Research Square

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Effectiveness and Risk Factors of CT-guided Transforaminal Epidural Steroid Injection for Cervical Spondylotic Radiculopathy in the Elderly: A Retrospective Study

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Abstract

Background

Cervical spondylotic radiculopathy (CSR) significantly impacts quality of life in elderly patients. Evidence on transforaminal epidural steroid injection (TFESI) efficacy and predictors of treatment response in this population remains limited. To evaluate the 6-month clinical efficacy of CT-guided TFESI in elderly patients with CSR and to identify factors influencing treatment outcomes.

Methods

This retrospective study included 148 elderly CSR patients undergoing CT-guided TFESI (July 2019–May 2024). Outcomes were assessed using modified MacNab scale and Numerical Rating Scale (NRS) at 6 months. Multivariate logistic regression with bootstrap resampling identified independent predictors.

Results

At 6 months, overall efficacy rate was 84.5% (125/148). Median NRS scores decreased from 7.00 (IQR 6.00–8.00) at baseline to 2.00 (IQR 1.00–4.00) at 6 months ($P < 0.001$). Number of treatment sessions was an independent predictor of treatment outcome ($P < 0.05$). Patients receiving multiple treatments had 2.74-fold higher risk of ineffectiveness compared to single treatment. No significant associations were found between efficacy and demographic characteristics, symptom duration, or baseline pain. No serious complications occurred. No serious procedure-related complications were observed during follow-up.

Conclusion

CT-guided TFESI demonstrates favorable 6-month efficacy (84.5%) in elderly CSR patients. Number of treatment sessions independently predicts therapeutic response. These findings support TFESI as an effective intervention for this population.

Trial registration:

The study was approved by the Human Ethical Committee of West China Hospital of Sichuan University and registered at www.chictr.org.cn (Identifier: ChiCTR2300077491).

Introduction

Cervical spondylotic radiculopathy (CSR) is the most common subtype of cervical spondylosis, accounting for 60% to 70% of cases[1]. It is characterized by unilateral or bilateral pain radiation and numbness in the upper limb[2]. CSR is a common condition in the elderly, usually associated with the degenerative changes in the cervical disc and intervertebral joint, which can cause mechanical compression[3, 4]. Additionally, the compression of the cervical nerve root vein congestion can stimulate

the nerve root and cause pain[5]. Pain in older adults can lead to a series of adverse consequences, including functional impairment, social withdrawal, depression, sleep disruption, and malnutrition[6].

Currently, conservative management and surgical intervention remain the primary treatment modalities for CSR. While surgical treatment has demonstrated definitive effects, many elderly patients are precluded from surgery due to significant comorbidities[7]. Moreover, even when surgery is performed, perioperative anesthesia risks and complication rates are significantly elevated, leading to increased hospitalization costs, prolonged recovery, and greater postoperative care demands[8]. As a result, conservative therapy, such as traction, physical therapy, and medication, is commonly preferred for CSR treatment[9–11]. When traditional conservative treatments such as pharmacological analgesia fail to achieve satisfactory results, transforaminal epidural steroid injection (TFESI) may be considered as an alternative clinical intervention[12].

TFESI is a minimally invasive, image-guided technique that precisely deliver a combination of local anesthetics, corticosteroids, and neurotrophic agents to the affected nerve root, offering high target specificity with low procedural invasiveness[12]. Although TFESI has been increasingly reported as an effective intervention for CSR, considerable uncertainty persists regarding its long-term clinical outcomes[13–15]. In addition, there is limited research on the predictive factors for the efficacy of TFESI treatment in the elderly population. Given the global aging trend[16] and the high prevalence of CSR among older adults, clarifying the efficacy of TFESI in this population and identifying characteristics of treatment responders is of substantial clinical relevance.

Methods

Study Design

This was a retrospective study that included patients with cervical spondylotic radiculopathy undergoing CT-guided TFESI at West China Hospital of Sichuan University (July 2019 to May 2024). The study was approved by the Human Ethical Committee of West China Hospital of Sichuan University and registered at www.chictr.org.cn (Identifier: ChiCTR2300077491).

Study Population

All patients met the following inclusion criteria: 1) ≥ 65 years of age; 2) diagnosed by two or more specialists with cervical spondylotic radiculopathy; 3) structural abnormalities identified on cervical spine imaging include disc herniation, nerve root compression, disc space narrowing, and spondylolisthesis; 4) CT-guided TFESI treatment for C3 ~ C8 nerve roots.

The exclusion criteria were as follows: 1) missed important data or lost at follow-up; 2) history of neurological diseases, malignant tumors, and autoimmune diseases; 3) patients with cognitive

impairment or communication difficulties.

Data Collection

Based on clinical significance, existing research evidence, and data availability within the inpatient information system, this study identified and included 11 potential risk factors for cervical spondylosis. Data collected comprised the following categories: (1) demographic characteristics (age, sex, height, weight, BMI, educational attainment); (2) medical history; (3) clinical characteristics; (4) laboratory examination results; (5) magnetic resonance imaging (MRI) findings (reviewed by a specialist radiologist at our hospital) ; and (6) treatment details including inpatient management and outpatient follow-up records. The data were collected through review of medical records and follow-up surveys, Patient data were independently extracted from medical records by two researchers not involved in analysis. All discrepancies were adjudicated through discussion until a consensus was reached.

TFESI

All TFESIs in this study were executed under computed tomography (CT) guidance at the level that best matched the patient's clinical presentation. Needle placement was precisely and rapidly guided by CT fluoroscopy to obtain direct visualization of the optimal path to the target.

The patients were placed prone on a radiologic table and vital signs (blood pressure, pulse oximetry, electrocardiogram) were monitored. The procedure commenced with a CT scan of the target cervical region to plan a puncture trajectory that meticulously avoided vascular and neural structures. Following routine disinfection and sterile draping, local anesthesia was administered via intradermal and subcutaneous infiltration at the predetermined skin entry point. The puncture needle was then advanced incrementally along the planned trajectory under intermittent CT guidance. Upon reaching the target intervertebral foramen, aspiration was performed to exclude intravascular or intrathecal placement. Thereafter, 0.5 mL of contrast agent was slowly injected. Contrast distribution within the intervertebral foramen and epidural space was confirmed by CT imaging. Upon confirmation of satisfactory contrast spread, a 3 mL therapeutic mixture (containing 0.5 mL of 2% lidocaine, 3.5 mg compound betamethasone, 0.5 mg methylcobalamin, and 1 mL saline) was injected into each target neural segment. Throughout the injection, patients were continuously assessed for adverse reactions, such as severe pain, dizziness, or perioral numbness. Patients were subsequently monitored in the recovery room for at least 30 minutes, with stable vital signs required prior to discharge to the ward.(Fig. 1)

Statistical Analysis

Data were analyzed using SPSS (version 27.0). Continuous data are reported as mean ± SD or median (IQR), and categorical data as n (%). Between-group differences were assessed using the t-test, Mann–Whitney U test, chi-square test, or Fisher's exact test, as appropriate. Multivariate logistic regression was

performed to identify predictors of treatment outcome, with variables showing P < 0.05 in univariate analysis included in the model. Bootstrap resampling (5,000 samples) was used to correct for potential bias and enhance the stability of the estimates. *P* < 0.05 were considered statistically significant.

Results

Characteristics of Individuals

A total of 163 elderly patients with cervical spondylotic radiculopathy (CSR) meeting the inclusion criteria were initially screened between July 2019 and May 2024. 15 patients were excluded based on exclusion criteria (including 2 patients with advanced malignant tumors, 1 patient with sequelae of cerebral infarction, 1 patient with language communication difficulties, and 11 patients lost to follow-up). Consequently, a final cohort of 148 patients was included in the analysis (Fig. 2) .

The median age of the 148 patients was 68.40(IQR 65.70-73.95) years and 93(62.8%) were female. In terms of education, 87.8% of patients had completed at least elementary school. Regarding comorbidities, hypertension was present in 79 patients (53.4%), osteoporosis in 60 patients (40.5%), diabetes mellitus in 33 patients (22.3%), and coronary heart disease in 12 patients (8.1%). The median duration of symptoms was 0.58(IQR 0.17-5.00) years, with 46.6% of patients experiencing symptoms for 1 year or more. A majority of patients with CSR present with lesions at multiple levels. The most commonly level was C6, with a total of 119 treatments (80.4%), followed by the C5 and C7 with 82 (55.4%) and 66 (44.6%) treatments respectively (Table 1) .

Treatment Efficacy at 6 Months

Based on the modified MacNab criteria assessed at the 6-month follow-up, the efficacy rate of TFESI treatment was 84.5%. The assessment showed that 46 patients (31.1%) were rated as “Excellent”, 47 (31.8%) as “Good”, 32 (21.6%) as “Fair”, and 23 (15.5%) as “Poor”. Patients were categorized into an effective group (n = 125; modified MacNab ratings of excellent, good, or fair) and an ineffective group (n = 23; modified MacNab ratings of poor) (Fig. 3) .

Pain Remission

We collected pain NRS scores pre- and post-TFESI (at 12 hours, 24 hours, and 6 months) from patient medical records and follow-up information. The median pre-operative NRS score was 7.00 (IQR 6.00–8.00). Scores significantly decreased to 2.00 (IQR 1.00–4.00) at 12h, 2.00 (IQR 1.00–3.00) at 24h, and 2.00 (IQR 1.00–4.00) at 6 months post-TFESI compared to baseline (P < 0.001) (Fig. 4) .

