Original Investigation

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Investigation of the Relationship Between the Frequency of Lumbar Facet Tropism and Disc Herniation and Spondylolisthesis in Patients with Low Back Pain Complaints

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ABSTRACT

Objective: The relationship between facet tropism (FT) and degenerative lumbar pathologies remains controversial due to conflicting evidence. This study aimed to determine the frequency of lumbar FT in patients with low back pain and to investigate its relationship with lumbar disc herniation (LDH) and degenerative spondylolisthesis (DS) at specific spinal levels.

Methods: This retrospective cross-sectional observational study included 92 patients aged 18-80 years who presented with low back pain between November 2023 and May 2025. Facet joint angles were measured on patients' lumbar magnetic resonance imaging at the L3-L4, L4-L5, and L5-S1 levels, with FT defined as a bilateral angular difference of 6 degrees or more at the same level. The relationship between the presence of FT and the presence of LDH and DS was evaluated using the chi-square test or Fisher's exact test.

Results: The mean age of the 92 patients included in the study was 42.30±11.66 years, and 63% were female. FT was most frequently observed at the L5-S1 level (54.3%), followed by L4-L5 (44.6%) and L3-L4 (31.5%). Statistical analyses revealed no significant association between the presence of FT and that of LDH or DS at any examined lumbar level (L3-L4, L4-L5, L5-S1) ($p>0.05$).

Conclusion: Despite the high prevalence of FT at the lower lumbar levels, no statistically significant association was observed between the presence of FT and either LDH or DS. The findings contribute to the body of contradictory results and suggest FT may not be an independent, determining risk factor in the multifactorial etiology of lumbar degeneration.

Keywords: Low back pain, spondylolisthesis, intervertebral disc disease, zygapophyseal joint, lumbar vertebrae, magnetic resonance imaging

INTRODUCTION

Low back pain is one of the most common musculoskeletal disorders and a significant global public health issue (1). As the leading cause of years lived with disability worldwide (2), it severely impairs individual quality of life while contributing substantially to work-related losses and societal burden (3). Annual prevalence ranges from 6% to 38% (4,5), with lifetime prevalence reaching 11% to 84% (6). This burden largely stems from age-related degenerative changes in the lumbar spine (7), which affect the intervertebral discs and facet joints and give rise to conditions such as lumbar disc herniation (LDH), degenerative disc disease, spondylosis, and facet joint osteoarthritis (8). Although LDH accounts for less than 5% of back pain cases, early diagnosis and identification of risk factors remain critical for both treatment planning and prevention (9,10).

Facet joints protect the intervertebral disc from excessive torsional stress by bearing approximately 33% of the axial load and, in particular, by limiting rotational forces (11). Facet tropism (FT) is defined as the asymmetry between the axial angles of both vertebral facet joints at the same level (12). It is theorized that this asymmetry alters the biomechanics of the lumbar segment, leading to abnormal and asymmetric stress distribution on the intervertebral disc and facet joints, which may predispose to annulus fibrosus tears, disc degeneration, and consequently, the development of LDH or instability (13,14).

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The relationship between FT and degenerative spinal pathologies such as LDH and degenerative spondylolisthesis (DS) has been extensively studied, although findings have been conflicting. A meta-analysis by Garg and Aggarwal (15) found a statistically significant relationship between FT and LDH and DS, but the heterogeneity and differences in the results are noteworthy. Another study found a positive relationship between FT and LDH only at the L3-L4 level (16). In contrast, another study suggested that severe FT may be associated with increased disc bulging only in the elderly patient subgroup and particularly at the L4-L5 level, and that this is not a universal finding (17). In another prospective study, 240 patients were evaluated, and no statistically significant relationship was found between FT and lumbar degeneration (18). While the existing literature remains polarized, the novelty of the study lies in its level-specific (L3-L4, L4-L5, L5-S1) analysis in a symptomatic Turkish population and provides detailed insights into whether FT acts as an independent risk factor or a congenital variant during the early-to-mid stages of spinal aging. This study aimed to determine the frequency of FT in a large population of patients presenting with low back pain and to examine the relationship between FT and the presence of LDH and DS at specific levels. The primary hypothesis of the study is that FT is associated with an increased prevalence of LDH and/or DS at the same level, particularly in the most mobile segments L4-L5 and L5-S1. The present study aims to highlight the clinical significance of FT and to shed light on future rehabilitation strategies for patients at risk.

