European Journal of Pain

ORIGINAL ARTICLE

Are Stabilisation Exercises Effective After Epidural Steroid Injection in Patients With Cervical Radiculopathy? A Prospective Randomised Controlled Trial

Umut Islam Tayboga[1,2] | Yucel Olgun[3] | Osman Hakan Gunduz[3] | Savas Sencan[3]

[1]Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Istanbul Medipol University, Istanbul, Turkey | [2]Department of Physical Medicine and Rehabilitation, Institute of Health Sciences, Marmara University, Istanbul, Turkey | [3]Division of Pain Medicine, Department of Physical Medicine and Rehabilitation, Marmara University Faculty of Medicine, Istanbul, Turkey

Correspondence: Umut Islam Tayboga (umut.tayboga@medipol.edu.tr) | Savas Sencan (savas-44@hotmail.com)

Received: 25 August 2024 | **Revised:** 22 November 2024 | **Accepted:** 16 December 2024

ABSTRACT

Background: Cervical radiculopathy is caused by dysfunction of nerve roots in the cervical spine. While many studies have assessed the effectiveness of interlaminar epidural steroid injection (ILESI) and stabilisation exercises separately for this condition, our study aims to evaluate the impact of different stabilisation exercise programmes following ILESI on treatment outcomes in radiculopathy patients.

Methods: Sixty-two patients with cervical radiculopathy were randomised into three groups: cervical ILESI-only (CO), neck stabilisation group (NSG) and scapular stabilisation group (SSG). The CO group received only ILESI, while NSG and SSG underwent stabilisation exercises following ILESI. Outcomes were assessed using the Numerical Rating Scale (NRS) for neck and arm pain, the Neck Disability Index (NDI) for functionality and the Short Form-12 (SF-12) for quality of life at baseline, 1 and 3 months posttreatment.

Results: When NRS, NDI and SF-12 parameters were analysed in all groups, a statistically significant improvement was observed in the 1st and 3rd months compared to the pretreatment period. While the improvement in SF-12 physical parameters was significant in SSG and NSG in the 1st month compared to the pretreatment period, no significant difference was found in the CO group in the posttreatment periods. When the 1st and 3rd month results were analysed in NSG, a greater improvement was observed in terms of NRS_{NECK} parameter in both evaluations compared to the other groups.

Conclusions: Stabilisation exercise programme, especially neck stabilisation, should be included after ILESI treatment due to positive effects on treatment outcomes.

Significance: To the best of our knowledge, our study is the first to investigate the effect of a stabilisation exercise programme after ILESI on treatment outcomes in patients with radiculopathy due to cervical disc herniation. It is a valuable study in terms of its prospective design, its specific and homogeneous patient population and its results. Our study will help clinicians when prescribing exercise programmes for these patients.

Trial Registration: NCT05307211

1 | Introduction

Cervical radiculopathy is a neurological disorder resulting from dysfunction of the nerve roots in the cervical spine. It typically presents with arm pain and may affect sensation, motor strength and reflexes along the innervation pathway of the affected root (Bogduk 2003). Cervical radicular pain and cervical radiculopathy frequently occur simultaneously, and cervical radicular pain may evolve into radiculopathy when the underlying disorder progresses (Peene et al. 2023). Stabilisation training is a conservative therapy often used with manual interventions in chiropractic and physiotherapy, aiming to achieve optimal stabilisation in the target area to manage pain effectively (Kuligowski et al. 2021).

The literature shows that physiotherapy for cervical radiculopathy typically includes nerve mobilisation, postural training, exercise and manual therapy for the cervical and thoracic spine (Shafique, Ahmad, and Shakil-Ur-Rehman 2019; Young et al. 2009). Cervical epidural steroid injections are often used in clinical practice as a key alternative for patients who do not respond to conservative treatments such as activity modification, medication and physical therapy (Stout 2011).

Overall, there is strong evidence supporting the efficacy of cervical interlaminar epidural steroid injections (ILESI) in the treatment of cervical disc herniation, as well as moderate evidence for their use in central spinal stenosis and postlaminectomy syndrome (Manchikanti et al. 2014). However, although studies support cervical transforaminal epidural injections, the level of evidence is lower (Borton et al. 2022). Additionally, while complications associated with cervical ILESI are rare, they are more common with transforaminal epidural injections (Manchikanti et al. 2014, 2019; Mesregah et al. 2020).

Cervical stabilisation training is applied to patients diagnosed with cervical disc herniation as an exercise programme to stabilise the cervical vertebrae, reduce pain and increase functionality (Buyukturan et al. 2017). In addition, it aims to retrain and strengthen deep cervical muscles, regulate the overwork of superficial muscles and has positive effects on chronic neck pain (Celenay et al. 2021). Cervical radiculopathy, especially affecting the C6 and C7 nerve roots, is commonly linked to scapular and interscapular pain, along with neurogenic symptoms and reflex changes in the upper extremity (Waldman 2022, 2024). Alterations in dynamic scapular stability have been found in patients with chronic neck pain. As the scapula connects the neck and shoulder, stability of this complex is crucial in these patients (Seo et al. 2020).

There are many studies in the literature that investigate the effectiveness of ILESI in radiculopathy due to cervical disc herniation or the effectiveness of stabilisation exercises and physical therapy modalities separately in these patients and show their effects (Akkan and Gelecek 2018; Cohen et al. 2014; Eubanks 2010). To our knowledge, no studies have identified the optimal exercise programme after injection or its impact on outcomes. Given the benefits of exercise for cervical disc herniation-induced radiculopathy, we hypothesised that post-ILESI stabilisation exercises could improve outcomes compared to no exercise therapy. Our primary aim was to evaluate the effects of different stabilisation exercises after ILESI on treatment outcomes and provide guidance for clinicians in selecting the best exercise programme for these patients.

2 | Materials and Methods

2.1 | Participants

The research received ethical committee permission from the Marmara University Faculty of Medicine Ethics Committee (Protocol No.: 09.2022.357, date of ethics approval: 04.03.2022). The protocol of the study was registered at ClinicalTrials.gov. Patients between the ages of 18 and 65 who wanted treatment from outpatient clinics for physical medicine and rehabilitation and pain medicine for at least 3 months due to arm and neck pain and who, following a clinical examination, cervical MRI and diagnosis of unilateral chronic radiculopathy due to cervical disc herniation, did not improve with conservative measures (physical therapy applications, medication therapy, exercise therapy, etc.) included in the study. All study participants received a cervical ILESI from a pain medicine specialist with at least 10 years of experience; the specialist was blind to the patient's group assignment once all relevant information was provided and the patient's written and verbal consent was obtained. During the follow-up, no new analgesic treatment was started, and the existing analgesic treatment was not changed.

