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SCIENTIFIC ARTICLE

Does facet tropism negatively affect the response to transforaminal epidural steroid injections? A prospective clinical study

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Abstract

Objective To examine the impact of the presence of facet tropism on the results of transforaminal epidural steroid injection for unilateral radicular pain induced by lumbar disc herniation.

Materials and Methods We included 112 patients diagnosed with unilateral, single-level lumbar disc herniation-induced radicular pain. Injection was planned at relevant levels. The patients were assessed using the Numerical Rating Scale, the Modified Oswestry Disability Index, and the Beck Depression Inventory before the injection and at hour 1, week 3, and month 3 after the injection. Presence of facet tropism was assessed by measuring the facet angles in the L3–4, L4–5, and L5–S1 segments of lumbar MRI T2 sequence axial section.

Results A significant decrease in the Numerical Rating Scale and an increase in the Modified Oswestry Disability Index scores were detected at all follow-ups in groups comprising 39 patients with and 61 without facet tropism ($p < 0.05$). On comparison, improvement in clinical parameters at week 3 and month 3 in the group without facet tropism was greater ($p < 0.05$). As treatment success is considered to be a ≥ 50% reduction in the Numerical Rating Scale scores, 55.2% of the patients attained treatment success at month 3. Further, although the treatment success rate in the group with facet tropism was 34.2%, it was 69% in that without facet tropism ($p < 0.05$).

Conclusion Facet tropism correlates with less success of transforaminal epidural steroid injection; therefore, facet tropism may be a worthwhile measurement in a discussion with patients of the benefits of the procedure.

Keywords Lumbar radicular pain · Transforaminal epidural steroid injection · Facet tropism

Introduction

Many studies have shown that the short-term efficacy of epidural steroid injections for radicular pain induced by lumbar disc herniation (LDH) make them a successful treatment option [1, 2]. Although they can be administered via transforaminal, caudal, and interlaminar routes, the transforaminal approach is more effective and frequently preferred because the injectate can reach the target area comparatively directly [3].

Numerous studies are available investigating the possible factors associated with lumbar transforaminal epidural steroid injection (TFESI) treatment outcomes. High baseline pain on the visual analog scale and McGill Pain Inventory, the absence of deteriorating pain while walking, and positive femoral stretch test were identified by McCormick et al. to be the high probability predictive factors of pain reduction following lumbar TFESI [4]. In a study by Karp et al., sleep disturbance has been shown to negatively affect treatment outcomes [5]. In a study by Ghahreman and Bogduk low-grade spinal root pressure due to disc herniation (DH) in lumbar MRI had a favorable effect on treatment outcome in comparison with

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high-grade spinal root pressure [6]. However, there are ongoing debates regarding the presence and importance of other factors that may be associated with TFESI treatment outcomes.

Facet joints are synovial joints located on the dorsolateral side of the vertebral column [7]. Normally, both facet joints are symmetrical. Facet tropism (FT) is defined as asymmetry between the angles of orientation of the joints, in which a facet joint in the same segment is more sagittally oriented than the other [8]. In 1967, Farfan and Sullivan first reported that FT is a possible risk factor for the development of DH [9]. However, this is controversial as there are other views advocating that FT is not a risk factor for the development of LDH [8, 10–15]. Further, it has been emphasized that patients with FT have a greater need for adjacent segment degeneration and new spinal surgery after spinal fusion surgeries than those without FT [16].

In the current literature, studies have been conducted to examine the clinical and radiological parameters that may be related to the effectiveness of lumbar TFESI. The aim of this study was to examine the effect of the presence of FT on TFESI results in patients with LDH-induced unilateral lumbar radicular pain.

Materials and methods

Initially, we included 118 patients (68 women, 50 men; mean age, 44.8 years) admitted to our pain medicine outpatient clinic with complaints of pain in their waist and unilaterally radiating pain in their legs; they were diagnosed with LDH-induced unilateral lumbar radicular pain based on clinical examination and lumbar MRI evaluation between May 2015 and September 2016. After evaluating these patients and based on the inclusion criteria, 112 of them were finally included in the study. TFESI was planned at the relevant levels for these patients with unilateral, single-level, and lumbar DH-induced radicular pain.