The pain remission rate (RR) was calculated using the following formula: [(Pre-TFESI NRS score – Post-TFESI NRS score) / Pre-TFESI NRS score] × 100%. Based on this formula, the pain RR at various post-TFESI time points (12h, 24h, and 6 months) were determined(Fig. 5). Within 12 hours post-operative, 106

patients (71.6%) achieved a pain remission rate (RR) ≥ 50%. Within 24 hours post-operative, 112 patients (75.7%) achieved a pain RR ≥ 50%. At 6 months post-TFESI, 96 patients (64.9%) achieved a pain RR ≥ 50% (Fig. 6) .

Treatment Outcomes and Safety

The median duration of hospitalization was 10.00 days (IQR 8.00–12.00). At the 6-month follow-up, 42 patients (28.4%) continued to use analgesic agents, 31 patients (20.9%) were readmitted due to recurrence of CSR symptoms. Review of their hospitalization records confirmed that all patients had initially received standardized drug therapy, including NSAIDs (e.g. loxoprofen, celecoxib), muscle relaxants (e.g. tizanidine), and combination analgesics (e.g. acetaminophen-codeine). No complications were observed in any patient throughout the 6-month follow-up period. Patient satisfaction, with a median score of 8.00 (IQR 6.00–10.00), suggested a favorable perception of TFESI treatment.

Between-Group Comparisons

Patients were stratified into effective and ineffective groups according to the modified MacNab criteria at the 6-month follow-up, and their baseline and clinical characteristics were compared between the two groups. There was a statistically significant difference in analgesia at 6months post-TFESI, the number of TFESI performed, analgesic use at 6months post-TFESI, 6-month readmission, and satisfaction NRS score between effective group and ineffective. Significant differences were not observed between the two groups in terms of their age, gender, BMI, comorbidities, clinical presentation, laboratory findings, or MRI indicators(Table 2) .

Spearman's rank correlation analysis revealed a strong positive correlation between pain remission rate and modified MacNab grade at 6 months post-TFESI ($\rho = 0.891$, $P < 0.001$), indicating that higher efficacy grades (from poor to excellent) were consistently associated with greater pain remission rate (Fig. 7).

Predictors of Treatment Response

To correct for potential small-sample bias in the univariate regression analysis, we performed a Bootstrap logistic regression analysis with 2000 resamples. The results indicate that the number of treatment TFESI performed and duration of symptoms are significant factors influencing TFESI efficacy ($P<0.05$) (Table 3). A multivariate logistic regression analysis with Bootstrap resampling (5,000 iterations) was then performed, which confirmed that the number of treatment performed was an independent predictor of treatment ineffectiveness (OR = 2.737, 95% BCa CI: 1.008–11.991, $P = 0.036$). Patients undergoing multiple treatments had a 2.74-fold higher risk of treatment ineffectiveness compared to those receiving a single treatment. The 95% confidence interval for the OR of symptom duration, after Bootstrap correction, included 1 (OR = 1.073, 95% BCa CI: 0.962–1.175), indicating an unstable association (Fig. 8) .The Hosmer-Lemeshow goodness-of-fit test indicated adequate model calibration ($\chi^2 = 11.161$, df = 7, $P = 0.132$). However, the model demonstrated poor discriminatory ability, with an area under the receiver operating characteristic curve (AUC) of 0.658 (95% CI: 0.521–0.795)

(Fig. 9). The lower bound of the confidence interval approached 0.5, indicating that the model's capacity to distinguish between patients with effective and ineffective outcomes was limited, performing only marginally better than chance.

Discussion

The study aimed to evaluate the 6-month clinical efficacy of CT-guided TFESI in elderly patients with cervical spondylotic radiculopathy and to explore potential predictors of therapeutic response in this population. The results revealed an overall efficacy rate of 84.5% at 6 months, the number of TFESI performed was identified as a significant predictor of treatment outcome.

Cervical spondylosis, a common degenerative condition of the cervical spine associated with aging, constitutes a significant proportion of the global disability burden[17, 18]. CSR, the most common form of cervical spondylosis, typically presents with unilateral or bilateral pain, sensory disturbances, or motor weakness in areas innervated by the cervical nerve roots, such as the neck, shoulders, and upper extremities[2]. These symptoms significantly compromise the quality of life and daily functioning of elderly patients. CSR in the elderly exhibits unique pathophysiological features. Compared to younger populations, its pathogenesis is more complex, treatment responses are often less favorable, and recurrence is more frequent[19, 20]. In light of the heightened surgical risks associated with advanced age and comorbidity burden, elderly patients with CSR who have not benefited from conservative therapies (such as lifestyle interventions, pharmacotherapy, and physical therapy) are considered candidates for epidural steroid injection. TFESI is a minimally invasive, image-guided technique that enables the targeted delivery of corticosteroids and local anesthetics into the epidural space surrounding the affected nerve root via the intervertebral foramen[21]. With its advantages of minimal trauma, reliable efficacy, rapid postoperative recovery, and shortened hospital stay, TFESI has become a widely adopted intervention for CSR[22].

To guide clinical decision-making in the management of elderly patients with CSR, it is imperative to determine the therapeutic efficacy of TFESI and to identify factors predictive of treatment response. In the study, the modified MacNab efficacy grading scale served as the primary instrument for assessing overall clinical outcomes at the 6-month follow-up after TFESI. Originally developed to assess lumbar spine surgical outcomes, the MacNab criteria have been widely applied to various spinal interventions; the modified version enhances clinical utility by incorporating patients' subjective experience and functional impact, enabling a more comprehensive and rapid assessment of postoperative recovery. This makes it especially appropriate for assessing the 6-month efficacy of TFESI in the elderly cohort of this study. Previous studies have reported the efficacy of TFESI for CSR ranging from 50% to 90% in adults[15, 23–27]. In the study, CT-guided TFESI achieved an 84.5% efficacy rate at 6-month post-TFESI in elderly patients with CSR. Compared with baseline, pain NRS scores were significantly reduced at 12 hours, 24 hours, and 6 months after treatment. Furthermore, 64.9% of patients achieved a pain remission rate of ≥ 50% at the 6-month follow-up. These findings indicate that within six months following TFESI, the

majority of elderly patients experienced substantial pain relief and improvements in both subjective well-being and daily functioning, underscoring the significant clinical value of TFESI in this population. In addition, the low rate of loss to follow-up may reflect high patient satisfaction and adherence, likely attributable to the favorable therapeutic response to TFESI.

The study identified the number of TFESI performed as a significant predictor of clinical efficacy following TFESI for CSR. Compared with a single session, patients receiving multiple treatments had a 2.74-fold increased risk of an ineffective outcome, and this association that remained robust after bootstrap resampling to correct for small-sample bias. This finding suggests that multiple TFESI treatments may confer no additional benefit. The results stand in contrast to prior research in which multiple TFESI injections were reported to be beneficial[28]. This may be explained by the differing follow-up periods across studies. In addition to TFESI, patients in this study also received concomitant pharmacological and physical therapy. Individuals who with a favorable response to a single session may have declined further treatment, while those with suboptimal responses were more likely to undergo repeated procedures, this could have introduced selection bias. Nevertheless, some studies have indicated that repeated TFESI may pose risks of soft tissue or neurological injury and could aggravate pain[24]. Prospective studies with larger sample sizes are needed to confirm and refine the association between the number of TFESI sessions and clinical outcomes.

It has been documented that shorter symptom duration is associated with better outcomes following TFESI, in contrast to the limited efficacy observed in patients with chronic symptoms[29, 30], most patients with acute cervical radiculopathy tend to have a favorable prognosis[2]. Nevertheless, some evidence contradicts this association. An earlier study showed comparable improvement following treatment among patients with long-standing symptoms and those with a recent onset, suggesting that symptom duration may not consistently predict therapeutic response[29]. Consistent with this finding, our results showed no significant association between symptom duration and treatment response. In the study, although symptom duration showed a statistically significant association with treatment outcome in the analysis ($P < 0.05$), this association was not robust after Bootstrap correction. The odds ratio had a confidence interval crossing unity (OR = 1.073, 95% BCa CI: 0.962–1.175), indicating considerable uncertainty in the estimate—likely attributable to the limited number of ineffective cases. This finding underscores the importance of employing appropriate statistical methods in small-sample studies to avoid overinterpretation of potentially spurious associations.

Previous studies on the efficacy of TFESI for cervical radiculopathy and its associated factors have included heterogeneous age populations[15, 23–27]. However, evidence specifically focusing on elderly patients (aged ≥ 65 years) remains scarce. This represents a key innovation and strength of the present study. Previous studies on TFESI for CSR and lumbar disc herniation with radicular pain have consistently identified age as a predictor of poor treatment response[29, 31]. However, this study did not find a significant association between age and the efficacy of TFESI treatment at 6 months post-treatment. This is consistent with a 2007 study involving 76 patients who received cervical epidural

steroid injections, which found that younger age was not a significant predictor of treatment efficacy[29]. Age was not found to be an independent predictor of treatment efficacy. However, given the distinct characteristics of the elderly population, their treatment response and safety remain important clinical considerations.