2.1.1 | Inclusion Criteria

- To be between the ages of 18–65
- Failure to respond to conservative treatment methods
- Presence of paracentral protruding disc herniation on cervical MRI responsible for the clinical presentation of the patient
- Complaint of neck and arm pain for at least 3 months
- NRS 4 and above
- Volunteering to participate in the study and signing a consent form

2.1.2 | Exclusion Criteria

- History of cervical surgery
- Cervical ILESI within the last 6 months
- Presence of entrapment neuropathy in the upper extremity
- Signs of trauma, fracture, malignancy or active infection
- Shoulder pathologies (adhesive capsulitis, rotator cuff tear, dislocation, fracture, etc.)
- Presence of rheumatological (RA-AS etc.) endocrinological (osteoporosis, Paget's disease, etc.) diseases that may change the anatomical or physiological structure of the relevant regions
- Bleeding diathesis
- Bilateral cervical radiculopathy
- Cervical central/for aminal spinal stenosis and extrude/sequestered disc herniation
- Pregnancy and breastfeeding

- Known history of allergic reaction to the injectables to be administered
- Presence of mental disorder or known psychiatric illness that may complicate the implementation of the study and follow-up steps
- Presence of cardiopulmonary disease that may lead to exercise intolerance
- Presence of cervical myelopathy
- Disc herniation above the level of C4-5 intervertebral disc

2.2 | Randomisation

Participants were randomly assigned to three groups using a computer-assisted randomisation programme: cervical ILESE-only (CO), neck stabilisation group (NSG) and scapular stabilisation group (SSG). Allocation concealment was ensured by keeping the randomisation numbers in sealed envelopes, which were opened by the physiotherapist in charge of the exercise programme just before the intervention. The randomisation process was carried out by a clinician who was independent of the study workflow to prevent any potential bias. These measures were implemented to minimise selection bias and ensure that the group assignment process was unbiased. During the follow-up phase, the physician evaluating the outcome measures was blinded to the groups to which the patients were assigned and the interventions administered. The study flow chart is shown in Figure 1.

2.3 | Intervention

2.3.1 | Cervical ILESI

The pain medicine clinic typically applies this interventional pain procedure in patients with chronic radicular pain due to cervical radiculopathy resulting from cervical disc herniation, who have not responded to conservative treatment. Patients are given detailed information regarding the injection before it is administered, and their written and verbal consent is obtained. The intravenous access line is opened to handle any problems and side effects. Throughout the procedure, all patients were monitored for blood pressure, heart rate and oxygen saturation. Patients are lying in a prone position, with a pillow placed beneath the chest to bring the head to maximum flexion. The region to be treated is cleansed three times with an antiseptic solution (povidone–iodine complex) and draped with a sterile cloth. Local anaesthesia is applied to the skin and subcutaneous tissues in the relevant area with 3 cc of 2% lidocaine. The procedure is performed under fluoroscopic guidance using a coaxial technique with an 18-gauge Tuohy needle on the right or left paramedian side of the C7-T1 interval in the direction of the patient's complaint. To visualise the

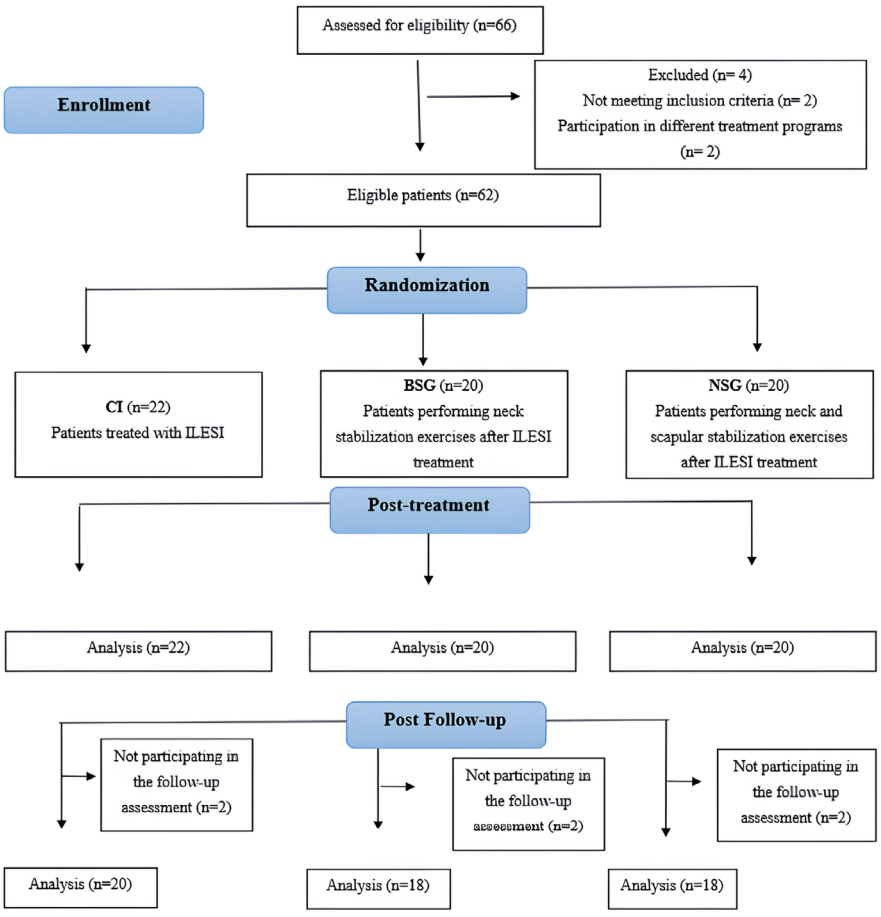

FIGURE 1 | Study flowchart.

depth of the needle, a contralateral oblique fluoroscopy angle of approximately 55°–60° is given, and the ventrospinolaminar area is approached with sequential images. After reaching the relevant area, the needle is confirmed to be in the epidural space using the hanging drop technique. Afterwards, 1 cc of iohexol contrast material is administered to check for possible intravenous and subdural/intrathecal spread. After checking that the needle is in the right place, a mixture of 12 mg dexamethasone, 1 cc 2% lidocaine and 1 cc 0.9% saline is injected. The patient is taken to the rest area after the procedure and followed up for 2 h for the presence of complications.

2.3.2 | Exercise Therapy

The first group in the study was the injection-only group, where patients received ILESI and were advised to remain active without any additional exercise programme. The second and third groups participated in a supervised exercise programme at the physical therapy unit, starting between 24 and 72 h post-ILESİ. The second group engaged in a neck stabilisation exercise programme, while the third group performed a scapular stabilisation exercise programme in addition to neck stabilisation.

Both groups engaged in warm-up exercises prior to the main exercise and cool-down exercises afterwards. Both the warm-up and cool-down phases included range of motion exercises (8–10 repetitions) and stretching exercises in all directions, with each stretch held for 15 s at the endpoint (five repetitions) (Figure 2). Exercise sessions were conducted three times a week for a duration of 4 weeks under the supervision of a physiotherapist. During the 1st week, the exercises consisted of 7–10 repetitions, followed by 10–12 repetitions in the 2nd and 3rd weeks and 12–15 repetitions in the 4th week. The number of repetitions was progressively increased based on the patient's condition and pain level.