Inclusion criteria were as follows:

1. Age 18–65 years
2. Presence of complaints of low back and unilateral leg pain with a >2-week history
3. Severity of pain based on numerical rating scale (NRS) ≥ 4
4. Presence of unilateral lumbar radiculopathy findings on physical examination
5. Presence of LDH in either of the L3–L4. L4–L5, or L5–S1 levels on MRI
6. Presence of associated unilateral L4, L5, or S1 spinal root pressure

Further, exclusion criteria were as follows:

1. Symptoms being bilateral or multiple segments causing symptoms
2. Having undergone lumbar surgery, such as lumbar fusion or laminectomy
3. Presence of lumbar spinal stenosis, spondylolysis, spondylolisthesis, and scoliosis
4. Lumbar epidural steroid injection (ESE) performed within the past 6 months
5. Bleeding diathesis
6. Presence of systemic or local infection

In the patients included, DH localization and size as per lumbar MRI, Modic alteration, presence of FT, and roots to be treated, were assessed by a physiatrist. The patients were divided into two groups: those with and those without FT. FT was defined as the presence of FT in at least one of the following: L3–4, L4–5, or L5-S1. In addition, we recorded the number of FTs and evaluated whether FT was at the same level of the herniated disc among these patients. Moreover, the same physiatrist also decided the injection level after assessment of clinical and radiological findings. Another physiatrist, who was unaware of the radiological findings in the patients, was responsible for completing an patient assessment form, including detailed physical examination findings, demographic characteristics (e.g., age and sex), analgesic drug registration, whether or not the patients were receiving physical therapy for the last 6 months; post-procedural follow-up, and evaluation of treatment outcomes. The fluoroscopy-guided TFESI procedure was implemented by a pain medicine specialist with a minimum of 10 years' experience in this area in the patients referred by the physiatrist who performed the radiological assessment.

The ethics committee of Marmara University approved the study. The patients were informed about the study, and written and verbal consent forms were obtained.

TFESI procedures

The patients with disc herniation were transferred to the intervention room for the TFESI procedure to the spinal nerve root under compression at a single level (i.e., unilateral L4, L5, or S1 spinal nerve root). Before TFESI, all patients were informed about the process by the individual administering injection, and the vascular access was established. The patients were placed in prone position with a pillow placed under their abdomen to reduce lumbar lordosis. The foramen to be injected was imaged by adjusting a fluoroscopic device at an oblique (average) angle of 0–30° and a cranial angle of 0–15°. The skin was cleaned three times with Batticon and covered with a sterile sheet. Short-acting local anesthetic (3 cc 2% prilocaine) was injected to anesthetize the skin and subcutaneous tissue. Regarding fluoroscopy, the position was determined at 6 o'clock just below the pedicle. In S1 TFESI administration, the superolateral annular foramen was targeted after the S1 foramen was imaged. Using a 22G 3.5-in spinal needle, the epidural space was approached using the coaxial technique in intermittent fluoroscopic imaging. Using a lateral view, the corresponding foramen was taken forward to the posterior third. Then, distribution pattern was examined on anteroposterior (AP) imaging by applying 1–2 cc of contrast agent (300 mg/50 ml iohexol; Fig. 1). Further, 80 mg methylprednisolone acetate, 1 cc physiological saline solution, and 1 cc (0.5%) bupivacaine were injected after confirming epidural and not vascular distribution. After the procedure, the patients were transferred to the observation room and observed for 1 h. Those who did not have any complications were evaluated at the end of the first hour after the injection and discharged with pertinent recommendations.

Radiological assessment

The type of LDH (bulge, protrusion, extrusion, and sequestration), localization (central, paramedian, foraminal, and extraforaminal) on lumbar MRI, focal or broad base formation, and Modic changes were recorded. Using the INFINITT PACS system for L3–4, L4–5, and L5–S1 levels, facet orientation angles were measured and assessed in terms of the presence of FT.

Assessment of FT was performed according to the measurement method used by Chadha et al. [8]. At the transdiscal level where facet joints are best assessed on the lumbar MRI T2 sequence axial sections, a line (MO [AO = OB]) was drawn through the midpoint of the spinous process base and

Fig. 1 Left S1 transforaminal epidural steroid injection (TFESI). Epidural spread of contrast agent in the left S1 foramen on anteroposterior imaging

disc center. Then, two lines (CD and EF) were drawn through the anteromedial and posterolateral margins of the right and left upper facet joints. The angles (a and b) that the lines form with the line "O" were measured (Fig. 2). When the difference between the two angles was >10°, the condition was accepted as FT.