METHODS

This study was a retrospective, cross-sectional observational study. Approval was obtained from the Scientific Research Ethics Committee of University of Health Sciences Türkiye, İstanbul Physical Therapy Rehabilitation Training and Research Hospital with protocol number 2025-45 (date: 12.05.2025), and the entire process was conducted in accordance with the principles of the World Medical Association's Declaration of Helsinki. The study was also registered in the ClinicalTrials.gov database with the identification number NCT06982118. Due to its retrospective nature, informed consent was waived.

The study population consisted of patients who presented to the Physical Medicine and Rehabilitation outpatient clinics at University of Health Sciences Türkiye, İstanbul Physical Therapy Rehabilitation Training and Research Hospital with complaints of back pain between November 1, 2023, and May 1, 2025. To determine the required sample size for the study, an a priori power analysis was conducted using the G*Power software (version 3.1). The analysis for the chi-square (χ^2) goodness-of-fit (contingency tables) test was based on an expected effect size (w=0.3), a Type I error probability (α=0.05), a targeted statistical power (1-β=0.80), and the degrees of freedom (df=1). The calculation indicated that a minimum sample size of 88 was required to satisfy these statistical criteria (critical χ^2=3.84, non-centrality parameter λ=7.92). The actual statistical power achieved with this sample size (n=92) was 0.820.

Male and female patients aged 18 to 80 years who presented to the outpatient clinic with complaints of low back pain were included in the study. Participants were required to have complete demographic and clinical data in their archive files and a lumbar magnetic resonance imaging (MRI) examination recorded in the hospital picture archiving and communication system (PACS). Patients who had previously undergone surgery in the lumbar region, had a history of trauma to this region, had active inflammatory joint disease, had central nervous system disease such as Parkinson's or multiple sclerosis, or a diagnosis of malignancy, as well as those with incomplete archive records, were excluded from the study. As illustrated in Figure 1, the study population was derived from an initial screening of 451 patients. The final sample size of 92 was reached after excluding cases with prior surgery, trauma, inflammatory diseases, and significant data gaps in hospital records.