This study did not identify a correlation between cervical nerve root compression and TFESI efficacy, and current evidence from other studies also fails to yield consistent and definitive conclusions. Bensler et al. suggested that nerve root compression serves as a protective factor for long-term TFESI efficacy[32]. Kwon et al. reported that patients with disc herniation achieved greater pain relief than those with spinal stenosis[29]. Conversely, Desai and Klessinger et al. found no correlation between the severity of cervical pathology and TFESI treatment outcomes[33, 34]. Ferrante and Kwon reported that patients presenting with signs and symptoms of nerve root compression achieve better outcomes than those with neck pain alone[29, 35]. In summary, there is no clear correlation between the degree of cervical nerve compression and the efficacy of TFESI. However, the location of compression and the precision of injection may directly influence treatment success. This implies that when opting for TFESI therapy, a physician's meticulous interpretation of the patient's imaging data (to pinpoint the exact location of compression) and their mastery of injection technique may be more critical than the severe or mild classifications described in imaging reports.

In terms of complications, earlier scholars generally believed that epidural steroid injections at higher cervical levels theoretically carry an increased risk of complications such as dural puncture and spinal cord injury[36, 37], leading to the recommendation that cervical injections should not be performed above C7–T1. However, recent studies have challenged this view. The safety of TFESI for cervical radiculopathy has been well documented in clinical practice, and published complications (even minor ones) remain exceedingly rare[38–41]. In addition, previous case reports have indicated that cervical epidural steroid injections using particulate steroids may lead to permanent neurological injuries, such as cerebral and spinal cord infarction[42–44]. It is hypothesized that these severe outcomes result from inadvertent intra-arterial injection of particulate steroids, causing vascular occlusion and subsequent central nervous system infarction. Consequently, most current guidelines recommend the use of non-particulate steroids for cervical epidural injections[45]. In this study, no severe complications occurred among the 148 elderly patients who received CT-guided TFESI with betamethasone (particulate steroids) for CSR. This finding aligns with previous reports documenting complication rates of 0%–1.8%[41, 46–48], indicating that TFESI performed by experienced physicians under imaging guidance is a safe and effective treatment for CSR. Future comparative studies between particulate and non-particulate steroids are warranted to further evaluate their respective efficacy and safety in TFESI for CSR.

This study has several limitations. First, as a single-center retrospective observational study, the generalizability of its findings is limited, and there is potential for missing data and recall bias. Second, the improvement in symptoms following cervical epidural steroid injection cannot be entirely attributed to the TFESI procedure itself. Third, regarding the analysis of influencing factors, this study did not

evaluate the impact of imaging parameters such as the severity of foraminal stenosis, types of medications, or psychosocial factors. Additionally, although needle placement accuracy and contrast agent distribution are considered clinically important predictors of efficacy, relevant data were not collected during hospitalization. In the statistical analysis, the limited number of patients in the ineffective group restricted the number of variables that could be reliably analyzed. Even after applying Bootstrap correction, confidence intervals remained wide, particularly for the estimate of symptom duration. Additionally, the model exhibited poor discriminative ability (AUC = 0.658), suggesting that other unmeasured factors may have a significant impact on treatment efficacy. Future well-designed prospective, multicenter randomized controlled trials are needed to further validate the efficacy of TFESI in elderly patients with cervical radiculopathy and to identify factors influencing treatment outcomes.

Conclusion

This study confirmed that CT-guided transforaminal epidural steroid injection (TFESI) offers significant clinical value in elderly patients with cervical spondylotic radiculopathy (CSR), demonstrating favorable efficacy and analgesic effects, with no procedure related complications observed, thereby supporting its safety and effectiveness. Exploratory analysis identified the number of treatment sessions as a significant predictor of therapeutic outcome, with multiple sessions being associated with an increased risk of ineffective response. However, the discriminative performance of the overall predictive model was suboptimal, underscoring the need for validation in larger prospective cohorts.

Abbreviations

Abbreviations
Full Forms
TFESI
Transforaminal Epidural Steroid Injection
CSR
Cervical Spondylotic Radiculopathy
CT
Computed Tomography
MRI
Magnetic Resonance Imaging
BMI
Body Mass Index
NLR
Neutrophil-to-Lymphocyte Ratio
dNLR
delta Neutrophil-to-Lymphocyte Ratio
MLR
Monocyte-to-Lymphocyte Ratio

NMLR
Monocyte-Neutrophil to Lymphocyte Ratio
SIRI
Systemic Inflammation Response Index
NRS
Numerical Rating Scale
RR
Remission Rate
SD
Standard Deviation
IQR
Inter-Quartile Range
OR
Odds Ratio
CI
Confidence Interval

Declarations

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. The study was approved by the Human Ethical Committee of West China Hospital of Sichuan University (Approval No.: 20231800) and registered at www.chictr.org.cn (Identifier: ChiCTR2300077491). Because this was a retrospective study, informed consent was not required.

Consent for publication

Not applicable. This manuscript does not contain any individual person's data in any form.

Conflict of Interest Statement

None declared.

Graphical abstract

Table 1. Demographic and clinical characteristics of study participants

Note

Data are presented as n (%), mean ± SD or median (IQR). Abbreviations: n (%), number and frequency; SD, standard deviation; IQR, inter-quartile range; BMI, body mass index.

Note

P < 0.05 indicated a statistically significant difference. Abbreviations:n (%), number and frequency; SD, standard deviation; IQR, inter-quartile range; BMI, body mass index; NLR, Neutrophil-to-Lymphocyte ratio; dNLR, delta Neutrophil-to-Lymphocyte ratio; MLR, Monocyte-to-Lymphocyte ratio; NMLR, Monocyte-Neutrophil to Lymphocyte ratio; SIRI, systemic inflammation response index; NRS, numerical rating scale; TFESI, transforaminal epidural steroid injection; RR, remission rate.

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Author Contribution

All authors conceived and designed the experiments. Chenyu Zhu and Yunjie Chen performed the experiments and collected the data. Maotong Liu developed the analytical tools and performed the computational analysis. Maotong Liu and Xueguang Zhang wrote the initial manuscript. Li Song supervised the project and revised the manuscript critically for important intellectual content. All authors discussed the results and approved the final submission.

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Data Availability

The original data generated and analyzed in this study are available upon reasonable request from the corresponding author.

References

1. Li W, Chang Y, Feng Q, et al. Balance chiropractic therapy for cervical spondylotic radiculopathy: A randomized controlled trial. Contemp Clin Trials Commun. 2024;41:101323.

10.1016/j.conctc.2024.101323.

2. Beckworth WJ, Abramoff BA, Bailey IM, et al. Acute Cervical Radiculopathy Outcomes: Soft Disc Herniations vs Osteophytes. Pain Med. 2021;22(3):561–6. 10.1093/pm/pnaa341.
3. Park MS, Ju YS, Moon SH, et al. Reoperation Rates After Anterior Cervical Discectomy and Fusion for Cervical Spondylotic Radiculopathy and Myelopathy: A National Population-based Study. Spine. 2016;41(20):1593–9. 10.1097/BRS.0000000000001590.
4. Chen B, Zhang C, Zhang RP, et al. Acupotomy versus acupuncture for cervical spondylotic radiculopathy: protocol of a systematic review and meta-analysis. BMJ Open. 2019;9(8):e029052. 10.1136/bmjopen-2019-029052.
5. Watkins RG 4th, Watkins RG 3. Cervical Disc Herniations, Radiculopathy, and Myelopathy. Clin Sports Med. 2021;40(3):513–39. 10.1016/j.csm.2021.03.006.
6. Bierman A, Lee Y. Chronic Pain and Psychological Distress Among Older Adults: A National Longitudinal Study. Res Aging. 2018;40(5):432–55. 10.1177/0164027517704970.
7. Hashimoto K, Aizawa T, Kanno H, Itoi E. Adjacent segment degeneration after fusion spinal surgery-a systematic review. Int Orthop. 2019;43(4):987–93. 10.1007/s00264-018-4241-z.
8. Baldo A, Chatzipanagiotou OP, Woldesenbet S, Akabane M, Spolverato G, Pawlik TM. New-Onset Geriatric Syndromes among Patients Undergoing Major Operation: Impact on Clinical Outcomes and Quality of Life. J Am Coll Surg. 2026;242(3):663–74. 10.1097/XCS.0000000000001661.
9. Bono CM, Ghiselli G, Gilbert TJ, et al. An evidence-based clinical guideline for the diagnosis and treatment of cervical radiculopathy from degenerative disorders. Spine J. 2011;11(1):64–72. 10.1016/j.spinee.2010.10.023.
10. Li W, Yao C, Zhou Y, Chen S. Changes of Endothelin-1 and Calcitonin Gene-Related Peptide Concentrations in Patients with Cervical Radiculopathy after Wrist-Ankle Acupuncture-Moxibustion and Hot Compression with Chinese Herbal Medicine. Genet Res. 2021;2021:5433742. 10.1155/2021/5433742.
11. Pan SL, Zheng SL, Zhou XH, Wang QL. Acupuncture combined with jingtong granule for nerve-root type cervical spondylosis and its effects on IL-6、TNF-α、IL-1β and hemorheological indexes. Zhongguo Zhen Jiu. 2019;39(12):1274–8. 10.13703/j.0255-2930.2019.12.005.
12. Bahar-Ozdemir Y, Sencan S, Ercalik T, Kokar S, Gunduz OH. The Effect of Pre-Treatment Depression, Anxiety and Somatization Levels on Transforaminal Epidural Steroid Injection: A Prospective Observational Study. Pain Physician. 2020;23(3):E273–80.
13. Wald JT, Maus TP, Geske JR, et al. Immediate pain response does not predict long-term outcome of CT-guided cervical transforaminal epidural steroid injections. AJNR Am J Neuroradiol. 2013;34(8):1665–8. 10.3174/ajnr.A3439.
14. Kim MS, Lee DG, Chang MC. Outcome of Transforaminal Epidural Steroid Injection According to Severity of Cervical Foraminal Stenosis. World Neurosurg. 2018;110:e398–403. 10.1016/j.wneu.2017.11.014.