In the NSG, the 1st week focused on tilt exercises activating the deep neck flexors in various positions, including supine, prone, on the elbows, crawling, sitting and standing (Figure 3). In the 2nd and 3rd weeks, a dynamic phase was introduced, incorporating tilt exercises with resistance bands to strengthen peripheral neck muscles through rotation and lateral flexion (Figure 4). By the 4th week, patients advanced to the functional

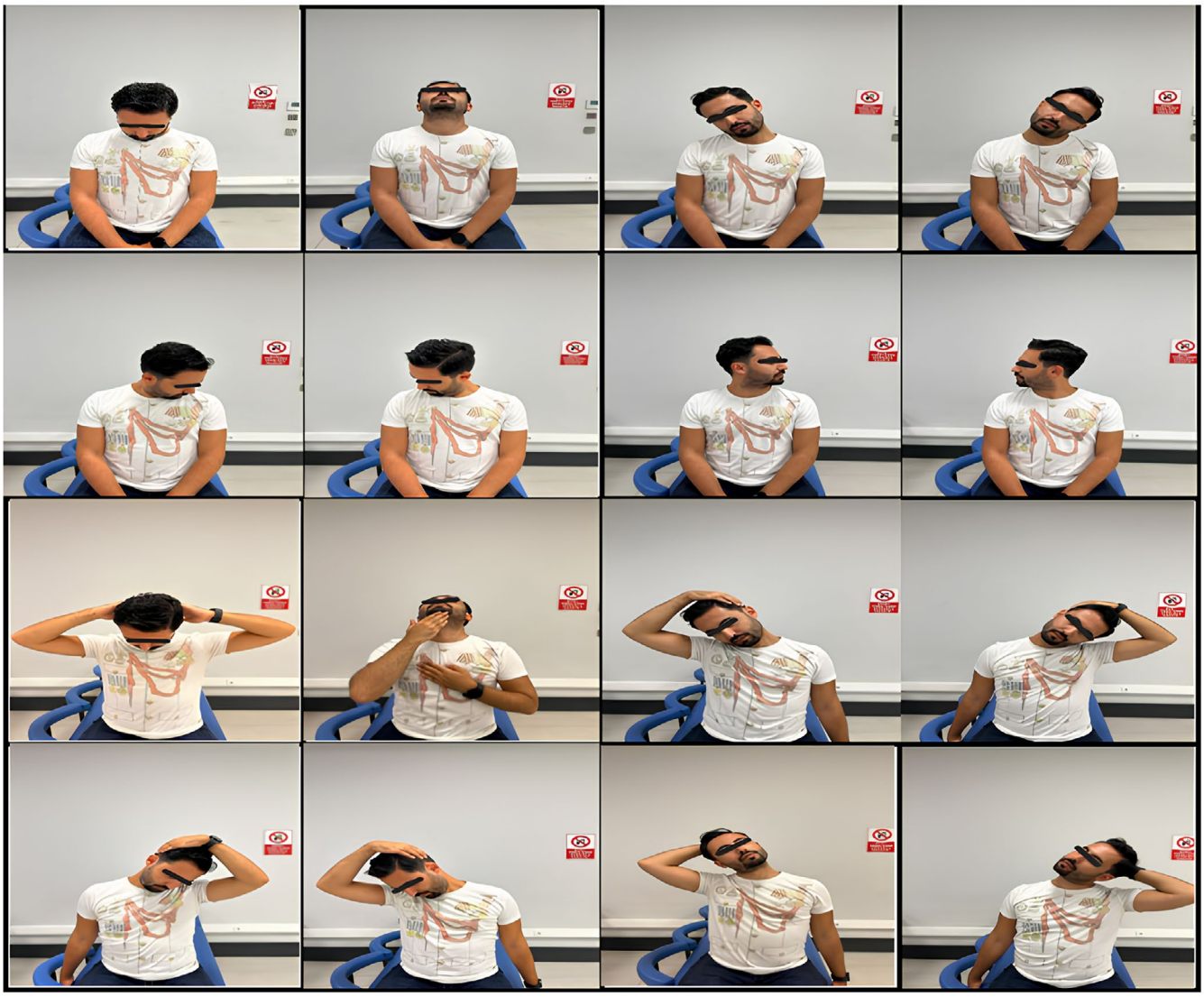

FIGURE 2 | Warm-up and cool-down exercises.

FIGURE 3 | Neck stabilisation exercises (1st-week static phase exercises).

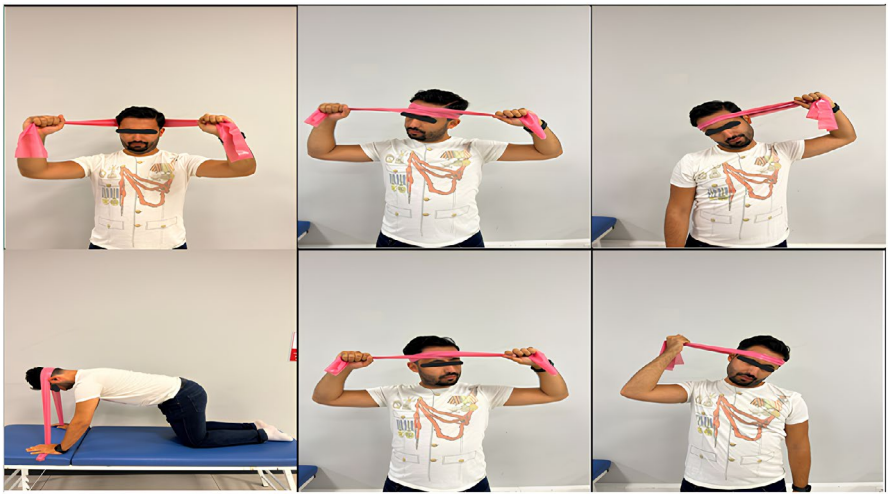

FIGURE 4 | Neck stabilisation exercises (2nd- and 3rd-week dynamic phase exercises).

phase, performing exercises with a Pilates ball and resistance bands to maintain neck tilt in increasingly challenging positions (Figure 5).

The SSG followed a similar structure but added exercises to strengthen and stabilise the scapular muscles. These included resistance exercises targeting scapular elevation, depression, retraction, protraction, abduction and adduction (Figure 6), supplementing the neck stabilisation exercises.

2.4 | Outcome Measures

All patients were evaluated face to face before the start of the programme with the Numerical Rating Scale (NRS) for neck and arm pain, the Neck Disability Index (NDI) for disability and functionality and the Short Form-12 (SF-12) Quality-of-Life Scale for quality of life. In patients in all three treatment programme groups (CO, NSG and SSG), pain intensity of the neck and arm was evaluated with NRS at the 1st-hour control after ILESI. In the NSG and SSG groups, NRS_{NECK}, NRS_{ARM}, NDI and SF-12 were evaluated at the 1st and 3rd months after the end of the 4-week exercise programme applied after injection. In the CO group, neck and arm NRS, NDI and SF-12 assessments were performed in the 1st and 3rd months after the injection treatment.

Demographic and clinical data: Information such as age, gender, body mass index (BMI), occupation, comorbidities, medications used, duration and side effects of symptoms and previous treatments were questioned in detail and recorded.

NRS: The NRS is widely used in research and clinical settings to assess pain severity (Griffin et al. 2020). In the NRS, the absence of pain is indicated as 0, and the most severe possible pain as 10 (Naylor et al. 2020). The NRS is moderately reliable, and it has been reported that a change of 1.0 points can be considered a clinically significant difference for patients with cervical radiculopathy (Cleland et al. 2006; Langevin et al. 2015).