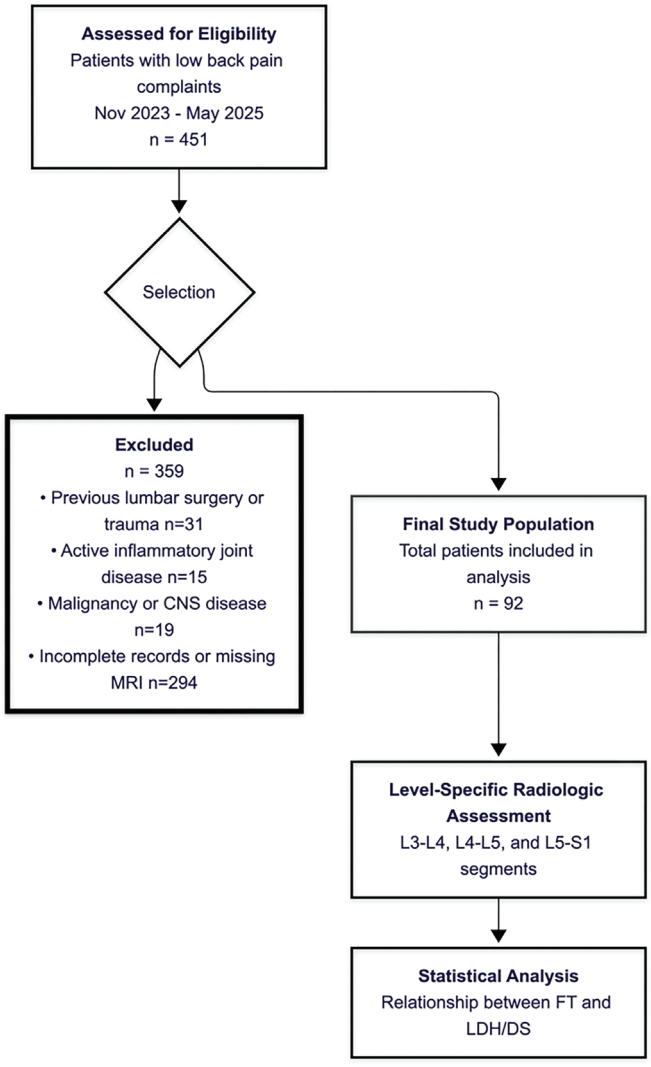


Figure 1. Flowchart of the patient selection process

CNS: Central nervous system, MRI: Magnetic resonance imaging, FT: Facet tropism, DS: Degenerative spondylolisthesis, LDH: Lumbar disc herniation

For angle measurement, a mid-axial reference line connecting the midlines of the posterior elements of the vertebral body was drawn, followed by a second line along the long axis of the facet joint surface. The angle between these two lines was recorded in degrees. This procedure was repeated for both the right and left facet joints at the same level (Figure 2). All facet angle measurements were performed by two researchers. If there was a difference of 1 degree or more between the two researchers' measurements, the measurements were re-evaluated jointly, and the final value was determined by consensus. For the FT definition, the difference between the right and left facet joint angles at the same vertebral level was calculated. Consistent with the literature, an angle difference of 6 degrees or more was considered indicative of FT (17). The presence of LDH and DS was determined from MRI reports created by specialist radiologists and recorded in the patients' hospital PACS system. The presence of LDH was defined as the report of at least one of the following disc morphology findings at the relevant level: "bulging", "protruding", "extruded", or "sequestered". The presence of DS was defined as slippage of Grade 1 or higher according to the Meyerding classification.

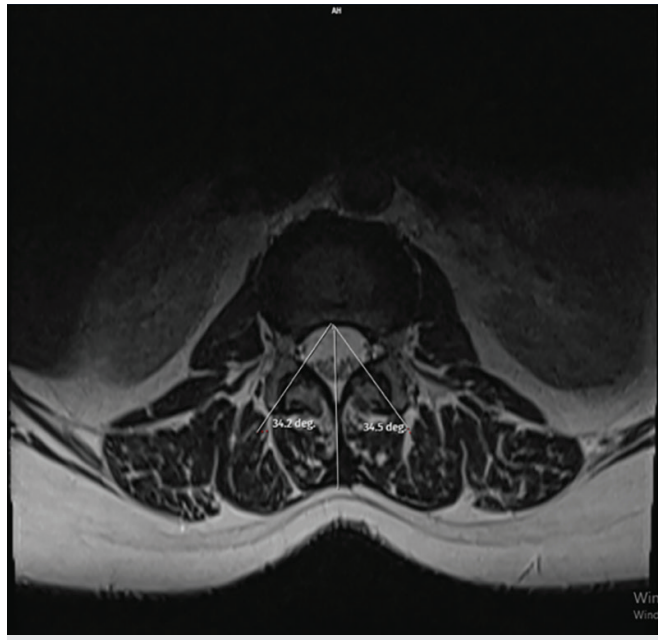


Figure 2. Facet angle measurement

Statistical Analysis

Statistical analysis of the data was performed using SPSS 26.0 (IBM Corp., Armonk, NY, USA). The normality of the variables was assessed using the Lilliefors-corrected Kolmogorov-Smirnov test. Continuous variables that followed a normal distribution were presented as mean ± standard deviation, while those that did not follow a normal distribution were presented as median (interquartile range). Categorical variables were summarized as frequency (n) and percentage (%). The Pearson chi-square test was used to evaluate the relationships among the categorical variables: presence or absence of FT, LDH, and DS. Fisher's exact test was applied when the expected cell frequencies were low (i.e., when more than 20% of expected cell frequencies were fewer than 5). Additionally, the Linear-by-Linear Association test was utilized to evaluate trends across ordinal categories, such as age groups. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 92 patients with complaints of low back pain who had complete demographic data and lumbar MRI results were included in this retrospective, cross-sectional observational study. Sixty-three percent (n=58) of the patients were female, and 37% (n=34) were male. The mean age was 42.30±11.66. When the treatment histories of the participants were examined, 80.4% had received drug therapy, and the most commonly used drugs in this group were non-steroidal anti-inflammatory drugs (68.5%) and local gels (63.0%). Opioid use was infrequent (2.2%). Fifty-four point three percent of patients received physical therapy. The clinical and demographic information of the patients is summarized in Table 1.