15. Kesikburun S, Aras B, Kelle B, Yavuz F, Yaşar E, Taşkaynatan MA. The effectiveness of cervical transforaminal epidural steroid injection for the treatment of neck pain due to cervical disc herniation: long-term results. Pain Manag. 2018;8(5):321–6. 10.2217/pmt-2018-0002.
16. Beard JR, Officer A, de Carvalho IA, et al. The World report on ageing and health: a policy framework for healthy ageing. Lancet. 2016;387(10033):2145–54. 10.1016/S0140-6736(15)00516-4.
17. Cohen SP. Epidemiology, diagnosis, and treatment of neck pain. *Mayo Clin Proc*. 2015;90(2):284–299. 10.1016/j.mayocp.2014.09.008
18. Murray CJ, Atkinson C, Bhalla K, et al. The state of US health, 1990–2010: burden of diseases, injuries, and risk factors. JAMA. 2013;310(6):591–608. 10.1001/jama.2013.13805.
19. Eubanks JD. Cervical radiculopathy: nonoperative management of neck pain and radicular symptoms. Am Fam Physician. 2010;81(1):33–40.
20. Vallée JN, Feydy A, Carlier RY, Mutschler C, Mompoint D, Vallée CA. Chronic cervical radiculopathy: lateral-approach periradicular corticosteroid injection. Radiology. 2001;218(3):886–92. 10.1148/radiology.218.3.r01mr17886.
21. Cyteval C, Thomas E, Decoux E, et al. Cervical radiculopathy: open study on percutaneous periradicular foraminal steroid infiltration performed under CT control in 30 patients. AJNR Am J Neuroradiol. 2004;25(3):441–5.
22. Shim E, Lee JW, Lee E, Ahn JM, Kang Y, Kang HS. Fluoroscopically Guided Epidural Injections of the Cervical and Lumbar Spine. Radiographics. 2017;37(2):537–61. 10.1148/rg.2017160043.
23. Conger AM, Randall DJ, Sperry BP, et al. The effectiveness of cervical transforaminal epidural steroid injections for the treatment of cervical radicular pain: A prospective cohort study reporting 12-month outcomes. Interv Pain Med. 2023;3(1):100379. 10.1016/j.inpm.2023.100379.
24. Conger A, Cushman DM, Speckman RA, Burnham T, Teramoto M, McCormick ZL. The Effectiveness of Fluoroscopically Guided Cervical Transforaminal Epidural Steroid Injection for the Treatment of Radicular Pain; a Systematic Review and Meta-analysis. Pain Med. 2020;21(1):41–54. 10.1093/pm/pnz127.
25. Borton ZM, Oakley BJ, Clamp JA, Birch NC, Bateman AH. Cervical transforaminal epidural steroid injections for radicular pain: a systematic review. Bone Joint J. 2022;104–B(5):567–74. 10.1302/0301-620X.104B5.BJJ-2021-1816.R1.
26. Dreyfuss P, Baker R, Bogduk N. Comparative effectiveness of cervical transforaminal injections with particulate and nonparticulate corticosteroid preparations for cervical radicular pain. Pain Med. 2006;7(3):237–42. 10.1111/j.1526-4637.2006.00162.x.
27. Lee SH, Kim KT, Kim DH, Lee BJ, Son ES, Kwack YH. Clinical outcomes of cervical radiculopathy following epidural steroid injection: a prospective study with follow-up for more than 2 years. Spine. 2012;37(12):1041–7. 10.1097/BRS.0b013e31823b4d1f.
28. Guntin J, Regalado L, Serhal A, Omar IM, Hsu WK, Garg A. Safety outcomes and improvement in pain scores after radiologist-performed fluoroscopy-guided interlaminar cervical epidural steroid injection. Skeletal Radiol. 2024;53(6):1145–52. 10.1007/s00256-023-04548-5.

29. Kwon JW, Lee JW, Kim SH, et al. Cervical interlaminar epidural steroid injection for neck pain and cervical radiculopathy: effect and prognostic factors. Skeletal Radiol. 2007;36(5):431–6. 10.1007/s00256-006-0258-2.
30. Diwan S, Manchikanti L, Benyamin RM, et al. Effectiveness of cervical epidural injections in the management of chronic neck and upper extremity pain. Pain Physician. 2012;15(4):E405–34.
31. Ekedahl H, Jönsson B, Annertz M, Frobell RB. The 1-Year Results of Lumbar Transforaminal Epidural Steroid Injection in Patients with Chronic Unilateral Radicular Pain: The Relation to MRI Findings and Clinical Features. Am J Phys Med Rehabil. 2017;96(9):654–62. 10.1097/PHM.0000000000000730.
32. Bensler S, Sutter R, Pfirrmann CW, Peterson CK. Long Term Outcomes from CT-guided Indirect Cervical Nerve Root Blocks and their relationship to the MRI findings–A prospective Study. Eur Radiol. 2015;25(11):3405–13. 10.1007/s00330-015-3758-4.
33. Desai A, Saha S, Sharma N, Huckerby L, Houghton R. The short- and medium-term effectiveness of CT-guided selective cervical nerve root injection for pain and disability. Skeletal Radiol. 2014;43(7):973–8. 10.1007/s00256-014-1843-4.
34. Klessinger S, Freund W, Karpel-Massler G, Halatsch ME. Response to transforaminal injection of steroids and correlation to mri findings in patients with cervical radicular pain or radiculopathy due to disc herniation or spondylosis. Pain Med. 2014;15(6):929–37. 10.1111/pme.12415.
35. Ferrante FM, Wilson SP, Iacobo C, Orav EJ, Rocco AG, Lipson S. Clinical classification as a predictor of therapeutic outcome after cervical epidural steroid injection. Spine. 1993;18(6):730–6. 10.1097/00007632-199305000-00010.
36. Huston CW. Cervical epidural steroid injections in the management of cervical radiculitis: interlaminar versus transforaminal. A review. Curr Rev Musculoskelet Med. 2009;2(1):30–42. 10.1007/s12178-008-9041-4.
37. Derby R, Lee SH, Kim BJ, Chen Y, Seo KS. Complications following cervical epidural steroid injections by expert interventionalists in 2003. Pain Physician. 2004;7(4):445–9.
38. Corey DL, Comeau D. Cervical radiculopathy. Med Clin North Am. 2014;98(4):791–9. 10.1016/j.mcna.2014.04.001.
39. Wald JT, Maus TP, Geske JR, et al. Safety and efficacy of CT-guided transforaminal cervical epidural steroid injections using a posterior approach. AJNR Am J Neuroradiol. 2012;33(3):415–9. 10.3174/ajnr.A2835.
40. El-Yahchouchi CA, Plastaras CT, Maus TP, et al. Adverse Event Rates Associated with Transforaminal and Interlaminar Epidural Steroid Injections: A Multi-Institutional Study. Pain Med. 2016;17(2):239–49. 10.1111/pme.12896.
41. Schultz DM, Hagedorn JM, Abd-Elsayed A, Stayner S. Safety of Interlaminar Cervical Epidural Injections: Experience With 12,168 Procedures in a Single Pain Clinic. Pain Physician. 2022;25(1):49–58.
42. Bose B. Quadriparesis following cervical epidural steroid injections: case report and review of the literature. Spine J. 2005;5(5):558–63. 10.1016/j.spinee.2005.03.015.

43. Kennedy DJ, Dreyfuss P, Aprill CN, Bogduk N. Paraplegia following image-guided transforaminal lumbar spine epidural steroid injection: two case reports. Pain Med. 2009;10(8):1389–94. 10.1111/j.1526-4637.2009.00728.x.
44. Ali D, El Khoumsi M, Gorur Y, Cardos B, Villalba NL. Rare Case of Ischaemic Stroke Following Cervical Transforaminal Injection. Eur J Case Rep Intern Med. 2019;6(3):001082. 10.12890/2019_001082.
45. Manchikanti L, Falco FJ. Safeguards to prevent neurologic complications after epidural steroid injections: analysis of evidence and lack of applicability of controversial policies. Pain Physician. 2015;18(2):E129–38.
46. McGrath JM, Schaefer MP, Malkamaki DM. Incidence and characteristics of complications from epidural steroid injections. Pain Med. 2011;12(5):726–31. 10.1111/j.1526-4637.2011.01077.x.
47. Manchikanti L, Malla Y, Cash KA, Pampati V. Do the gaps in the ligamentum flavum in the cervical spine translate into dural punctures? An analysis of 4,396 fluoroscopic interlaminar epidural injections. Pain Physician. 2015;18(3):259–66.
48. Stephens AR, Rogerson A, Patel RK, El-Hassan R. Rates of complications after cervical transforaminal epidural steroid injections for patients with cervical radiculopathy utilizing a large national database. Interv Pain Med. 2025;4(3):100606. 10.1016/j.inpm.2025.100606.