Outcome measures

Pain severity was determined using the NRS before and after injection at hour 1, week 3, and month 3. We considered treatment success to be a ≥50% reduction in the NRS scores at month 3 relative to the initial NRS scores based on a study by Manchikanti et al. [17]. Functional impairment was assessed, and the Modified Oswestry Disability Index (ODI) was used before injection and at week 3 and month 3 after the injection. Psychological assessment of the patients was performed using the Beck Depression Inventory (BDI) before the injection and at week 3 and month 3 after the injection.

Statistical analysis

In the study, descriptive characteristics were examined with *n* and % values in categorical variables and with mean ± standard deviation in continuous variables. Chi-squared and Fisher's exact tests were used to compare categorical variables. Cochran Q analysis was used for repeated measures in nonsequential categorical variables. Paired *t* test was used in independent groups for the comparison of measured data, and variance analysis in repeated measures was used in the appropriate areas. Further, Friedman test was used for repeated measures in the ordinal data. p values <0.05 were considered statistically significant. Analysis was performed using SPSS 20.

Results

Initially, we included 118 patients with unilateral, single-level, lumbar radicular pain induced by LDH. Six patients who were injected at the upper lumbar levels, L3 or L4, were excluded because of an insufficient number of patients. Twelve patients were lost during follow-up after the injection. Following MRI evaluations, 100 patients who were included in the study were divided into two groups based on the presence of FT: those with (39 patients) and without (61 patients) FT (Fig. 3).

Notably, there were no significant differences between the groups in terms of demographic features and clinical parameters (Table 1). Both groups were also similar in terms of DH characteristics (type, size, and localization), Modic changes, and physical examination findings (straight leg raise test, extensor hallucis longus and gastrocnemius muscle strength, the presence of sensory loss in L5 and S1 dermatomes, and patellar and Achilles tendon reflex changes).

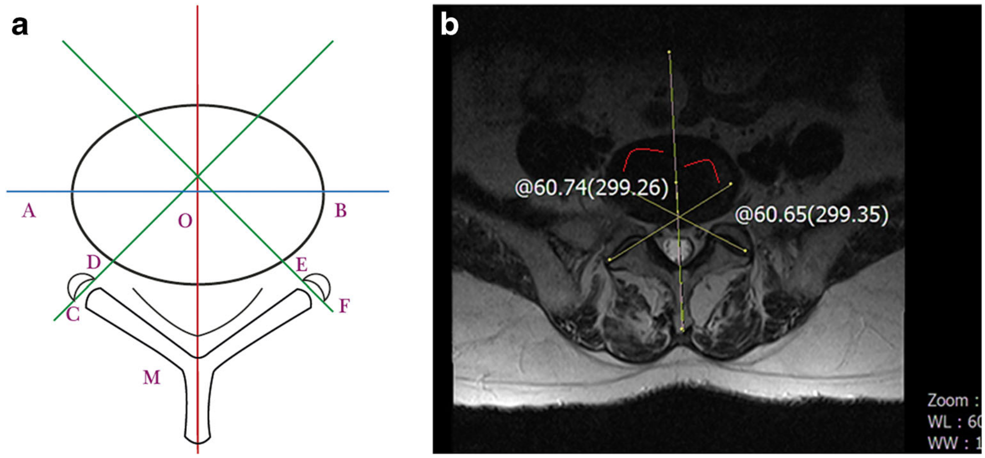

Fig. 2 **a** Diagram of facet joint angles measurement. **b** T2 sequence axial view, measurement of facet angles of the INFINITT PACS system at the L5–S1 transdiscal level is shown on the MRI

Significant changes were observed in the NRS and ODI scores in both groups following the injection ($p < 0.001$). Rate of change in the NRS scores at hour 1 after injection was similar between the groups. In the follow-ups at week 3 and month 3 after the injection, the change in the NRS and ODI scores was significantly lower in the group with FT compared with that without FT ($p < 0.001$). Further, there was no significant difference in the terms of the BDI scores in both groups after injection (Table 2). Similarly, there was no significant difference between the time-dependent changes of the NRS, ODI, and BDI scores among the patients with DH at the same level as FT and at different levels.

