proprioceptive signalling underlies persistent pain, impaired postural control, and functional limitations that may endure despite conventional rehabilitation [2-3]. Cervical pain and inflammatory processes can impair cervical mechanoreceptor function and disrupt sensorimotor control, underscoring the importance of proprioception protocol In cervical spine disorders. TECAR is a form of radiofrequency diathermy in which high-frequency electromagnetic currents (0.3–1.2 MHz) are delivered via capacitive and resistive modes to generate endogenous deep heating within target tissue by selectively elevating temperature in muscular and nearby regions. Also, TECAR can enhance local microcirculation, modulate nociceptive input, facilitate functional recovery, relieves pain and augments functional outcomes. Furthermore, improve regional blood flow, and reduce musculoskeletal discomfort, effects that support more efficient joint and muscle performance [7,8,9].

Clinically, cervical proprioceptive protocol is likely to achieve greater benefits when performed in a tissue environment characterized by reduced pain and improved local perfusion. By enhancing these conditions, TECAR therapy may facilitate more effective sensorimotor retraining when combined with cervical proprioception protocol. Nevertheless, the therapeutic value of this combined approach for improving JPE, ROM, PPT, and NDI in patients with disc-related cervical radiculopathy remains insufficiently investigated. Therefore, the present study aimed to determine whether the TECAR plus designed cervical proprioception protocol provides superior enhancement in cervical pain and function than cervical proprioceptive exercises alone in this patient population.

## 2. MATERIALS AND METHODS

### 2.1 Study Material

This study employed a single-blind randomized controlled design and was conducted over the period from July 2025 to March 2026. Participants were enrolled at the outpatient clinic of the Faculty of Physical Therapy, Cairo University, and all intervention sessions took place in a private physiotherapy clinic. Written informed consent was obtained from each participant prior to study enrolment.

### 2.2 Sample Collection

The required sample size was estimated using G*Power (version 3.1.9.2) for a repeated-measures design, employing an effect size of f=0.277 derived from a pilot study. This calculation indicated a minimum of 54 participants. To accommodate a projected 10% attrition rate, the target sample was increased to 60 participants (30 per group).

### 2.3 Extraction Procedure

Sixty consecutive patients aged 30–40 years with MRI-confirmed cervical radiculopathy secondary to disc bulgr and symptoms longer than three months were enrolled (Figure 1). Patients with cervical trauma or myelopathy, diabetes, polyneuropathy, or contraindications to TECAR were excluded. After baseline evaluation, participants were randomized (1:1) to active or sham TECAR using a computer-generated sequence with allocation concealment (opaque, sequentially numbered envelopes prepared by an independent researcher, opened by the treating therapist after baseline). Outcomes were assessed by a physiotherapist blinded to group assignment. Sham TECAR reproduced the active protocol but with device output set to zero.