Tables

Table 1. Demographic and clinical characteristics of study participants

Variables	Total (n=148)
Demographics	
Age (years), median (IQR)	68.40(65.70-73.95)
Gender (n□%)	
Men	55(37.2%)
Women	93(62.8%)
Height (m), mean ± SD	1.60±0.08
Weight (kg), mean ± SD	62.56±9.70
BMI (kg/m²), median (IQR)	24.21(22.38-26.63)
Education level (n□%)	
Illiteracy	18(12.2%)
Elementary and middle school	61(41.2%)
Senior high school	50(33.8%)
Bachelor's degree and above	19(12.8%)
Comorbidities (n□%)	
Hypertension	79(53.4%)
Diabetes	33(22.3%)
Coronary heart disease	12(8.1%)
Osteoporosis	60(40.5%)
Duration of symptoms (years), median (IQR)	0.58(0.17-5.00)
□3 months	38(25.7%)
3 months-1 year	41(27.7%)
≥1 year	69(46.6%)
Treatment of nerve segments(n□%)	
C3	6(4.1%)
C4	23(15.5%)
C5	82(55.4%)
C6	119(80.4%)
C7	66(44.6%)

C8	2(1.4%)

Note

Data are presented as n (%), mean ± SD or median (IQR). Abbreviations: n (%), number and frequency; SD, standard deviation; IQR, inter-quartile range; BMI, body mass index.

Table 2. Demographic and clinical characteristics by treatment response (effective vs. ineffective)

Variables	Effective Group (n=125)	Ineffective Group (n=23)	χ^2-value	*P*-value
Demographics				
Age (years), median (IQR)	68.10(65.70-73.15)	69.30(66.70-74.70)		0.284
Gender (n□%)			0.045	0.832
Men	46(36.8%)	9(39.1%)		
Women	79(63.2%)	14(60.9%)		
Height (m), mean ± SD	1.60±0.08	1.59±0.07		0.985
Weight (kg), mean ± SD	62.46±9.72	63.11±9.79		0.771
BMI (kg/m²), median (IQR)	24.17(22.32-26.50)	24.97(22.60-27.47)		0.525
Education level (n□%)			0.319	0.972
Illiteracy	15(12.0%)	3(13.0%)		
Elementary and middle school	51(40.8%)	10(43.5%)		
Senior high school	43(34.4%)	7(30.4%)		
Bachelor's degree and above	16(12.8%)	3(13.0%)		
Comorbidities (n□%)				
Hypertension	65(52.0%)	14(60.9%)	0.614	0.433
Diabetes	30(24.0%)	14(13.0%)	1.346	0.246
Coronary heart disease	11(8.8%)	1(4.3%)	0.092	0.762
Osteoporosis	53(42.4%)	7(30.4%)	1.154	0.283
Duration of symptoms (n□%)			1.086	0.581
□3 months	33(26.4%)	5(21.7%)		
3 months - 1 year	36(28.8%)	5(21.7%)		
≥1year	56(44.8%)	13(56.5%)		
Clinical presentation (n□%)				
Neck rigidity	50(40.0%)	6(26.1%)	1.599	0.206
Hypoesthesia or Paresthesia	34(27.2%)	3(13.0%)	2.076	0.150
Upper limb weakness	17(13.6%)	4(17.4%)	0.024	0.878
Spurling's test	38(30.4%)	9(39.1%)	0.683	0.408

Eaten's test	65(52.0%)	10(43.5%)	0.564	0.453
Pain NRS score at admission, median (IQR)	7.00(6.00-8.00)	7.00(5.50-8.00)		0.831
The level of pain at admission			0.889	0.675
Mild	3(2.4%)	1(4.3%)		
Moderate	67(53.6%)	13(56.5%)		
Severe	55(44.0%)	9(39.1%)		
Laboratory findings, median (IQR)				
WBC ($\times10^9$/L)	5.49(4.52-6.59)	5.44(4.63-6.68)		0.826
NEU ($\times10^9$/L)	3.03(2.42-3.97)	2.94(2.46-3.89)		0.868
NEUT%	57.60(50.30-63.50)	55.30(50.70-62.60)		0.781
LYM ($\times10^9$/L)	1.59(1.25-2.04)	1.72(1.30-2.19)		0.296
MONO ($\times10^9$/L)	0.42(0.35-0.53)	0.46(0.36-0.51)		0.486
NLR	1.85(1.41-2.53)	1.72(1.30-2.41)		0.645
dNLR	0.83(0.80-0.87)	0.83(0.81-0.86)		0.725
MLR	0.27(0.20-0.33)	0.26(0.20-0.31)		0.814
NMLR	2.10(1.62-2.97)	1.94(1.62-2.73)		0.781
SIRI ($\times10^9$/L)	0.78(0.55-1.13)	0.80(0.61-1.11)		0.977
Magnetic Resonance Imaging				
Disc herniation	104(83.2%)	19(82.6%)	□0.001	□ 0.999
Root compression or contact	65(52.0%)	13(56.5%)	0.159	0.690
Stenosis	15(12.0%)	3(13.0%)	□0.001	□ 0.999
Spondylolisthesis	5(4.0%)	1(4.3%)		□ 0.999
Length of hospitalization(day), mean ± SD	10.50±2.83	10.39±2.33		0.867
Analgesia at 12h Post-TFESI (n□ %)			0.552	0.457
RR□50%	29(23.2%)	7(30.4%)		

RR≥50%	96(76.8%)	16(69.6%)		
Analgesia at 24h Post-TFESI (n□%)			0.084	0.771
RR□50%	26(20.8%)	6(26.1%)		
RR≥50%	99(79.2%)	17(73.9%)		
Analgesia at 6m Post-TFESI (n□%)			50.274	□ 0.001
RR□50%	29(23.2%)	23(100.0%)		
RR≥50%	96(76.8%)	0(0.0%)		
The number of TFESI performed (n□%)			4.170	0.041
1	58(46.4%)	16(69.6%)		
≥2	67(53.6%)	7(30.4%)		
Analgesic use at 6m Post-TFESI (n□%)	31(24.8%)	11(47.8%)	5.067	0.024
6-month readmission (n□%)	20(16.0%)	11(47.8%)	10.038	0.002
Length of hospitalization (day), mean ± SD	10.50±2.83	10.39±2.33		0.867
Satisfaction NRS score, median (IQR)	9.00(8.00-10.00)	3.00(0.00-5.00)		□ 0.001

Note

P < 0.05 indicated a statistically significant difference. Abbreviations:n (%), number and frequency; SD, standard deviation; IQR, inter-quartile range; BMI, body mass index; NLR, Neutrophil-to-Lymphocyte ratio; dNLR, delta Neutrophil-to-Lymphocyte ratio; MLR, Monocyte-to-Lymphocyte ratio; NMLR, Monocyte-Neutrophil to Lymphocyte ratio; SIRI, systemic inflammation response index; NRS, numerical rating scale; TFESI, transforaminal epidural steroid injection; RR, remission rate.

Table 3. Bootstrap logistic regression analysis of variables

Variables	Adjusted OR	95% Bootstrap CI	*P*-value
Age	1.040	0.959-1.116	0.261
Gender			
Men	Ref	Ref	Ref
Women	1.104	0.383-2.688	0.829
BMI	1.027	0.876-1.183	0.701
Duration of symptoms	1.069	0.975-1.148	0.046
Pain NRS score at admission	1.017	0.750-1.429	0.917
Hypoesthesia or Paresthesia			
No	Ref	Ref	Ref
Yes	2.491	0.648-6.987	0.103
Spurling's test			
No	Ref	Ref	Ref
Yes	0.680	0.273-2.092	0.406
Eaten's test			
No	Ref	Ref	Ref
Yes	1.408	0.537-3.98	0.471
The number of TFESI performed			
1	Ref	Ref	Ref
≥2	0.379	0.135-0.864	0.032
RR at 12h Post-TFESI	0.992	0.973-1.011	0.365
RR at 24h Post-TFESI	0.989	0.967-1.007	0.242

Abbreviations: BMI, body mass index; NRS, numerical rating scale; TFESI, transforaminal epidural steroid injection; RR, remission rate.
Abbreviations: TFESI, transforaminal epidural steroid injection; NRS, numerical rating scale.
Abbreviations: TFESI, transforaminal epidural steroid injection; RR, remission rate.
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Figures