Lumbar MRI scans of all patients were retrospectively reviewed to determine mean facet joint angles and the prevalence of spinal pathologies. No significant difference was found in the prevalence

Table 1. Demographic, clinical, and treatment characteristics of the study population

Characteristic	Variable	Number (n)	Percentage (%)
Total number of patients		92	100.0
Gender	Female/male	58/34	63.0/37.0
Age	Mean ± SD	42.30±11.66 years	
Treatment received	Medication use	74	80.4
	Oral NSAIDs	63	68.5
	Local NSAID	58	63.0
	Opioid	2	2.2
	Physical therapy	50	54.3
Patients with lumbar pathology	LDH	72	78.3
	DS	16	17.4

NSAID: Non-steroidal anti-inflammatory, LDH: Lumbar disc herniation, DS: Degenerative spondylolisthesis, SD: Standard deviation

of FT between age groups (p>0.05), nor was a monotonic trend in FT prevalence observed with age (Table 2).

The frequencies of FT, LDH, and DS in the study group are shown in Table 3. The chi-square test evaluating relationships between categorical variables found no statistically significant relationship between the presence of lumbar FT and the presence of LDH and DS (p>0.05). Details are shown in Table 4.

DISCUSSION

In this study, lumbar MRI scans of 92 patients who presented with low back pain were retrospectively examined to determine the frequency of FT and its relationship with LDH and DS. The main finding of the study was that lumbar FT was most frequently observed at the L5-S1 level (54.3%), followed by the L4-L5 (44.6%) and L3-L4 (31.5%) levels. The prevalence of LDH was highest at the L4-L5 level (66.3%), whereas DS was most frequently detected at the L5-S1 level (10.9%). However, analyses revealed no significant relationship between the presence of FT and either LDH or DS at any lumbar level (L3-L4, L4-L5, L5-S1) (p>0.05). These findings imply that FT alone is unlikely to act as a definitive, independent risk factor for the development of these degenerative spinal pathologies.

The results of this study contribute to the ongoing, conflicting literature on the relationship between FT and degenerative spinal pathologies. While some studies report a positive relationship between FT and LDH (14,16,19), other studies, consistent with the results, have not found a significant relationship (18,20-22). A notable finding in articles reporting a significant relationship between LDH and FT is that this relationship has not been demonstrated across all lumbar segments. A systematic review and meta-analysis examining the relationship between FT and various lumbar and cervical degenerative disorders showed that FT is significantly associated with degenerative diseases, including LDH and DS (15). However, in the subgroup analysis by level performed in the same meta-analysis, no significant differences were found among L3-L4, L4-L5, and L5-S1. The lack of results from the subgroup analyses creates uncertainty about whether the study findings are clinically valid at all levels. This indicates that the overall findings of the meta-analysis cannot be refined to a more detailed level by subgroup analysis. This

Table 2. Comparison of facet tropism prevalence by age groups

Age group	n	L3-L4 FT (%)	L4-L5 FT (%)	L5-S1 FT (%)
20-29	18	22.2	33.3	55.6
30-39	16	56.3	68.8	25.0
40-49	34	26.5	38.2	61.8
50-59	17	35.3	41.2	58.8
60+	7	14.3	57.1	71.4
χ^2 value (Pearson)		6.731	5.786	7.279
p-value (Pearson)		0.151	0.216	0.122
Trend p		0.653	0.810	0.191

FT: Facet tropism, Trend P: Linear-by-Linear Association p-value, χ^2: Chi-square