NDI: The NDI is a validated 10-item questionnaire that measures a patient's self-reported disability due to neck pain. The score ranges from 0 (no disability) to 100 (total disability). For patients with cervical radiculopathy, the minimum detectable

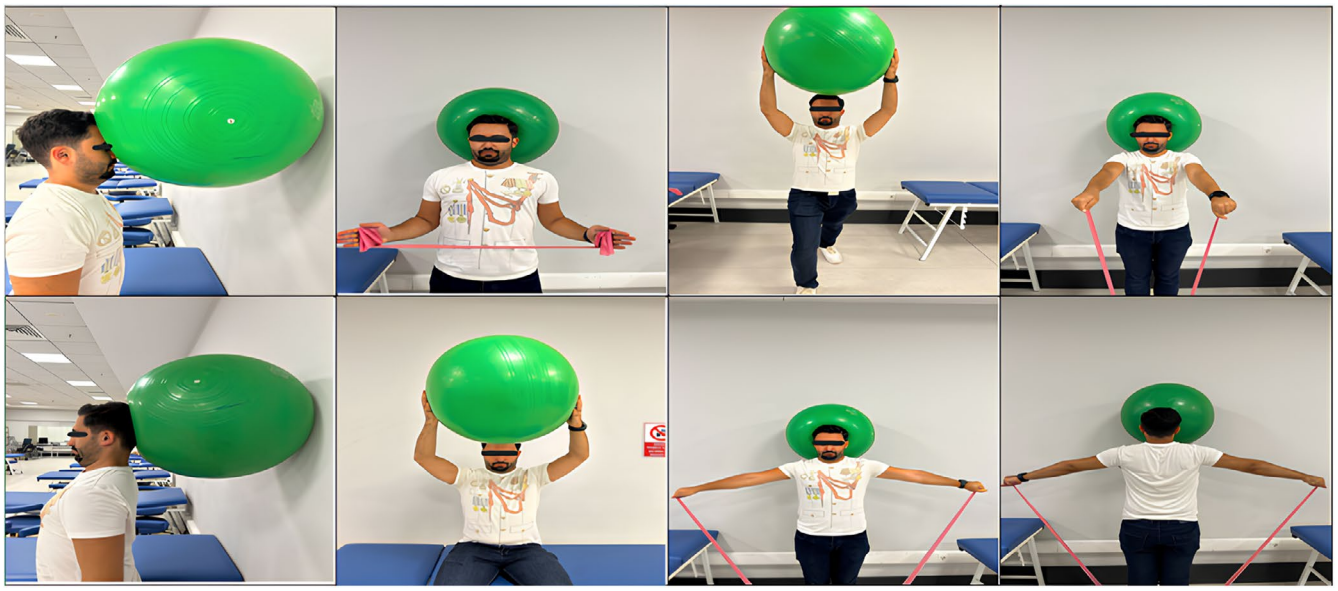

FIGURE 5 | Neck stabilisation exercises (Week 4 functional phase exercises).

FIGURE 6 | Scapular stabilisation exercises.

change is 10 points, and the clinically important difference (CID) is 14 points (Langevin et al. 2015).

SF-12 Quality-of-Life Scale: The SF-12, developed in 1994, is a scale that assesses the quality of life for the last 4 weeks without focusing on a specific age or disease group. It consists of 12 questions, all selected from the SF-36 Health Questionnaire. The SF-12 consists of physical functioning, physical role, pain, general health, emotional role, mental health, social functioning and vitality subcomponents (Sönmez et al. 2007). The summary of the mental components has six items, and the summary of the physical components also has six items. Physical and mental standardisation values are calculated separately for the answers given by the individuals. In the final stage, the summary of the physical components is calculated by adding 56,57,706 to the sum of the physical standardisation obtained for 12 questions, and the summary of the mental components is obtained by adding 60,75,781 to the sum of the mental standardisation calculated for 12 questions. High scores are considered to reflect a good health status (Derya, Erdemoğlu, and Özşahin 2019).

2.5 | Sample Size

The power analysis to determine the number of patients to be included in the study was calculated in the G Power 3.1 programme. According to the data of a study conducted by Manchikanti et al. (2010) on the efficacy of cervical ILESI applied to patients with chronic cervical disc herniation and radiculitis, it was determined that 18 patients from each group should be included in the study for 80% power at $\alpha = 0.05$ and

wide level (0.80) based on a significant decrease in NRS score at 3 months. Considering the patients who would be excluded in the follow-up, a total of 66 patients were included in the study, including at least 20 patients from each group.

2.6 | Statistical Analysis

Descriptive statistics of the measurements were calculated as mean, standard deviation, first (25th) and third (75th) quartiles, median, number and % frequencies. The conformity of the numerical data to the normal distribution was analysed by the Shapiro–Wilk test. The Kruskal–Wallis test was used to compare the groups in terms of numerical measurements that did not show a normal distribution, and Dunn's test was used to determine the different groups. The Friedman test was used for the comparison of the periods in each group, and Dunn's test was used to determine the different periods. A one-way ANOVA and post hoc Tukey test were used to compare the groups in terms of numerical measurements with a normal distribution. One-way repeated measures analysis of variance and the post hoc Sidak test were used to compare the periods in each group separately. The distribution of gender, occupation, type of analgesic medication used and education levels according to the groups was evaluated by the Pearson chi-square test. $p < 0.05$ was accepted as a statistical significance level, and the SPSS version 23 (IBM Corp., Armonk, NY) programme was used for statistical analysis.

3 | Results

A total of 62 patients were included in the study. Of these, 20 were in the CO group, 18 were in the NSG and 18 were in the SSG. The average age of the patients in the CO and NSG groups were 48.80 ± 9.84 and 48.11 ± 8.20, respectively, while the average age in the SSG group was 46.11 ± 9.88. There was no significant difference between the three groups in terms of age, gender, BMI, pain medications used and symptom duration (Table 1).

In all groups, a significant improvement was observed in NRS scores at the 1st h, 1st month and 3rd month compared to preprocedural NRS ($p < 0.001$). Significant improvements were also found in NDI and SF-12 scores in the 1st and 3rd months compared to preprocedural scores. However, while the improvement in SF-12 physical parameters was significant in the SSG and NSG groups in both the 1st and 3rd months compared to the pretreatment period, no significant difference was found in the CO group during the posttreatment periods (Table 2). When evaluating the changes in NRS, NDI and SF-12 scores between the preprocedure and the 1st and 3rd months, it was determined that the positive changes were more pronounced in all groups, particularly in the 1st month. However, the improvement in NRS neck, NDI and SF-12 physical scores from preprocedural to 1 month was greater in the NSG compared to the other groups. Additionally, the improvement in SF-12 physical scores from preprocedural to 3 months was again more pronounced in the NSG than in the other groups (Table 3).