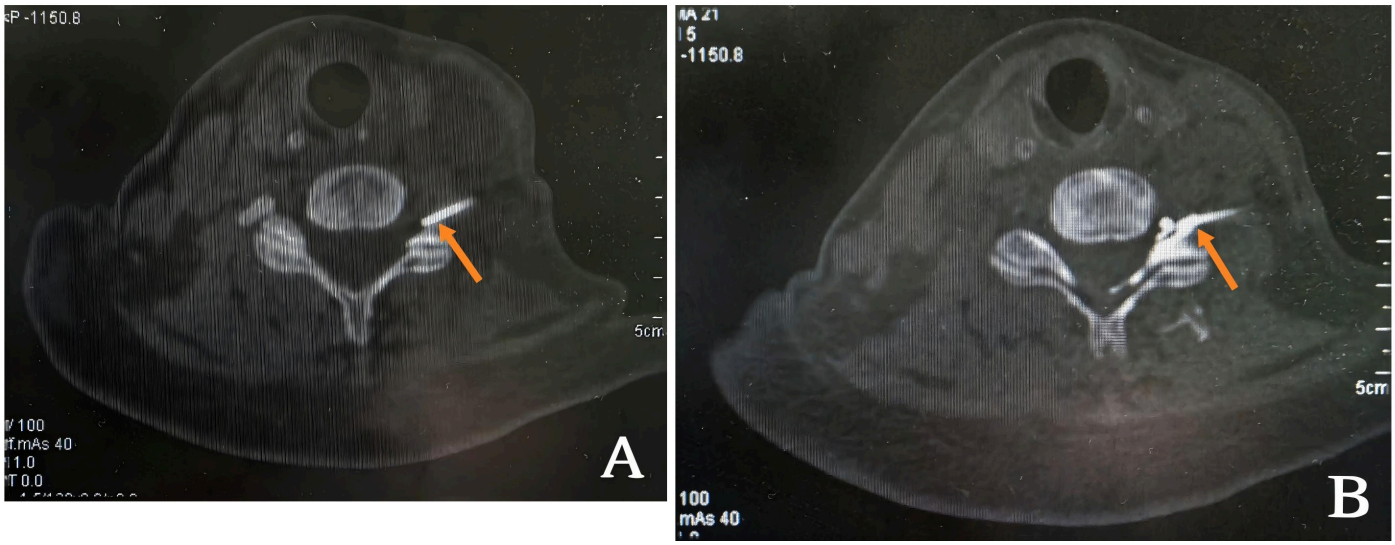


Figure 1

TFESI technique as demonstrated in a 65-year-old woman with CSR. A) Computed tomography fluoroscopy image demonstrates the needle advanced into the epidural space. The orrange arrow shows the needle path. B) 0.5 ml of contrast medium was injected into the epidural space. The orrange arrow shows the contrast medium.

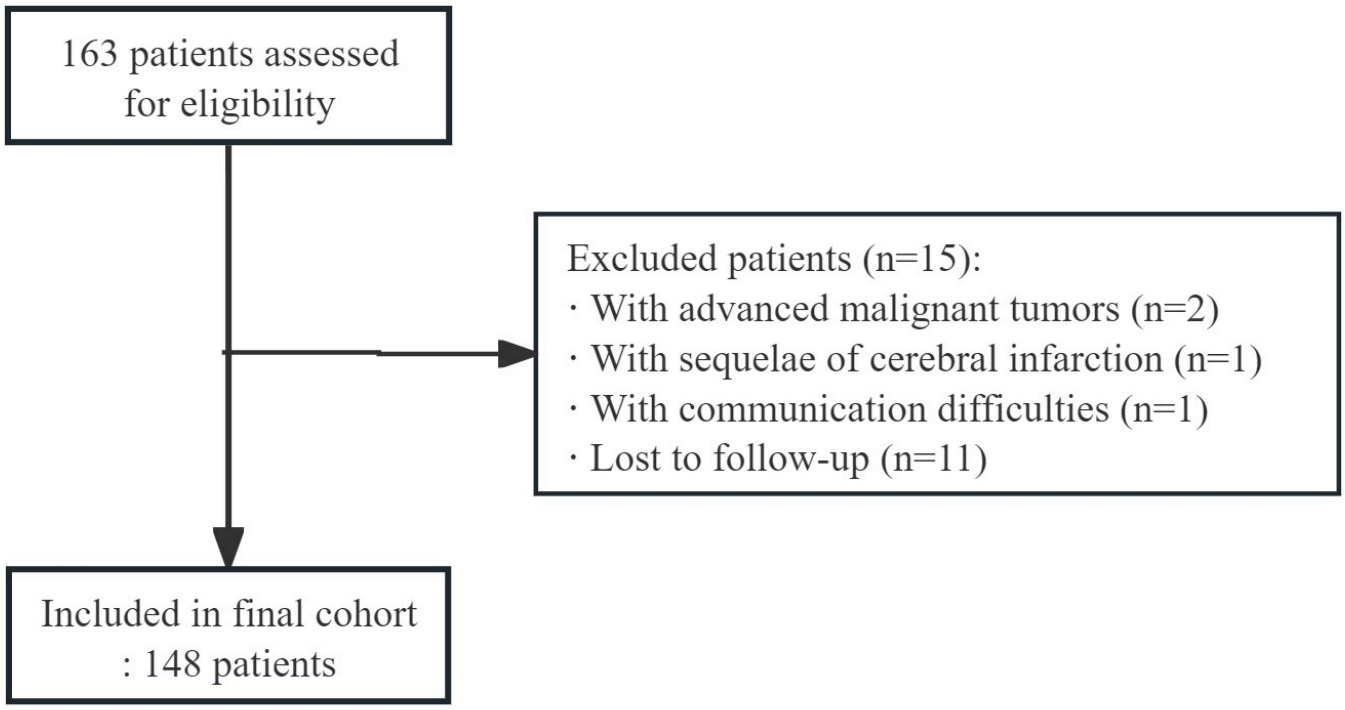


Figure 2

Flow diagram of patients included in this study.

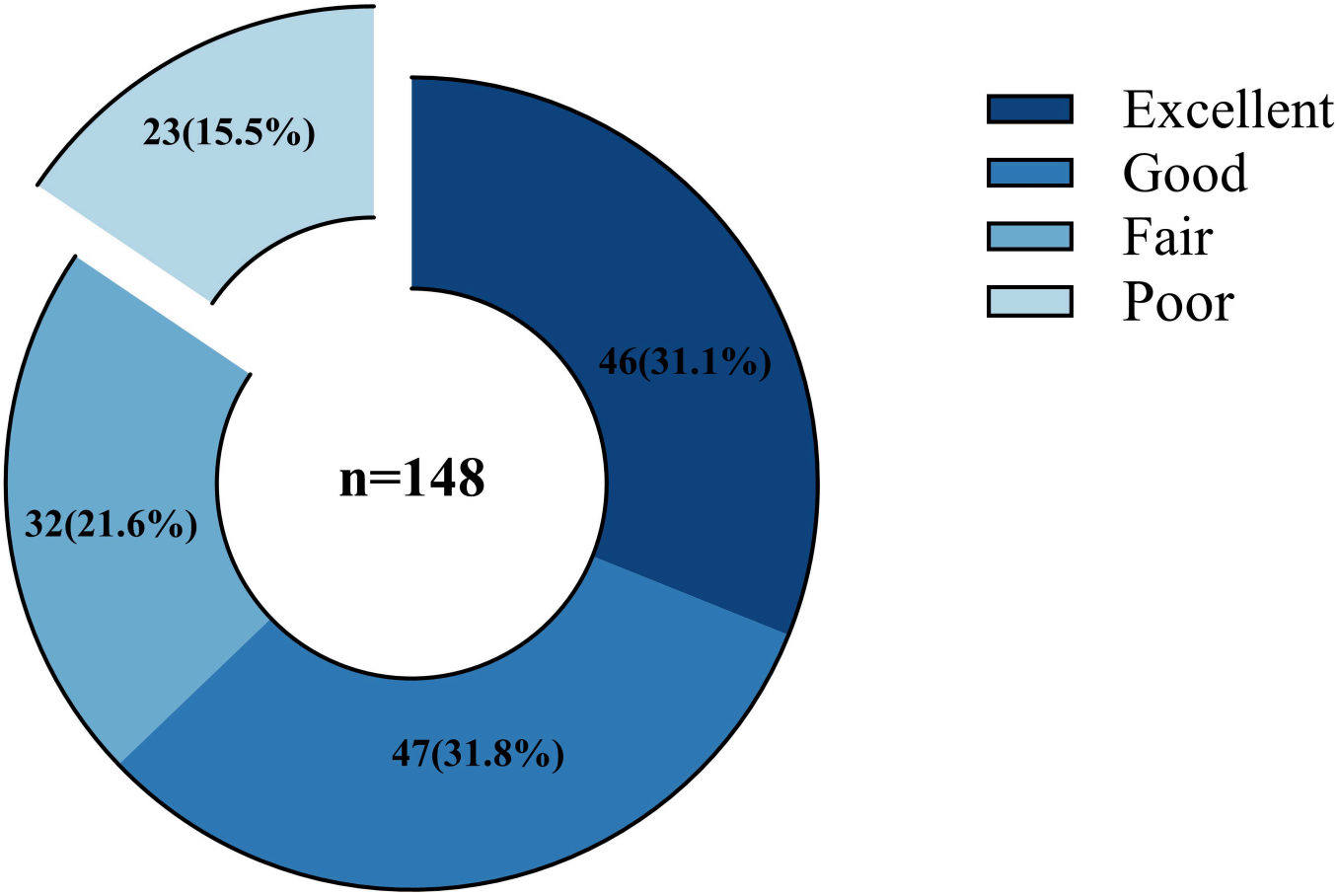


Figure 3

At the 6-month follow-up, treatment outcomes were evaluated according to the modified MacNab grading scale to determine the distribution of patients across efficacy categories (counts and percentages).