Table 3. Prevalence of lumbar pathologies

Level	Facet tropism	Disc herniation	Spondylolisthesis
L3-L4	31.5% (n=29)	34.8% (n=32)	5.4% (n=5)
L4-L5	44.6% (n=41)	66.3% (n=61)	5.4% (n=5)
L5-S1	54.3% (n=50)	48.9% (n=45)	10.9% (n=10)

Table 4. Association between facet tropism and the presence of disc herniation or degenerative spondylolisthesis by lumbar level

Pathology	Lumbar level	Chi-square value (χ^2)	p-value	OR	95% CI
LDH	L3-L4	0.967	0.325	0.62	(0.24-1.62)
	L4-L5	1.561	0.212	1.77	(0.73-4.29)
	L5-S1	0.372	0.542	0.77	(0.35-1.72)
DS	L3-L4	1.987	0.321*	3.52	(0.56-22.17)
	L4-L5	0.045	1.000*	0.82	(0.13-5.15)
	L5-S1	1.108	0.336*	2.12	(0.52-8.66)

CI: Confidence interval, DS: Degenerative spondylolisthesis, LDH: Lumbar disc herniation, OR: Odds ratio, *: Fisher's exact test p-value

level-specific inconsistency is also evident in individual studies. For example, this study's failure to find a relationship at L4-L5 is supported by Chadha et al. (19) but not by Degulmadi et al. (23) and Arzpeyma et al. (24). Similarly, failure of the study to detect a significant relationship at L5-S1 is consistent with Degulmadi et al. (23) but contradicts the findings of Chadha et al. (19). Similarly, studies evaluating LDH and control groups in young adults, as well as studies evaluating age-independent non-specific low back pain patients, have reported that FT is not a primary factor in the etiology of LDH (21-25).

Similarly, this study, which did not find a significant relationship between DS and FT, contradicts the literature on this subject. In this study, no significant relationship was found between FT and DS at any level. In a retrospective study, no significant relationship was found between FT and DS at the L3-L4 and L5-S1 levels, while a statistically significant relationship was found at the L4-L5 level (23). Another radiological study found that FT was significantly more prevalent in DS patients not only at the level of slippage but also in adjacent segments, and concluded that FT is a pre-existing morphological factor predisposing to DS development rather than a secondary condition (26). In contrast, a study conducted on adolescents found no significant relationship between FT and spondylolysis at any level (27). Taking this a step further and offering a different perspective on the finding of "no meaningful relationship", a recent study reported that the presence of FT in low-grade DS patients showed a negative correlation with joint instability and the degree of slippage, suggesting that FT may have a protective effect on instability (28). Although the lack of associations in adolescents can be explained by developmental factors, Carneiro et al.'s (28) finding suggests that FT is not an invariant risk factor for DS but may instead be protective against instability. This supports the findings of this study.

The apparent inconsistencies in the literature are considered to be due to methodological differences and population diversity. First, there is no universally accepted standard angular threshold value for the definition of FT; studies use different "cut-off" values such as ≥5°, ≥7°, ≥8°, or ≥10°, which directly affects prevalence and relationship analyses (13,15,18,29). Second, differences in measurement methods may be another cause of inconsistencies. Measuring the cephalad and caudal portions of the facet joint separately may yield different results, and it has been shown that only FT in the cephalad portion is associated with L4-L5 LDH (30). Similarly, it has been emphasized that FT should be assessed using multiplanar or three-dimensional methods, as measurements based on single two-dimensional axial slices reduce the complex three-dimensional facet surface to a single planar proxy and may materially influence the measured values (29). Notably, a Turkish case-control study employing an identical FT classification threshold (6°) reported significantly higher rates of FT in young male patients with isthmic spondylolysis compared to controls, particularly at the L5-S1 level (31). Although spondylolysis and DS represent distinct pathological entities—the former resulting from a pars interarticularis defect and the latter from chronic facet joint degeneration without bony discontinuity—this finding lends indirect support to the biomechanical relevance of facet asymmetry at the L5-S1 level across different lumbar pathologies.