The CID values determined from the literature for NRS and NDI were 1.0 and 14.0 points, respectively (Cleland et al. 2006; Langevin et al. 2015). It was observed that the 1-month and 3-month changes in NRS neck were significantly higher than the CID in all three groups. For NRS arm, the 1-month and 3-month changes were considerably higher than the CID in the NSG and SSG groups. However, in the injection group, the 1-month and 3-month changes were similar to the CID (Table 4). No major complications were detected during the injections. There were two minor complications: a vasovagal reaction in one patient in the CO group and a transient increase in pain at the injection site in one patient in the SSG group.

4 | Discussion

This study aimed to investigate the effects of different stabilisation exercises on short-term treatment outcomes after ILESI in patients with radiculopathy due to cervical disc herniation. Our study results support our hypothesis that a stabilisation exercise programme has a positive effect on treatment

TABLE 1 | Demographic and clinical data between the groups.

Variable value	CO ($n = 20$)	NSG ($n = 18$)	SSG ($n = 18$)	p
Age (years)	48.80 ± 9.84	48.11 ± 8.20	46.11 ± 9.88	0.663
BMI (kg/m^2)	26.71 ± 3.55	28.01 ± 5.80	27.33 ± 5.49	0.726
Symptom duration (months)	18.85 ± 12.34	9.00 ± 18.43	25.22 ± 22.67	0.483
Gender (n)				
Male	8	6	9	0.592
Female	12	12	9	
Pain medications (n)				
NSAIDs	3	9	5	0.381
Opioids	1	1	0	
Gabapentinoids	11	4	8	

Abbreviations: BMI, Body Mass Index; CO, Cervical ILESI-Only; NSG, Neck Stabilisation Group; SSG, Scapular Stabilisation Group.

TABLE 2 | Changes in NRS, NDI, and SF-12 scores over time in the CI, NSG, and NSG groups.

Variable	CO (Mean* ± SD)	*p*	NSG (Mean* ± SD)	*p*	SSG (Mean* ± SD)	*p*
NRS_{NECK} Pre	$8.15^{c} \pm 1.27$	**0.001****	$8.11^{d} \pm 1.32$	**0.001****	$7.94^{d} \pm 1.80$	**0.001****
NRS_{NECK} 1.hour	$1.75^{a} \pm 2.22$		$0.61^{a} \pm 1.33$		$2.11^{a} \pm 2.03$	
NRS_{NECK} 1.month	$5.05^{b} \pm 2.06$		$2.61^{b} \pm 1.91$		$4.17^{b} \pm 1.92$	
NRS_{NECK} 3.month	$5.70^{b} \pm 2.15$		$4.28^{c} \pm 1.64$		$5.39^{c} \pm 2.40$	
NRS_{ARM} Pre	$7.05^{c} \pm 2.91$	**0.001****	$6.22^{c} \pm 3.57$	**0.001****	$7.39^{c} \pm 2.43$	**0.001****
NRS_{ARM} 1.hour	$1.85^{a} \pm 2.52$		$1.28^{a} \pm 2.67$		$2.56^{a} \pm 2.59$	
NRS_{ARM} 1.month	$4.75^{b} \pm 2.79$		$2.33^{a} \pm 2.09$		$4.39^{a} \pm 2.09$	
NRS_{ARM} 3.month	$4.90^{b} \pm 2.38$		$3.22^{b} \pm 2.24$		$5.50^{b} \pm 2.41$	
NDI Pre	$52.56^{c} \pm 20.51$	**0.005****	$45.83^{c} \pm 14.86$	**0.001****	$45.40^{b} \pm 13.32$	**0.001****
NDI 1.month	$40.23^{a} \pm 21.21$		$21.43^{a} \pm 17.78$		$31.33^{a} \pm 14.31$	
NDI 3.month	$41.06^{b} \pm 20.84$		$29.87^{b} \pm 16.69$		$38.35^{b} \pm 15.32$	
$SF\text{-}12_{MENTAL}$ Pre	$34.88^{a} \pm 7.15$	**0.005*****	$43.62^{a} \pm 8.34$	**0.049*****	$33.99^{a} \pm 11.07$	**0.003*****
$SF\text{-}12_{MENTAL}$ 1.month	$43.38^{b} \pm 10.61$		$48.69^{c} \pm 8.60$		$43.61^{c} \pm 8.02$	
$SF\text{-}12_{MENTAL}$ 3.month	$41.35^{b} \pm 7.31$		$42.86^{a} \pm 9.64$		$40.79^{b} \pm 9.04$	
$SF\text{-}12_{PHYSICAL}$ Pre	33.80 ± 7.46	0.427***	$30.47^{a} \pm 5.45$	**0.001*****	$33.82^{a} \pm 7.51$	**0.001*****
$SF\text{-}12_{PHYSICAL}$ 1.month	36.08 ± 9.14		$49.41^{c} \pm 7.21$		$40.67^{b} \pm 6.70$	
$SF\text{-}12_{PHYSICAL}$ 3.month	34.75 ± 6.17		$43.38^{b} \pm 8.43$		$36.66^{a} \pm 7.31$	

Note: Values with $p < 0.05$ are indicated in bold in the table.
Abbreviations: CO, Cervical ILESI-Only; NDI, Neck Disability Index; NRS, Numerical Rating Scale; NSG, Neck Stabilization Group; Pre, Before the injection; SD, Standard Deviation; SF-12, Short Form 12; SSG, Scapular Stabilization Group.
*Superscripts (a, b, c) indicate statistically significant differences between groups or periods ($p < 0.05$).
**Friedman test and post hoc Dunn test.
***One Way Repeated measurement analysis of variance and post hoc Sidak test.

outcomes in patients with radiculopathy due to cervical disc herniation. Additionally, the findings suggest that a neck stabilisation exercise programme may be a better option for this patient group.

Epidural steroid injections in the cervical region can be applied using transforaminal and interlaminar methods. Both methods can be preferred in patients with chronic cervical radiculopathy who do not respond to conservative treatment (House et al. 2018). In a study conducted on patients with cervical radicular pain, one group received an epidural steroid injection via the interlaminar method, while the other group received it via the transforaminal method. When the results were analysed, significant improvements were observed in NRS and NDI parameters in the 1st and 3rd months. However, minor side effects, such as a transient increase in pain and paraesthesia, were more common in patients who underwent the transforaminal method (Sim et al. 2021). When we look at the literature, we see that the treatment effects of these two methods are similar, but the transforaminal method causes more serious catastrophic complications (Manchikanti et al. 2014). For this reason, we chose the interlaminar method as the epidural injection approach in our study because it is safer. In our study, we did not observe any serious complications except for a vasovagal reaction in one patient and a transient increase in pain at the injection site in another patient. At the same time, we found significant improvement in NRS scores and NDI in the short term in all three treatment groups, similar to the literature.