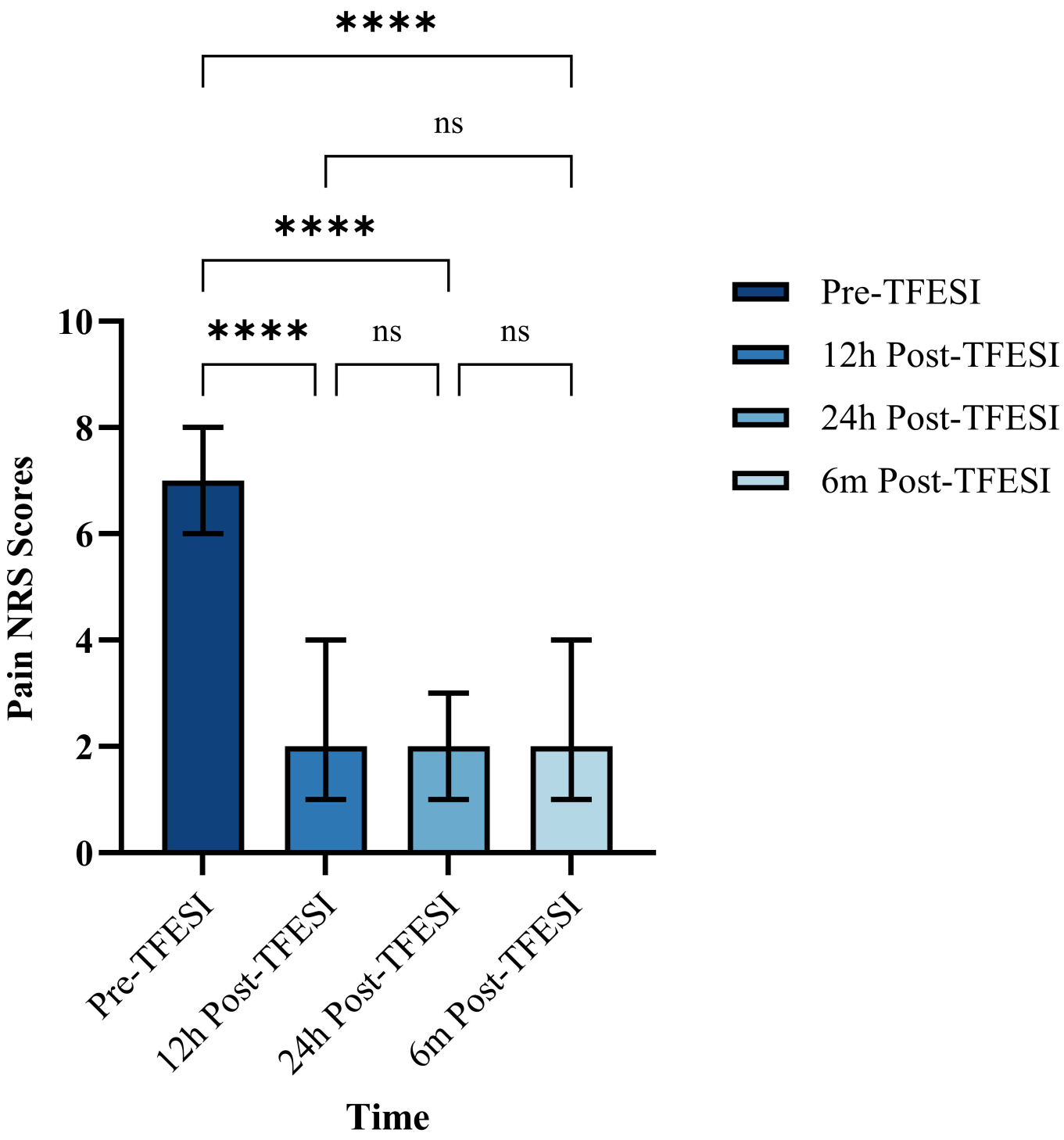


Figure 4

Pre-TFESI and post-TFESI (12 hours, 24 hours, 6 months) pain NRS scores(n = 148).

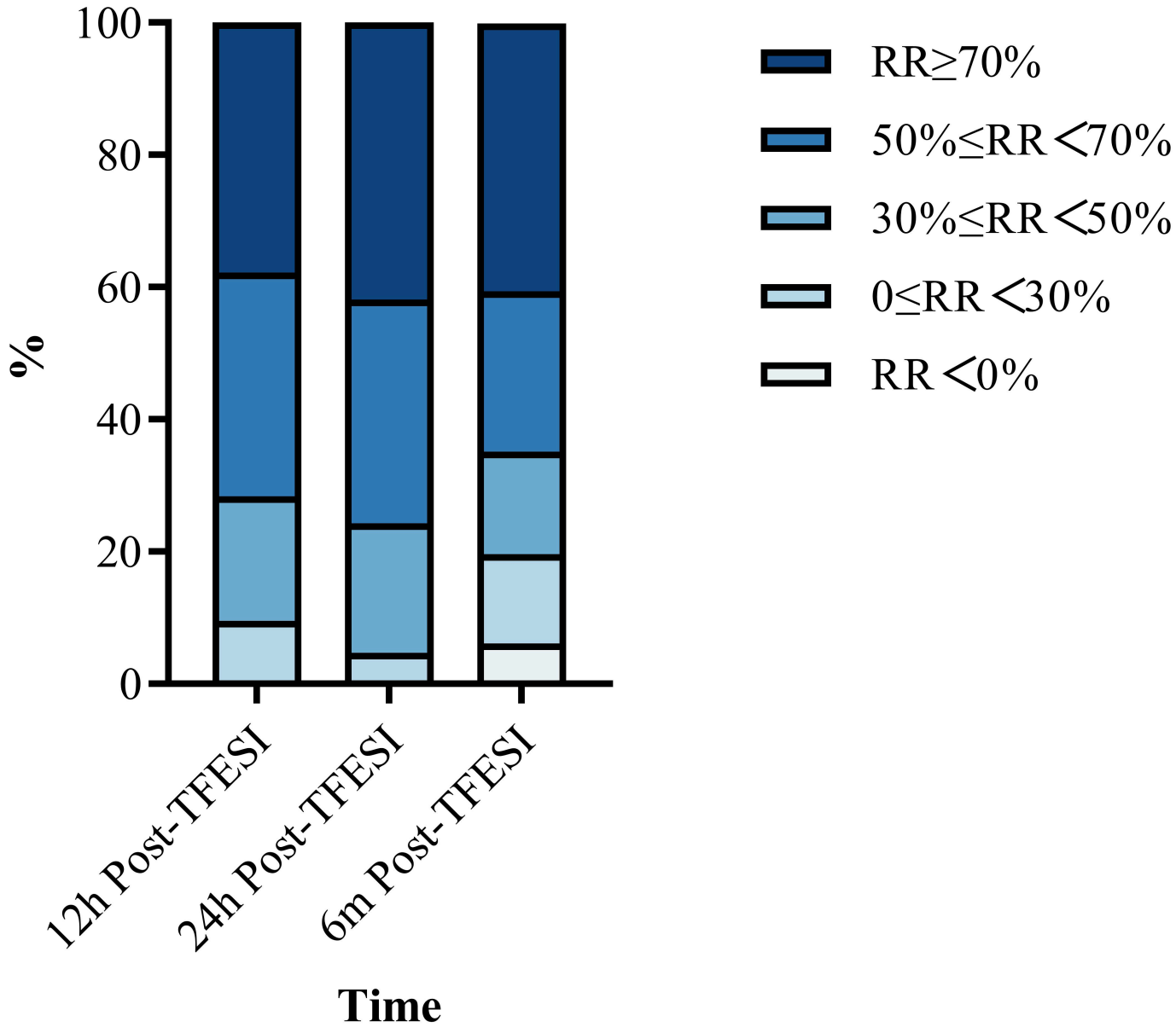


Figure 5

Percentage of patients experiencing pain RR at various post-TFESI time points (12 hours, 24 hours, and 6 months) (n = 148) .