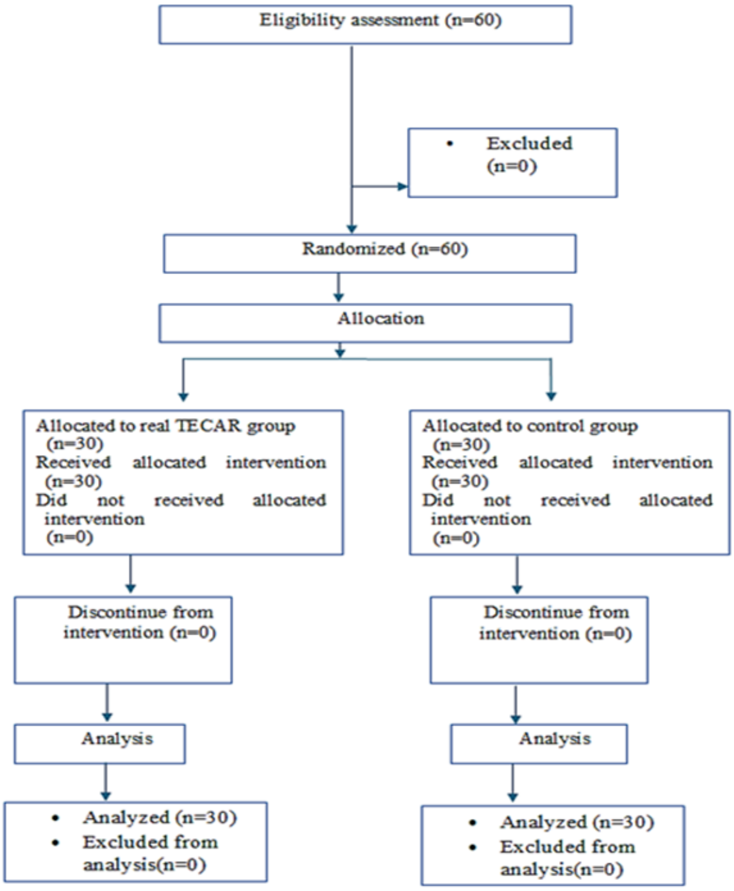


**Figure 1.** Participant flow diagram

**2.4 Analytical Methods**

All patients were assessed before the start of treatment and again after one month of intervention.

Cerviacl proprioception errrors

Cervical joint position error in the sagittal plane was quantified using a Cervical Range of Motion (CROM) device (Lindstrom, MN, USA), affixed to the participant's head according to the manufacturer's specifications. In the target head position test, maximal active flexion and extension in sagittal plane were first determined for each participant. The head was then passively positioned at 50% of this individual maximum for 3 seconds, returned to neutral, andwith eyes closedthe participant attempted to return to the target position; The absolute angular deviation between the 50% target position and the participant's reproduced position was measured in degrees as the repositioning error, and the mean of three trials in each movement direction was used for analysis [10,11].

Cervical range of motion

Cervical range of motion was measured (CROM) device (Lindstrom, MN, USA) with participants seated upright on a stable chair. Shoulder and trunk motion were restricted with straps, and under therapist instruction participants moved the head to end-range flexion and extension without trunk or shoulder movement; one familiarization trial preceded recording. [12].

Pain pressure threshold

Mechanical pain sensitivity over the upper trapezius was measuredusing a handheld pressure algometer with a 0.785 $cm^2$ rubber tip. The probe was positioned perpendicularly to the mid-belly of the right and left upper trapezius, and pressure was raised at a constant rate until participants, who could not see the display, reported that the sensation changed from pressure to pain; this value in $kg/cm^2$ was recorded as the pain pressure threshold (PPT), with three measurements per site averaged for analysis. [13].

Neck Disability Index (NDI)

Neck disability was assessed using NDI, a 10-item self-report questionnaire scored 0–5 per item (total 0–50, higher scores indicating greater disability). Total scores were expressed as a percentage (0–100) by multiplying by two, with 0 representing no limitation and 50 representing maximal disability [14,15].

Intervention

*TECAR therapy*

Active TECAR group received treatment with a Fisioline device (Fisioline SRL, Italy) delivering radiofrequency energy in the 300 kHz–1 MHz range. Each session was applied in prone and consisted of *15* minutes in resistive mode with a bracelet electrode over the cervical zygapophyseal joints, followed by *15* minutes in capacitive mode over the cervical soft tissues with a disc electrode, with intensity adjusted to a comfortably warm sensation (approximately 30–40% of maximum power), yielding a mild–moderate thermal dose. Sessions lasted one hour and were administered three times per week for one month, in line with established TECAR protocols for cervical conditions [16,17].

*Proprioception training*

Both groups underwent the same designed proprioception program. Active head movements into flexion, extension, and rotation were lead by LASER pointer. Participants then tried to return the head to neutral. Initially, exercises were done with eyes open for two sets of eight repetitions (30 second rest), then progressed by adding shape tracing tasks and varying posture (e.g. standing, walking), thereby increasing duration, repetitions, sets, and task complexity; later, the same tasks were repeated with eyes closed to further challenge cervical sensorimotor control [18].

*Treatment protocol*

The real TECAR group got 30 minutes of active TECAR therapy followed by 30 minutes of designed proprioception program, for a total session time of 60 minutes. In comparison, the sham TECAR group received TECAR application under identical placement and manual contact settings, but with the device power output set to zero, before completing the same proprioceptive exercise programme. Both groups received treatment three sessions each week for one month.

**2.5 Statistical Analysis**

Assumptions underlying MANOVA were verified before conducting the main analyses, including normality (Shapiro–Wilk), equality of variances (Levene's), homogeneity of covariance matrices (Box's M), and inspection of Pearson correlation coefficients and residual plots to exclude major violations of normality or homoscedasticity. Baseline comparability between groups was examined with independent-samples t tests for continuous variables and a chi-square test for sex. Treatment effects were analysed using a two-way mixed-model MANOVA with time (pre vs post) as the within-subject factor and group (active TECAR plus exercises vs exercises alone) as the between-subject factor, simultaneously entering cervical JPE (flexion, extension), cervical ROM (flexion, extension), RT-PPT, LT-PPT, and NDI as dependent variables; when multivariate tests were significant, Bonferroni-corrected post hoc comparisons and follow-up univariate ANOVAs were applied. All statistical procedures were conducted in IBM SPSS Statistics version 23, with the alpha level set at $p = 0.05$.