Treatment success was accepted as a ≥ 50% reduction in the NRS scores following the injection. Accordingly, treatment was successful in 97% of the patients at hour 1, 73% at week 3, and 55.2% at month 3. Regarding treatment success between the groups, there was no significant difference between them at hour 1 following the injection, whereas the rate of change in the patients with FT at week 3 and month 3 was significantly lower than in those without FT ($p = 0.02$ and $p = 0.001$ respectively; Fig. 4). In 24 (61.5%) and 15 (38.5%) patients with FT, FT was present at single and multiple levels respectively. Notably, there was no significant difference in terms of treatment success among the patients with single or multiple FT at all follow-ups. However, one patient from the group with FT and 3 from that without FT underwent surgical treatment after the follow-up at week 3. Further, there was no significant difference between the groups in terms of undergoing surgical treatment.

Discussion

Consequently, despite the significant decrease in the NRS and ODI scores at all follow-ups after the treatment in both groups, the improvement was greater in the group without FT at follow-ups at week 3 and month 3. Because treatment success was accepted to be a ≥50% reduction in the NRS scores, 55.2% of patients were considered to attain treatment success

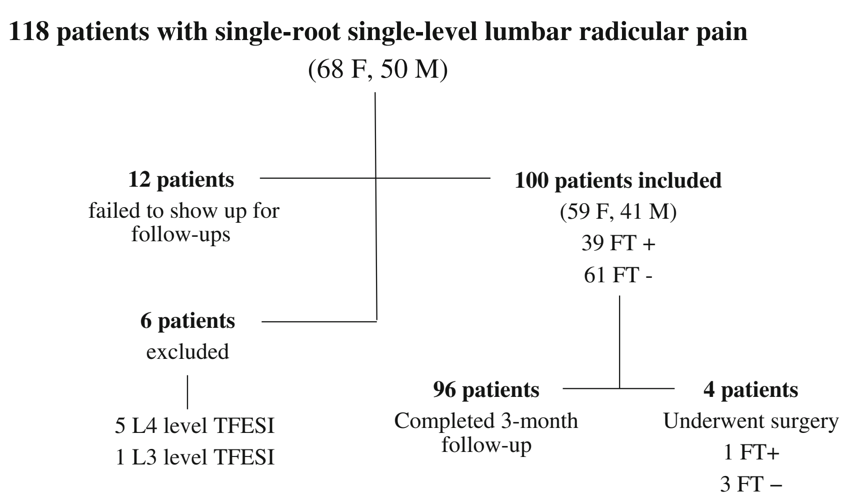

Fig. 3 Flow diagram showing how patients progressed through the study

Table 1 Distribution of demographic and clinical parameters

		Facet tropism present		Facet tropism absent		*p* value
		n	%	*n*	%	
Sex	Female	22	56.4	37	60.7	0.674
	Male	17	43.6	24	39.3	
Age (years)		45.0	9.2	44.5	12.1	0.838
BMI (kg/m^2)		27.6	4.1	27.1	4.3	0.529
Duration of symptoms (months)		14.8	12.6	13.2	7.6	0.479
Medication used before the treatment	None	0	0.0	5	8.2	0.092
	NSAIDs	18	46.2	30	49.2	
	Gabapentin	1	2.6	3	4.9	
	Pregabalin	12	30.8	18	29.5	
	NSAIDs + pregabalin	8	20.5	3	4.9	
	NSAIDs + gabapentin	0	0.0	1	1.6	
	Duloxetine	0	0.0	1	1.6	
Duration of medication use (months)		4.8	7.7	3.0	2.6	0.162
History of physical therapy	Not received	29	76.3	44	73.3	0.741
	Received	9	23.7	16	26.7	

NSAIDs nonsteroidal anti-inflammatory drugs

at month 3. However, in the group with FT, the treatment success rate was 34.2%, whereas it was significantly higher (69%) in the group without FT.

Facet tropism is defined as the asymmetry between the angles of orientation of the joints, in which a facet joint in the same segment is more sagittally oriented than the other [8]. In the literature, different values have been used to determine the presence of FT: >1°, >5°, or >10° [8, 11, 12, 18, 19]. While assessing the presence of FT, Chadha et al. stated that there are concerns whether or not small differences would indeed be regarded FT, and they considered a difference in threshold limit of 10° to be ideal because larger values (15–20°) are encountered in very few segments [8]. Accordingly, we also used a 10° difference in our study to evaluate the presence of FT, because small values can be due to measurement errors.