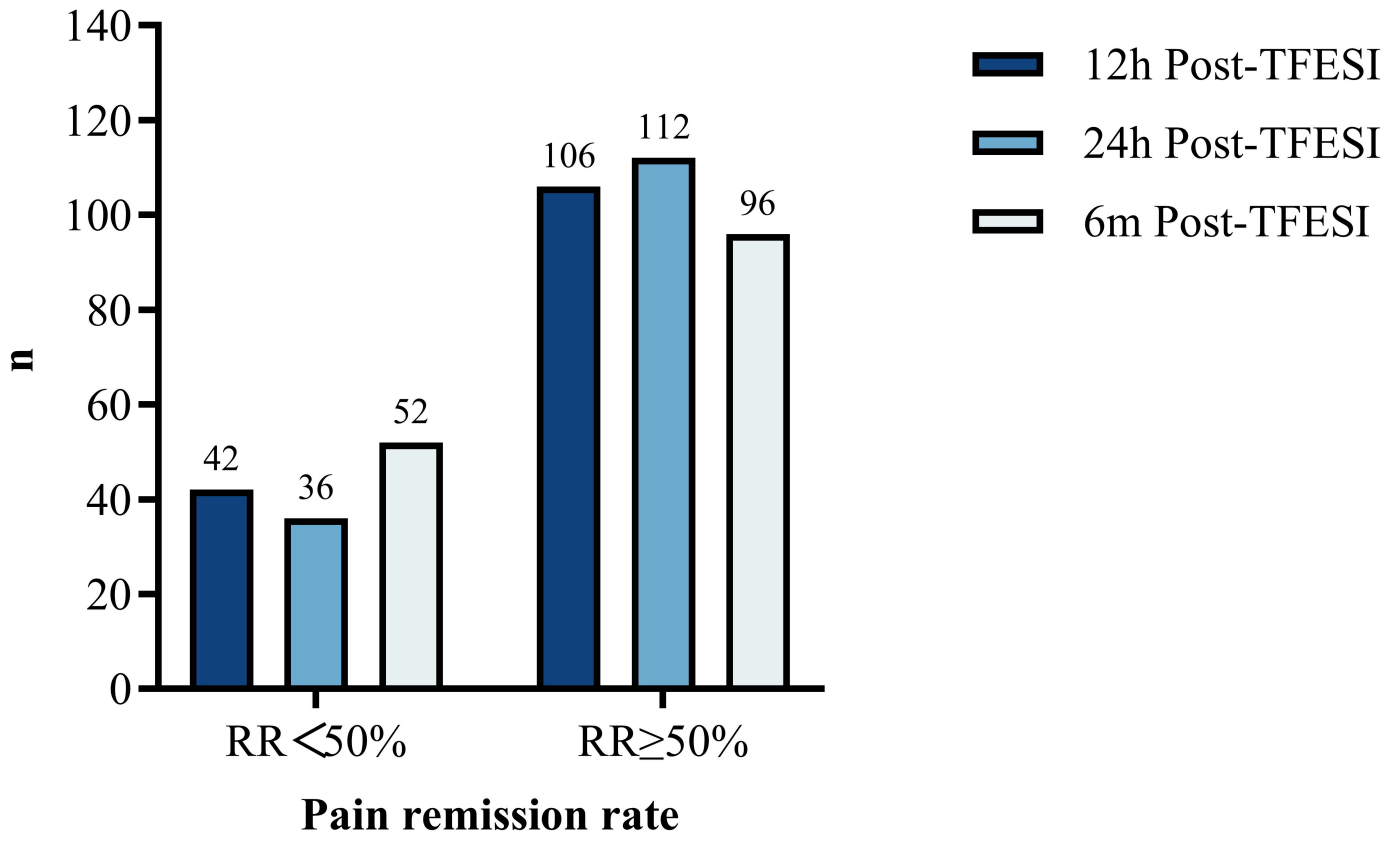


Figure 6

Number of patients experiencing pain RR at various post-TFESI time points (12 hours, 24 hours, and 6 months) (n = 148) .

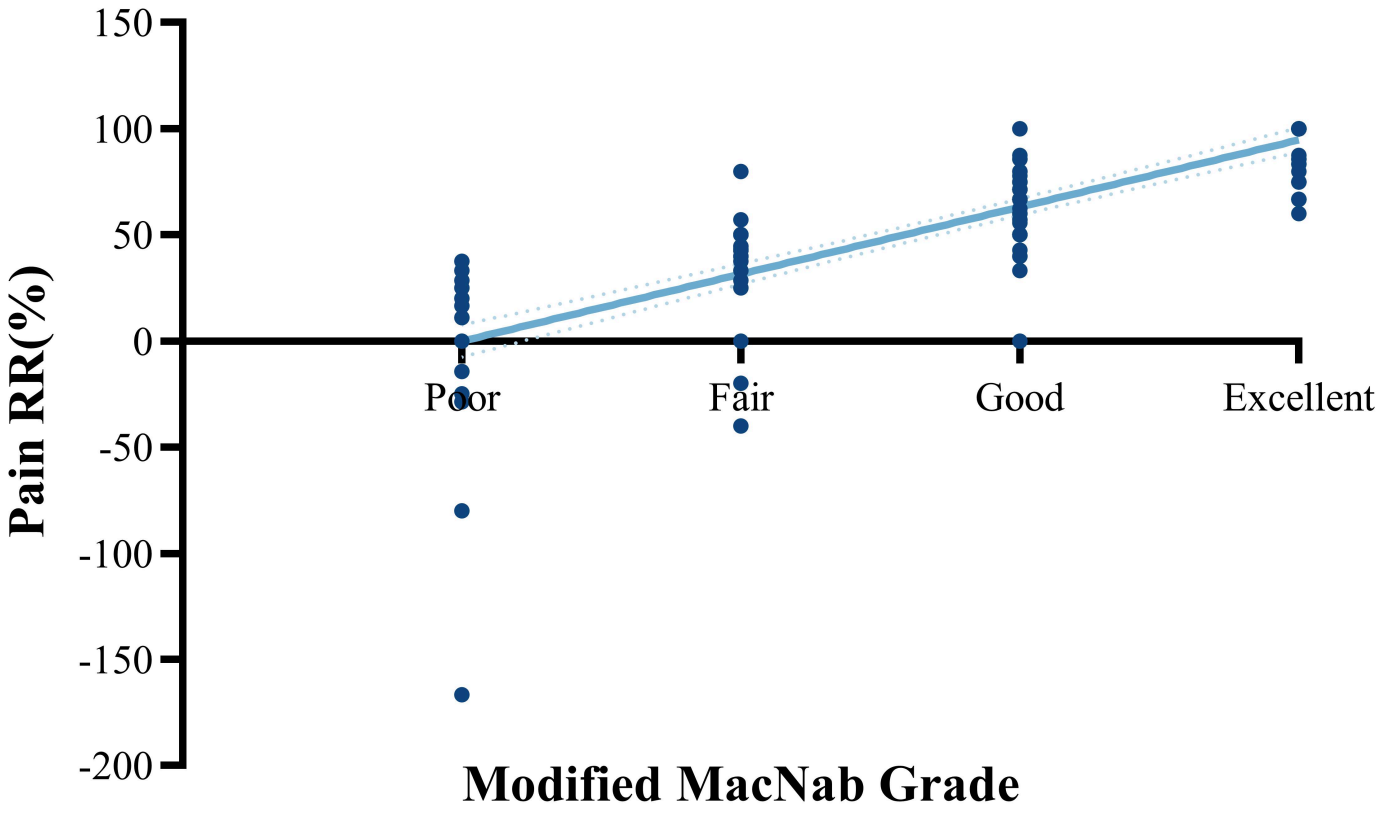


Figure 7

A positive correlation between pain remission rate and modified MacNab grade at 6 months post-TFESI.

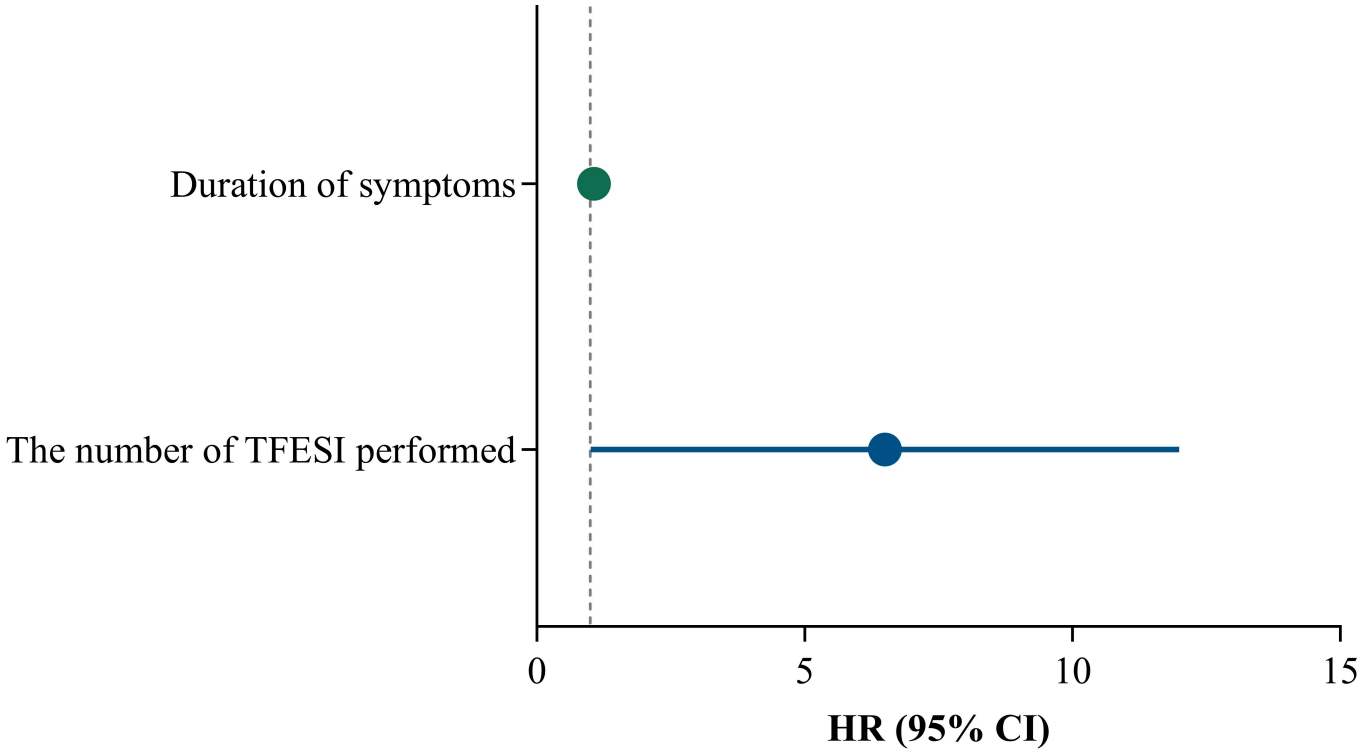


Figure 8

Independent predictors of TFESI ineffectiveness: a multivariate Bootstrap logistic regression forest plot.

Supplementary Files

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