In the study conducted by Cohen et al. (2014), patients with cervical radicular pain of less than 4 years' duration were included and randomly divided into three groups. The first group received pharmacotherapy and physiotherapy; the second group received ILESI therapy; and the third group received a combination of these treatments. The results of the study showed that patients who received the combination of treatments were superior to the other groups in some criteria. In this trial, where the physiotherapy programme included massage, ultrasound, electrotherapy and exercise, there is no information about the specific exercise programme given, whether it was supervised by a physiotherapist or done as a home exercise programme. However, in our study, patients underwent physiotherapist-supervised stabilisation exercises starting as early as 24 h and no later than 72 h after ILESI, three times a week for 4 weeks, with a recommendation to continue at home thereafter. In addition, no other physiotherapy modalities were applied to the patients in our study, allowing a more objective assessment of the effect of stabilisation exercises on the results of injection therapy. In reviewing our results, significant improvements were observed in all groups, similar to the aforementioned study, with patients

TABLE 3 | Descriptive values of the changes between pre-injection and the 1st and 3rd months by group.

Variable	Groups	Initial – 1st month difference		Initial – 3rd month difference	
		Mean change* ± SD change	p**	Mean change* ± SD change	p**
NRS_{NECK}	CO	3100[a] ± 2222	**0.003**	2450 ± 2523	0.092
	NSG	5500[b] ± 2065		3833 ± 1790	
	SSG	3778[a] ± 1768		2556 ± 2121	
NRS_{ARM}	CO	2300 ± 2958	0.348	2150 ± 3133	0.461
	NSG	3889 ± 3142		3000 ± 2787	
	SSG	3000 ± 1782		1889 ± 1779	
NDI	CO	12,339[a] ± 18,913	**0.039**	11,507 ± 21,228	0.188
	NSG	24,391[b] ± 18,549		15,956 ± 17,207	
	SSG	14,071[a] ± 10,924		7,047 ± 12,050	
$SF\text{-}12_{MENTAL}$	CO	−8502 ± 12,510	0.730	−6474 ± 9934	0.126
	NSG	−5068 ± 12,386		0.756 ± 13,702	
	SSG	−9624 ± 11,685		−6807 ± 10,154	
$SF\text{-}12_{PHYSICAL}$	CO	−2275[a] ± 7423	**0.001**	−0.944[a] ± 6804	**0.001**
	NSG	−18,941[b] ± 7924		−12,907[b] ± 8771	
	SSG	−6851[a] ± 7931		−2840[a] ± 7441	

Note: Values with $p < 0.05$ are indicated in bold in the table.
Abbreviations: CO, Cervical ILESI-Only; NDI, Neck Disability Index; NRS, Numerical Rating Scale; NSG, Neck Stabilization Group; SD, Standard Deviation; SF-12, Short Form 12; SSG, Scapular Stabilization Group.
*Superscripts (a, b) indicate statistically significant differences between groups or periods ($p < 0.05$).
**Kruskal–Wallis and post hoc Dunn test.

TABLE 4 | Comparison of 1-month and 3-month changes with CID in each group separately.

Variable	Groups	Initial – 1st month difference			Initial – 3rd month difference		
		Mean change ± SD change	CID*	p	Mean change ± SD change	CID*	p
NRS_{NECK}	CO	3100 ± 2222	1.0	**<0.001**	2450 ± 2523	1.0	**0.019**
	NSG	5500 ± 2065		**<0.001**	3833 ± 1790		**<0.001**
	SSG	3778 ± 1768		**<0.001**	2556 ± 2121		**0.006**
NRS_{ARM}	CO	2300 ± 2958		0.064	2150 ± 3133		0.117
	NSG	3889 ± 3142		**0.001**	3000 ± 2787		**0.001**
	SSG	3000 ± 1782		**<0.001**	1889 ± 1779		**0.049**
NDI	CO	12,339 ± 18,913	14.0	0.699	11,507 ± 21,228	14.0	0.606
	NSG	24,391 ± 18,549		**0.029**	15,956 ± 17,207		0.636
	SSG	14,071 ± 10,924		0.978	7047 ± 12,050		**0.026**

Note: Values with $p < 0.05$ are indicated in bold in the table.
Abbreviations: CO, Cervical ILESI-Only; NDI, Neck Disability Index; NRS, Numerical Rating Scale; NSG, Neck Stabilization Group; SD, Standart Deviation; SSG, Scapular Stabilization Group.
*The clinically important difference (CID) is 1.0 point for NRS and 14.0 points for NDI.

who received stabilisation exercises in addition to injection therapy showing superiority in terms of improvement in certain parameters.

Cervical stabilisation exercises are a safe method employed to enhance cervical spine stability. Additionally, these exercises can improve mobility, vertebral alignment and sensorimotor function (Oh and Yoo 2016). The findings of a randomised controlled trial suggest that a protocol incorporating various physiotherapeutic interventions, such as hot packs, electrotherapy, exercise and patient education, effectively reduces pain severity and perceived disability in patients with cervical disc herniation in the short term. Moreover, the integration of stabilisation exercises into a standard neck exercise programme has been

demonstrated to yield similar improvements in parameters like pain severity, grip strength, level of disability and quality of life, except for posture. Multifaceted physiotherapy programmes exhibit short-term efficacy in Akkan and Gelecek (2018). We recognise the significance of stabilisation exercises and their potential as a safe intervention. Therefore, in our study, we opted for stabilisation exercises within the selected exercise regimen for our patients. Consistent with the aforementioned studies, we observed notable enhancements in pain, functionality and quality of life in the stabilisation exercise groups in addition to the ILESI method. Furthermore, significant changes over time in the NRS_{NECK} parameter were found to exceed the CID in all control periods compared to the group of patients advised to remain active without exercise therapy. Additionally, the stabilisation exercise group exhibited superior, significant improvements in the NDI parameter at 1 month and in the NRS_{NECK} parameter at 1 and 3 months compared to the other groups.

In a study of people with chronic neck pain, active scapular correction exercises were compared with passive scapular correction treatments. The study found that in the treatment group, active scapular correction exercises immediately reduced pain and tenderness at the most symptomatic cervical segment in people with chronic neck pain and scapular dysfunction. No effect was observed in those who received passive scapular correction (Lluch et al. 2014). In another study of patients with nonspecific neck pain, participants in the treatment group received neck-focused exercises and scapular stabilisation training, while participants in the control group received neck-focused exercise training only. The study found significant improvements in neck pain and disability levels after treatment in both groups, with no differences observed between the groups (Yildiz, Turgut, and Duzgun 2018). Similarly, in our study, we observed positive effects and significant improvements in pain, functionality and quality of life in the group that added scapular stabilisation exercises to cervical stabilisation exercises after ILESI compared to before treatment. In addition, similar to the study by Yildiz et al., we found that adding scapular stabilisation exercises to neck stabilisation exercises did not provide any additional benefit to the outcome of neck stabilisation exercises.

Several factors have been identified in the literature to influence the outcome of cervical ILESI. In a retrospective study by Sencan et al. (2020), severe foraminal stenosis and a high degree of herniation were identified as factors that may adversely affect the short- and medium-term outcomes of patients with cervical radiculopathy undergoing ILESI. Central/foraminal spinal stenosis and high-level disc herniation (above the C4-5 level) have been identified in the literature as negative predictors of ILESI success (Celenlioglu et al. 2023; Sencan et al. 2020) and were one of the exclusion criteria in our study. In our study, in addition to these radiological findings, other radiological characteristics such as disc herniation size and location, as well as demographic and clinical characteristics such as age, BMI, gender, duration of symptoms and analgesic treatments used, were similar between the groups. While only the $SF\text{-}12_{MENTAL}$ scores were significantly better in the NSG than in the other two groups during the pretreatment period, this difference disappeared after treatment. This allowed us to evaluate the effect of stabilisation exercise programmes on the treatment outcome of cervical ILESI differently from the literature.