There are many studies in the literature that examined the association between FT and LDH [8, 10–15]. In the study by Ghandhari et al., 66 patients with L4–L5 LDH and 63 patients with L5–S1 LDH were compared with 61 normal subjects, and FT was found to be particularly associated with L4–L5-level LDH [14]. In the study by Lee et al. examining 149 levels in 140 adolescents with LDH and 119 levels in 111 adults with LDH, no relationship was found between the presence of FT and the development of LDH [15]. Therefore, the relationship between the presence of FT and the development of LDH is controversial, and its clinical implication has not yet been fully elucidated.

Table 2 Distribution of time-dependent changes in scale scores based on the presence of facet tropism

Changes in facet tropism and the scale scores		Facet tropism present	Facet tropism absent	*p* value
NRS	Before injection	7.1 ± 2.3	7.7 ± 2.0	<0.001
	1 h after injection	0.6 ± 1.3	0.9 ± 1.6	
	Week 3	3.4 ± 3.1	2.4 ± 2.3	
	Month 3	5.4 ± 3.3	3.3 ± 2.8	
ODI	Before injection	55.9 ± 16.8	60.3 ± 16.4	<0.001
	Week 3	39.6 ± 20.7	36 ± 18.4	
	Month 3	48.3 ± 21.1	33.4 ± 21.1	
BDI	Before injection	16.9 ± 8.9	16.4 ± 13.1	0.316
	Week 3	13.2 ± 8.4	10.6 ± 9.9	
	Month 3	12.5 ± 7.1	8.7 ± 8.4	

NRS Numerical Rating Scale, *ODI* Modified Oswestry Disability Index, *BDI* Beck Depression Inventory