**3. RESULTS AND DISCUSSION**

3.1 RESULTS

A two-way mixed-model MANOVA showed significant main effects of group (Wilks' $\Lambda = 0.15$, $F(7, 52) = 43.63$, $p < 0.001$, partial $\eta^2 = 0.86$) and time (Wilks' $\Lambda = 0.01$, $F(7, 52) = 1031.27$, $p < 0.001$, partial $\eta^2 = 0.99$), together with a significant group-by-time interaction (Wilks' Λ = 0.12, $F(7, 52) = 54.11$, $p < 0.001$, partial $\eta^2 = 0.88$).Post-treatment, all outcome measures differed significantly between groups in favour of the real TECAR intervention, as shown in Table 2 (all $p < 0.05$). Within-group analyses showed significant pre–post improvements in all outcomes in both arms, with larger changes consistently observed in the real TECAR group (Table 3, all $p < 0.05$). In this group, NDI scores decreased by 26.2 points over 4 weeks—well above the reported MCID of 7–8 points for neck pain cohorts—while cervical JPE in flexion and extension improved by approximately 12–13°, indicating clinically meaningful recovery of cervical joint position sense[14].

**Table 1.** Baseline demographic and clinical profile of the study sample (N = 60)

| Characteristics | TECAR group (n = 30) | Sham TECAR group (n = 30) | t value | p value |
|---|---|---|---|---|
| Age (years) | 38.5 ± 3.75 | 37.4 ± 4.42 | 1.04 | 0.30 |
| Weight (kg) | 77.43 ± 3.23 | 78.20 ± 4.09 | −0.81 | 0.42 |
| Height (cm) | 170.77 ± 3.26 | 170.50 ± 3.42 | 0.31 | 0.76 |
| BMI (kg/m²) | 26.56 ± 1.06 | 26.88 ± 0.53 | −1.50 | 0.14 |
| Chronicity (weeks) | 17.67 ± 3.35 | 18.13 ± 3.66 | −0.52 | 0.61 |
| Gender, n (%) | | | | |
| Female | 17 (56.7%) | 14 (46.7%) | $\chi^2 = 0.6$ | 0.44 |
| Male | 13 (43.3%) | 16 (53.3%) | | |

BMI, body mass index; $\chi^2$, chi-square test. Data are presented as mean ± SD for continuous variables and as number (%) for categorical variables. Statistical significance was set at $p < 0.05$

**Table 2.** Pre- and post-intervention values clinical characteristics of patients (N = 60)

| Outcomes | Time | TECAR group group (n = 30) | Sham TECAR group (n = 30) | MD (95% CI)* | p value |
|---|---|---|---|---|---|
| JPE of cervical flexion (degrees) | Baseline | 18.65 ± 3.17 | 19.64 ± 2.83 | −0.99 (−2.53, 0.55) | 0.20 |
| | After 4 weeks | 6.34 ± 2.09 | 14.74 ± 3.11 | −8.40 (−9.77, −7.03) | <0.001 |
| JPE of cervical extension (degrees) | Baseline | 21.26 ± 2.52 | 20.62 ± 3.79 | 0.64 (−1.03, 2.30) | 0.45 |
| | After 4 weeks | 7.71 ± 1.38 | 14.89 ± 3.24 | −7.18 (−8.47, −5.89) | <0.001 |
| Cervical flexion ROM (degree) | Baseline | 36.2±4.14 | 35.6±3.59 | 0.6(-2.69,3.89) | 0.72 |
| | After 4 weeks | 70.23±6.95 | 65.67±4.64 | 4.57(1.51,7.62) | 0.004 |
| Cervical extension ROM (degree) | Baseline | 34.33±5.37 | 32.67±4.4 | 1.67(-1.39,4.72) | 0.28 |
| | After 4 weeks | 59.47±4.93 | 49.47±5.27 | 10(7.36,12.64) | 0.001 |
| RT-PPT (kg/cm²) | Baseline | 2.15 ± 0.33 | 2.02 ± 0.24 | 0.13 (−0.02, 0.28) | 0.09 |
| | After 4 weeks | 3.65 ± 0.37 | 2.81 ± 0.30 | 0.84 (0.67, 1.02) | <0.001 |
| LT-PPT (kg/cm²) | Baseline | 1.99 ± 0.19 | 2.00 ± 0.20 | −0.01 (−0.11, 0.09) | 0.84 |
| | After 4 weeks | 3.36 ± 0.21 | 2.78 ± 0.23 | 0.59 (0.47, 0.70) | <0.001 |
| NDI (score) | Baseline | 33.33 ± 3.47 | 34.03 ± 3.57 | −0.70 (−2.52, 1.12) | 0.44 |