4.1 | Limitations

When the literature is examined, it is stated that to achieve significant efficiency from strength and stabilisation exercises, a programme should be applied for 4 to 8 weeks with a gradual increase in intensity, 2–3 days a week (Garber et al. 2011). Previous studies on patients with chronic nonspecific neck pain and cervical radiculopathy have demonstrated that long-term exercise training can sustain pain reduction and improve functionality over extended follow-up periods (Halvorsen et al. 2016; Zhang et al. 2024). In our study, an exercise programme was applied 3 days a week for 4 weeks under the supervision of a physiotherapist. After the intervention, a home exercise programme was recommended to the patients to continue their exercises during the time they came for evaluations, but a control evaluation was not performed. For our study, our results would have been more favourable if the whole exercise process had been performed under the supervision of a physiotherapist, the fact that there was no group in which only scapular stabilisation was applied after ILESI made it difficult for us to fully demonstrate the effect of scapular stabilisation. In our study, the fact that there was an additional which only scapular stabilisation was applied after ILESI made it difficult for us to fully demonstrate the effect of scapular stabilisation. However, it does not seem to provide additional contribution when combined with neck stabilisation exercises. In addition, the short follow-up period can be counted among the other limitations of our study. The treating practitioner was not blinded; however, the practitioner cannot be blinded to the technique used when providing stabilisation exercises. The evaluations were conducted by a clinician independent of the study. Patients self-reported outcome measures, reducing provider bias and influence. A single physical therapist provided all exercise interventions, increasing the consistency of patient–practitioner interactions. Despite all these limitations, it is a valuable study in terms of its prospective design, including a specific and homogeneous patient population, and its results, being the first study to investigate the effect of a stabilisation exercise programme after ILESI on treatment outcomes in patients with radiculopathy due to cervical disc herniation.

5 | Conclusions

In patients with chronic radiculopathy due to cervical disc herniation, ILESI is a safe treatment option that provides short-term pain relief, improved functionality and quality of life. In these patients, stabilisation exercises, especially neck stabilisation exercises, should be added to the pain rehabilitation programme as a component of multimodal treatment due to the positive contribution of stabilisation exercises to treatment outcomes in the postinjection period. However, to fully clarify the role of stabilisation exercises, multicentre prospective randomised controlled trials with long-term follow-up and large patient population groups comparing stabilisation exercises with different exercise programmes are needed in the future.

Author Contributions

Conception and design: Savas Sencan and Umut Islam Tayboga; acquisition of data: Osman Hakan Gunduz and Yucel Olgun; analysis and

interpretation of data: all authors; drafting the article: Savas Sencan, Umut Islam Tayboga and Yucel Olgun; revising the article: all authors; and final approval: all authors.

Ethics Statement

Ethics approval and consent to participate: All participants signed written information and provided an informed consent form, and the study was conducted according to the principles of the Declaration of Helsinki. The research received ethical committee permission from the Marmara University Faculty of Medicine Ethics Committee (Protocol No.: 09.2022.357, date of ethics approval 04.03.2022).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

Akkan, H., and N. Gelecek. 2018. "The Effect of Stabilization Exercise Training on Pain and Functional Status in Patients With Cervical Radiculopathy." *Journal of Back and Musculoskeletal Rehabilitation* 31, no. 2: 247–252.

Bogduk, N. 2003. "The Anatomy and Pathophysiology of Neck Pain." *Physical Medicine and Rehabilitation Clinics* 14, no. 3: 455–472.

Borton, Z. M., B. J. Oakley, J. A. Clamp, N. C. Birch, and A. H. Bateman. 2022. "Cervical Transforaminal Epidural Steroid Injections for Radicular Pain: A Systematic Review." *Bone & Joint Journal* 104-B(5): 567–574. https://doi.org/10.1302/0301-620X.104B5.BJJ-2021-1816.R1.

Buyukturan, B., A. Guclu-Gunduz, O. Buyukturan, Y. Dadali, S. Bilgin, and E. E. Kurt. 2017. "Cervical Stability Training With and Without Core Stability Training for Patients With Cervical Disc Herniation: A Randomized, Single-Blind Study." *European Journal of Pain* 21, no. 10: 1678–1687.

Celenay, S. T., O. Mete, A. Sari, and D. O. Kaya. 2021. "A Comparison of Kinesio Taping and Classical Massage in Addition to Cervical Stabilization Exercise in Patients With Chronic Neck Pain." *Complementary Therapies in Clinical Practice* 43: 101381.

Celenlioglu, A. E., I. Solmaz, S. Eksert, F. Simsek, S. Ilkbahar, and E. Sir. 2023. "Factors Associated With Treatment Success After Interlaminar Epidural Steroid Injection for Cervical Radicular Pain." *Turkish Neurosurgery* 33, no. 2: 326–333. https://doi.org/10.5137/1019-5149.JTN.42539-22.2.

Cleland, J. A., J. M. Fritz, J. M. Whitman, and J. A. Palmer. 2006. "The Reliability and Construct Validity of the Neck Disability Index and Patient Specific Functional Scale in Patients With Cervical Radiculopathy." *Spine* 31, no. 5: 598–602.

Cohen, S. P., S. Hayek, Y. Semenov, et al. 2014. "Epidural Steroid Injections, Conservative Treatment, or Combination Treatment for Cervical Radicular Pain: A Multicenter, Randomized, Comparative-Effectiveness Study." *Anesthesiology* 121, no. 5: 1045–1055.

Derya, Y. A., Ç. Erdemoğlu, and Z. Özşahin. 2019. "Üniversite Öğrencilerinde Menstrual Semptom Yaşama Durumu ve Yaşam Kalitesine Etkisi." *Acıbadem Üniversitesi Saglık Bilimleri Dergisi* 2: 176–181.

Eubanks, J. D. 2010. "Cervical Radiculopathy: Nonoperative Management of Neck Pain and Radicular Symptoms." *American Family Physician* 81, no. 1: 33–40.

Garber, C. E., B. Blissmer, M. R. Deschenes, et al. 2011. "American College of Sports Medicine Position Stand. Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise." *Medicine and Science in Sports and Exercise* 43, no. 7: 1334–1359. https://doi.org/10.1249/MSS.0b013e318213fefb.

Griffin, R. S., M. Antoniak, P. D. Mac, V. Kramskiy, S. Waldman, and D. Mimno. 2020. "Imagined Examples of Painful Experiences Provided by Chronic Low Back Pain Patients and Attributed a Pain Numerical Rating Score." *Frontiers in Neuroscience* 13: 1331.

Halvorsen, M., D. Falla, L. Gizzi, K. Harms-Ringdahl, A. Peolsson, and Å. Dedering. 2016. "Short- and Long-Term Effects of Exercise on Neck Muscle Function in Cervical Radiculopathy: A Randomized Clinical Trial." *Journal of Rehabilitation Medicine* 48, no. 8: 8. https://doi.org/10.2340/16501977-2120.