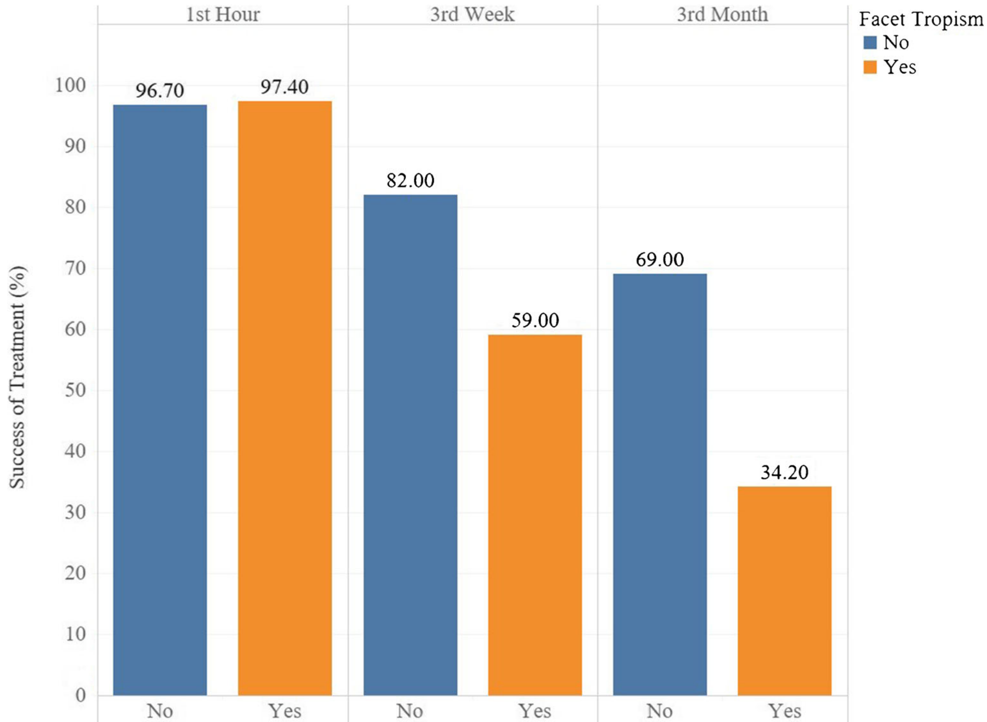

Fig. 4 Temporal distribution of inter-group treatment success

Several biomechanical factors have been implicated in the relationship between the presence of FT and the development of LDH. In the presence of FT, a single-plane motion in the sagittal axis can be transformed into a complex, multi-planar motion as a result of disrupted biomechanical consequences [20]. Therefore, the shear force is increased following additional torsion force or resistance to shear force is decreased [18, 21]. It has been emphasized that, in particular, movement of the flexion with torsion causes mechanical stress in the intervertebral disc, injuries in the posterolateral annulus, and pushing of the nucleus toward the posterolateral annulus [19, 22–24]. In addition, patients with FT have been found to be at an increased risk for adjacent segment degeneration and new spinal surgery after spinal fusion surgeries compared with those without FT [16, 25]. Okuda et al. suggested that FT accelerates the thickening of the ligamentum flavum by affecting rotational stability, thereby causing spinal canal stenosis [25]. In our study, the fact that the treatment success of patients with FT was lower than that of patients without FT may be associated with the adverse effects of the above-mentioned biomechanical changes. Despite the well-known analgesic and anti-inflammatory effects of TFESI, the relationship between TFESI and biomechanical/structural changes is still unclear. This may explain the failure of TFESI in the patients with FT. To support this hypothesis, there is a need for clinical and biomechanical studies involving larger patient groups and longer follow-up periods.

In a study by Roy et al., in 30 patients with LDH-induced radicular pain, a significant improvement was detected on the NRS and Roland–Morris scales at a 6-month follow-up after TFESI treatment [26]. In a study by Ahadian et al., in 98 patients with lumbar radiculopathy, a significant improvement was detected in terms of the ODI scores at month 3 after TFESI treatment [27]. In addition, it was reported in a study by Benny and Azari that there was strong evidence for both short- and long-term efficacies of TFESI in the treatment of lumbosacral radicular pain in a comprehensive literature review [28]. However, our study does not include long-term follow-up, and an improvement in the NRS and ODI scores was observed in both groups during the 3-month follow-up. These results are consistent with those available in the literature [1, 26–28].

In a retrospective study, Kaufmann et al. considered a ≥50% reduction in the NRS scores as effective treatment, the data of 2,026 patients who underwent single-level TFESI treatment were analyzed, and 45.6% of the patients who were injected during a 2-month follow-up were found to have successful treatment [29]. In our study, the rate of patients achieving treatment success at month 3 was 55.2%, i.e., the success rates of treatment in both studies were similar. However, on comparing the two groups, the treatment success was significantly higher in the group without FT. Further, there was no difference between the two groups in terms of demographic characteristics, physical examination findings, treatments taken before the application and their duration, duration of symptoms, the BDI scores before injection, characteristics of DH in lumbar MRI, and Modic changes. The fact that these factors that may have an effect on TFESI treatment success were similar in the two groups allows us to evaluate the effect of FT alone.

There was no significant difference in the number of patients receiving physical therapy within the last 6 months before the procedure and the amount of analgesic and neuropathic pain agents between the groups. In addition, during a 3-month follow-up following the procedure, none of the patients received physical therapy following the TFESI procedure and no post-procedural adjustment for the analgesics and neuropathic pain agents was made. Based on these findings, the treatment success at 3 months can be attributed to the TFESI procedure itself. However, based on the finding that FT adversely affected the TFESI results in our study, we are still in need of further studies to shed light on the definite effects of FT on the response to conservative treatment.

The FT group included not only those with FT at the level of injection, but also those with FT in one of the adjacent segments. The subgroup analyses were performed according to the FT status (present versus absent) at the injection level and the presence of FT involving one or more levels. These analyses revealed no significant difference in the treatment results, supporting the opinion that FT may also alter the biomechanical properties of the adjacent segments. Nonetheless, we recommend further comprehensive and large-scale studies to identify the effects of the presence of FT (at the level of primary pathology versus at the level of the adjacent segment) on the TFESI results.

This study is valuable in terms of its design, with prospective and homogenous groups, and the evaluation of a large number of clinical and radiological parameters. However, there are certain limitations to our study, such as the presence of FT in patients being evaluated by a single physician, the small sample size, and the lack of a long-term follow-up.

Facet tropism correlates with the lower success rate of TFESI; therefore, FT may be a worthwhile measurement in a discussion with patients of the benefits of the procedure, and, perhaps, with further research, a factor for determining treatment pathways.

Compliance with ethical standards

Conflicts of interest The authors declare that they have no conflicts of interest.

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