| | | | | | |
|---|---|---|---|---|---|
| | After 4 weeks | 7.13 ± 2.33 | 19.23 ± 2.84 | −12.10 (−13.44, −10.76) | <0.001 |
| MD, mean difference; CI, confidence intervalRT, right; LT, left<br>*MD = (real TECAR) − (sham TECAR) | | | | | |

**Table 3.** Within-group comparisons for all outcome measures

| Outcome | TECAR group (n = 30) MD (95% CI)* | p value | Sham TECAR (n = 30) MD (95% CI)* | p value |
|---|---|---|---|---|
| JPE – cervical flexion (degrees) | 12.31 (11.10, 13.51) | <0.001 | 4.89 (3.69, 6.10) | <0.001 |
| JPE – cervical extension (degrees) | 13.55 (12.49, 14.61) | <0.001 | 5.73 (4.67, 6.79) | <0.001 |
| Cervical flexion ROM (degree) | -34.03(-35.92,-32.15) | 0.001 | -30.07(-31.95,-28.18) | 0.001 |
| Cervical extension ROM (degree) | -24.83(-27.67,-22) | 0.001 | -16.5(-19.33,-13.67) | 0.001 |
| Right PPT (kg/cm²) | −1.50 (−1.63, −1.37) | <0.001 | −0.79 (−0.91, −0.66) | <0.001 |
| Left PPT (kg/cm²) | −1.37 (−1.45, −1.29) | <0.001 | −0.77 (−0.85, −0.69) | <0.001 |
| NDI (points) | 26.20 (24.65, 27.75) | <0.001 | 14.80 (13.25, 16.35) | <0.001 |
| *MD = pre-treatment − post-treatment. Positive MD indicates improvement (reduction) in JPE and NDI, whereas negative MD indicates improvement (increase) in PPT. | | | | |

### 3.2 Discussion

Integrating TECAR into a designed proprioception exercise program yielded greater therapeutic benefits than proprioception training only in individuals with cervical radiculopathy secondary to disc bulge .Patients who received combined intervention showed larger improvements in cervical JPS, PPT, cervical ROM, and NDI, indicating a stronger therapeutic effect on both sensory and functional outcomes.

The NDI improvement after active TECAR was both statistically and clinically relevant. In the experimental group, the mean reduction of 26.2 points after four weeks was well above the MCID of 7–8 points for neck pain, suggesting a meaningful functional gain in daily life[14]. The parallel decreases of about 12–13° in JPE for flexion and extension, together with better cervical ROM (flexion MD = 4.57°, extension MD = 10.0°) and higher bilateral trapezius PPT, indicate recovery of proprioceptive control and attenuation of pain-related sensitization in this population [19].

The present findings are in line with earlier evidence indicating that multimodal rehabilitation is beneficial in cervical disorders. In chronic neck pain, proprioceptivon training enhance PPT, JPE, ROM, and disability, and additional gains have been reported when exercise is combined with adjunctive therapeutic modalities [16, 20, 21,22].

The disability reduction in the present trial was more pronounced than in previous reports: the 26.2-point between-group decrease in NDI was greater than the 14.9-point improvement reported by Sari et al. and the usual 10–15-point range described in comparable multimodal rehabilitation studies. This may indicate that both the characteristics of the study sample and the intervention methodology contributed to the stronger effect observed here [24, 25].