House, L. M., K. Barrette, R. Mattie, and Z. L. McCormick. 2018. "Cervical Epidural Steroid Injection: Techniques and Evidence." *Physical Medicine and Rehabilitation Clinics* 29, no. 1: 1–17.

Kuligowski, T., B. Cieślik, N. Kuciel, A. Dębiec-Bąk, and A. Skrzek. 2021. "Effect of Core Stabilizing Training on Young Individuals Presenting Different Stages of Degenerative Disc Disease-Preliminary Report." *International Journal of Environmental Research and Public Health* 18, no. 7: 3499. https://doi.org/10.3390/ijerph18073499.

Langevin, P., F. Desmeules, M. Lamothe, S. Robitaille, and J.-S. Roy. 2015. "Comparison of 2 Manual Therapy and Exercise Protocols for Cervical Radiculopathy: A Randomized Clinical Trial Evaluating Short-Term Effects." *Journal of Orthopaedic and Sports Physical Therapy* 45, no. 1: 4–17. https://doi.org/10.2519/jospt.2015.5211.

Lluch, E., M. D. Arguisuelas, O. C. Quesada, et al. 2014. "Immediate Effects of Active Versus Passive Scapular Correction on Pain and Pressure Pain Threshold in Patients With Chronic Neck Pain." *Journal of Manipulative and Physiological Therapeutics* 37, no. 9: 660–666.

Manchikanti, L., K. A. Cash, V. Pampati, B. W. Wargo, and Y. Malla. 2010. "The Effectiveness of Fluoroscopic Cervical Interlaminar Epidural Injections in Managing Chronic Cervical Disc Herniation and Radiculitis: Preliminary Results of a Randomized, Double-Blind, Controlled Trial." *Pain Physician* 13, no. 3: 223–236.

Manchikanti, L., F. J. E. Falco, S. Diwan, J. A. Hirsch, and H. S. Smith. 2014. "Cervical Radicular Pain: The Role of Interlaminar and Transforaminal Epidural Injections." *Current Pain and Headache Reports* 18, no. 1: 389. https://doi.org/10.1007/s11916-013-0389-9.

Manchikanti, L., V. Pampati, A. Parr, et al. 2019. "Cervical Interlaminar Epidural Injections in the Treatment of Cervical Disc Herniation, Post Surgery Syndrome, or Discogenic Pain: Cost Utility Analysis From Randomized Trials." *Pain Physician* 22, no. 5: 421–431.

Mesregah, M. K., W. Feng, W.-H. Huang, et al. 2020. "Clinical Effectiveness of Interlaminar Epidural Injections of Local Anesthetic With or Without Steroids for Managing Chronic Neck Pain: A Systematic Review and Meta-Analysis." *Pain Physician* 23, no. 4: 335–348.

Naylor, J. C., J. D. Kilts, L. J. Shampine, et al. 2020. "Effect of Pregnenolone vs Placebo on Self-Reported Chronic Low Back Pain Among US Military Veterans: A Randomized Clinical Trial." *JAMA Network Open* 3, no. 3: e200287.

Oh, S.-H., and K.-T. Yoo. 2016. "The Effects of Stabilization Exercises Using a Sling and Stretching on the Range of Motion and Cervical Alignment of Straight Neck Patients." *Journal of Physical Therapy Science* 28, no. 2: 372–377.

Peene, L., S. P. Cohen, B. Brouwer, et al. 2023. "2. Cervical Radicular Pain." *Pain Practice: Official Journal of World Institute of Pain* 23, no. 7: 800–817. https://doi.org/10.1111/papr.13252.

Sencan, S., I. S. Edipoglu, G. Yazici, F. N. Yucel, and O. H. Gunduz. 2020. "Are Foraminal Stenosis Severity and Herniation Level Associated With the Treatment Success of Cervical Interlaminar Epidural Steroid Injection?" *Pain Physician* 23, no. 3: 325–332.

Seo, Y. G., W. H. Park, C. S. Lee, et al. 2020. "Is Scapular Stabilization Exercise Effective for Managing Nonspecific Chronic Neck Pain?: A Systematic Review." *Asian Spine Journal* 14, no. 1: 122–129.

Shafique, S., S. Ahmad, and S. Shakil-Ur-Rehman. 2019. "Effect of Mulligan Spinal Mobilization With Arm Movement Along With Neurodynamics and Manual Traction in Cervical Radiculopathy Patients: A Randomized Controlled Trial." *Japan Pharmaceutical Manufacturers Association* 69: 1601–1604.

Sim, J. H., H. Park, Y. Kim, et al. 2021. "Comparative Effectiveness of Parasagittal Interlaminar and Transforaminal Cervical Epidural Steroid Injection in Patients With Cervical Radicular Pain: A Randomized Clinical Trial." *Pain Physician* 24, no. 2: 117–125.

Sönmez, Y., R. Uçku, Ş. Kitay, et al. 2007. "İzmir'de Bir Sağlık Ocağı Bölgesinde Yaşayan 75 yaş ve Üzeri Bireylerde Yaşam Kalitesi ve Etkileyen Etmenler." *Dokuz Eylül Üniversitesi Tıp Fakültesi Dergisi* 21, no. 3: 145–153.

Stout, A. 2011. "Epidural Steroid Injections for Cervical Radiculopathy." *Physical Medicine and Rehabilitation Clinics* 22, no. 1: 149–159.

Waldman, S. D. 2022. "Chapter 3—Manny Perez: A 48-Year-Old Male With Neck Pain Radiating Into the Right Shoulder." In *The Spine*, edited by S. D. Waldman, 32–44. Philadelphia, PA: Elsevier. https://doi.org/10.1016/B978-0-323-75636-5.00003-8.

Waldman, S. D. 2024. "16—Cervical Radiculopathy." In *Atlas of Common Pain Syndromes*, edited by S. D. Waldman, 5th ed., 72–76. Philadelphia, PA: Elsevier. https://doi.org/10.1016/B978-0-443-11105-1.00016-9.

Yildiz, T. I., E. Turgut, and I. Duzgun. 2018. "Neck and Scapula-Focused Exercise Training on Patients With Nonspecific Neck Pain: A Randomized Controlled Trial." *Journal of Sport Rehabilitation* 27, no. 5: 403–412.

Young, I. A., L. A. Michener, J. A. Cleland, A. J. Aguilera, and A. R. Snyder. 2009. "Manual Therapy, Exercise, and Traction for Patients With Cervical Radiculopathy: A Randomized Clinical Trial." *Physical Therapy* 89, no. 7: 632–642.

Zhang, Y., W. Lin, M. Yi, J. Song, and L. Ding. 2024. "Effect of Long-Term Cervical Extensor Exercise Program on Functional Disability, Pain Intensity, Range of Motion, Cervical Muscle Mass, and Cervical Curvature in Young Adult Population With Chronic Non-Specific Neck Pain: A Randomized Controlled Trial." *Journal of Orthopaedic Surgery and Research* 19, no. 1: 9. https://doi.org/10.1186/s13018-023-04487-w.