Whether tropism is part of age-related degeneration or a congenital feature remains a matter of debate. On the one hand, a prospective study in patients with back pain showed a significant correlation between age and FT at the L4-L5 and L5-S1 levels (18). Furthermore, a study using kinetic MRI reported that the severity of FT at the L4-L5 level tended to increase with age, particularly in the population aged 41 years and older (17). These findings support the theory that FT may develop as part of an age-related degenerative cascade. On the other hand, a study conducted on patients with non-specific low back pain found no significant difference in FT type and development between age groups and suggested that this condition may be an innate characteristic independent of advancing age (21). The results also did not reveal a statistically significant correlation between age and FT, supporting the second view. The mean age of the study population, 42.3, is a critical point in this discussion. Considering that the relationship between FT and degenerative changes is particularly evident in the population over 50 years of age, the fact that this age-related degenerative effect has not yet reached a statistically significant level in this relatively young population may explain this confusion (17,30). This suggests that patient age is a critical variable when evaluating the clinical significance of FT.

The findings of this study, namely the failure to detect a statistically significant relationship between FT and LDH and between FT and DS, contribute to the controversial literature regarding clinical practice. Although comprehensive meta-analyses and some large-scale studies suggest that FT is associated with degenerative processes (especially DS) in the general population, other studies with similar negative findings suggest that this relationship may not be universal or causal. The fact that no significant relationship between FT and LDH has been found in important studies conducted in Türkiye is consistent with the findings and raises doubts about the universality of the FT-LDH relationship (18,20,21,25). These findings indicate that FT alone should not be the primary factor driving aggressive changes to treatment plans for patients from similar populations. This aligns with the broader understanding of lumbosacral morphology in the literature, the relationship between morphological alterations and LDH often presents a "chicken and egg" dilemma, making it difficult to discriminate whether morphological changes contribute to the herniation or arise as a compensatory postural effect (32). These findings suggest that FT alone should not be considered a decisive diagnostic marker without corroborating clinical and radiological evaluation.

Study Limitations

The first limitation of this study is that, due to its retrospective and cross-sectional nature, a causal relationship among FT, LDH, and DS could not be established. Importantly, our retrospective design lacked data on key multifactorial drivers of lumbar

degeneration, including body mass index, occupational demands, and physical activity levels, which limits our ability to perform a comprehensive biomechanical assessment of the cohort. Second, the absence of a healthy control group has resulted in limited information on the prevalence of FT in the community. Another limitation is the relatively low number of DS cases in this population. This may have reduced the statistical power of the study to detect a potential association between FT and DS, particularly in level-specific analyses. Evaluating FT statically and in a single plane also limited assessment of the dynamic effect of tropism. Although facet angle measurements were performed jointly by two physicians, the lack of statistical validation of inter-observer reliability using the intraclass correlation coefficient is a methodological limitation. Finally, the relatively young age of this population (mean age 42.3 years) limits the ability to fully assess the interaction between FT and age-related degenerative processes. The lack of significant association may stem from the younger demographic, suggesting that FT could be a preexisting morphological variant that predates symptomatic degeneration typically observed in older populations.

CONCLUSION

In this retrospective cross-sectional study, evaluation of lumbar MRI images from 92 patients with low back pain revealed that, although the prevalence of FT was highest at the L5-S1 level (54.3%), there was no statistically significant relationship between FT and disc herniation or spondylolisthesis. The findings, consistent with previous studies conducted in Türkiye, add to the conflicting results in the literature and suggest that FT should be evaluated as a parameter interacting with age, biomechanical factors, and individual characteristics rather than as an isolated determinant in the multifactorial etiology of lumbar degeneration.

Ethics

Ethics Committee Approval: Approval was obtained from the Scientific Research Ethics Committee of University of Health Sciences Türkiye, İstanbul Physical Therapy Rehabilitation Training and Research Hospital with protocol number 2025-45 (date: 12.05.2025), and the entire process was conducted in accordance with the principles of the World Medical Association's Declaration of Helsinki.

Informed Consent: Due to its retrospective nature, informed consent was waived.

Footnotes

Author Contributions: Concept - M.A., E.K.; Design - M.A., E.K.; Data Collection and/or Processing - M.A., E.K.; Analysis and/or Interpretation - M.A., E.K.; Literature Search - M.A., E.K.; Writing - M.A., E.K.

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