The greater improvement seen in the experimental group may reflect a biologically plausible synergy between TECAR therapies and structured sensorimotor training in cervical radiculopathy. In contrast to nonspecific neck pain, cervical radiculopathy involves pain together with established sensorimotor deficits, including alterd muscle spindle afferent input, disrupted gamma motor neuron activity, and reduced cervicocephalic movement sense accuracy due to nerve root compression [19,26]. As a result, these patients often begin rehabilitation with more marked proprioceptive impairment, leaving more room for improvement when pain and sensorimotor dysfunction are addressed together. By reducing pain and improving the conditions for sensorimotor retraining, TECAR combined with proprioceptive exercise provides a coherent explanation for the larger functional and proprioceptive gains observed in this study [19,20].

These findings are also consistent with the known physiological effects of TECAR therapy. By transferring capacitive and resistive radiofrequency energy, TECAR produces endogenous heat in superficial and deep cervical tissues, which may enhance local microcirculation, reduce muscle guarding, and promote removal of inflammatory mediators [27,28] . The associated rise in pressure pain threshold in the present study likely reflects reduced nociceptive input and peripheral sensitization. This is clinically relevant because persistent nociceptive input can alter gamma motor neuron activity and degrade afferent signaling from cervical mechanoreceptors, thereby reducing proprioceptive accuracy and cervicocephalic kinesthetic control [19,21]. By limiting these pain-related disturbances, TECAR may have allowed more accurate proprioceptive feedback during exercise, improved repositioning performance, and supported more effective sensorimotor adaptation[20,22]. In this sense, pain reduction is not simply symptomatic relief but may be a necessary condition for effective proprioceptive retraining. TECAR may also act through non-thermal electromagnetic mechanisms, including regulation of membrane ion channel activity and tissue electrophysiological characteristics, which could further facilitate neuromuscular activation and motor learning[16,27] Together, these effects offer a credible explanation for the superior outcomes in TECAR group, in which TECAR appears to have created a more favorable neurophysiological environment for structured proprioceptive rehabilitation.

These findings should be viewed in light of the broader evidence base and not taken as general support for TECAR in all patients with neck pain. Marked variability in treatment effects reported across TECAR trials, with $I^2$ values reaching 97%, and noted that several studiee especially those involving chronic myofascial paindid not show a clear advantage of TECAR over sham treatment or conventional exercise alone was reported [29]. Asystematic review revealed that proprioception exercises for neck and low back pain found conflicting and low-quality data to indicate any extra benefits beyond standard physiotherapy. [30].

These inconsistencies likely arise from differences in patient characteristics and treatment protocols rather than from opposing biological effects. Trials reporting modest or nonsignificant results have usually involved nonspecific chronic neck pain or myofascial pain syndrome, both of which tend to show less severe and less uniform sensorimotor impairment than disc-related cervical radiculopathy [19,26]. In such populations, the room for additional benefit from TECAR-related analgesia and improved local circulation is probably smaller. Added to this, variation in TECAR dosage, treatment length, and the frequent absence of structured sensorimotor training in earlier studies may have limited the synergistic effect expected in the present trial. Even so, Almeida et al. still found significant between-group standardized mean differences favoring TECAR despite substantial heterogeneity, at four weeks (SMD = 1.04) and eight weeks (SMD = 1.80), indicating that meaningful clinical benefit is achievable under appropriate conditions[29]. Thus, the heterogeneity more likely reflects differences in clinical samples and treatment design than a true lack of efficacy

Limitations of the study:

The study was included only participants aged 30–40 years. Second, outcomes were assessed only post one month, so the persistence of the observed effects remains unknown. Future multicenter studies with larger samples, longer follow-up, rigorous sham control, and well-defined patient subgroups are needed to confirm the value of TECAR-enhanced proprioceptive rehabilitation for cervical radiculopathy [21,22].

## 4. CONCLUSION

TECAR therapy plus designed cervical proprioception protocol produced greater improvement in cervical pain and functional outcomes in cervical radiculopathy secondary to disc bulge.

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**AUTHOR CONTRIBUTIONS**

**I. Abu Ella:** Conceptualization, Investigation**, M. A. Behiry:** Methodology**, H. A. Hamada:** Data analysis, **S. S. Youssef:** Writing, Review**, R. A. Toson:** Formal Analysis**, Radwa M. Yehia:** Editing.

**CONFLICT OF INTEREST**

The authors declare that there is no conflict of interest.

**ETHICS STATEMENT**

Ethical approval for the study protocol was obtained from the Clinical Research Ethics Committee of the Faculty of Physical Therapy, Cairo University (P.T.REC/012/005936). The trial was registered on ClinicalTrials.gov under the identifier NCT07289607.

**DATA AVAILABILITY STATEMENT**

Not applicable

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