Hindawi
Journal of Healthcare Engineering
Volume 2022, Article ID 2486745, 7 pages
https://doi.org/10.1155/2022/2486745

Research Article

A Systematic Review and Meta-Analysis of the Facet Joint Orientation and Its Effect on the Lumbar

Zhirui Zheng, Youqiang Wang, Tong Wang, Yue Wu, and Yuhui Li

The Second Affiliated Hospital of Harbin Medical University Orthopedic Surgery Three Ward, Harbin, China

Correspondence should be addressed to Zhirui Zheng; zhengzhirui824@163.com

Received 4 November 2021; Revised 21 December 2021; Accepted 10 January 2022; Published 22 February 2022

Academic Editor: Rahim Khan

Facet tropism is recognized as the difference in the positioning of the facet joints in association with each other in the sagittal plane. This guides to an imbalanced biomechanical force over the facet joints and the intervertebral disc during rotation and other physiological activities. A systematic review and meta-analysis of Web of Science, EMBASE, PubMed, Cochrane Library, SCOPUS, and CINHAL from 2004 to 2021 to recognize the related research studies was performed. The data for meta-analysis were obtained from multiple studies to get the combined effect of the facet tropism on the lumbar disc herniation (LDH) and the degenerative lumbar spondylolisthesis (LDS). 117 articles were incorporated in the systematic review, where 41 studies were selected for meta-analysis, out of which 7 studies were found eligible as per the inclusion criteria. When degenerative lumbar spondylolisthesis was compared with the normal group, 95% CI was observed at 1.94 (1.59, 2.28). There was a comparison of disc herniation with the normal group in L4/L5, with a 95% CI of 0.60 (0.05, 1.14). The L5/S1 disc herniation was compared with the normal group and was found to be 0.21 (−0.48, 0.90). Therefore, it was observed that facet tropism is related to lumbar disc herniation and degenerative lumbar spondylolisthesis. Our meta-analysis demonstrated a unique link between the facet tropism and the lumbar disk degeneration along with degenerative lumbar spondylolisthesis.

1. Introduction

The facet joints are also known as the apophyseal joints or the zygomorphous joints, located in the dorsolateral direction of the spine between the adjoining vertebrae. They possess a crucial role in stabilizing the sectional unit of the spine and can regulate the spinal kinematic position. It is understood that the substantial sagittal facet joint positioning can restrict the axial rotation and enhance the torsional intensity [1].

The degraded variations in the spinal region might cause back pain and different spinal pathology. Therefore, to restrain the degenerative spinal disorder and choose suitable treatments, it is necessary to recognize the factors that encourage the process of degeneration [2].

Multiple studies have concentrated on the facet joint positioning as a preenduring morphological factor in the occurrence of degenerative spondylolisthesis [3]. Hence, it is suggested that a more sagittal positioning of the facet joint encourages anterior flowing by decreasing the struggle towards the anterior shear intensity [4].

The facet joint positioning and the facet tropism have been proposed, as the anatomical factors encourage the spinal degeneration process; from these internal factors, herniation of the relative disc or degradative spondylolisthesis might result [5]. Multiple previous types of research have experimented with proposing the association between the distortions of the facet joints and the lumbar degenerative variations. However, there have still been multiple arguments in this research area. Such degenerative variations comprise the degenerative spondylolisthesis (DS) as well as the lumbar disc herniation (LDH) [6].

The facet tropism is interpreted as the asymmetry between the left and the right angles of the facet joints, along with one joint, which has a more sagittal positioning than the other. This was intended to enhance risks for the degradative disorder in the equivalent disc herniation and the rotational variability of the spinal segment [7]. The degenerative spondylolisthesis is

recognized as a lumbar vertebral body sliding ahead of the adjoining vertebral body without the neural arch flaw because of the variable effect of the progressive variation. It frequently forms at the L4-L5 level and usually in females above the age of 40 years. It is predicted that the patients suffering from the abnormality facet joint angle possess lower resistance to the shearing strength than the usual. This guide to the ligament flexibility, reduction, and anterior gliding of a vertebra prevails. Lumbar disc herniation is another degradative disorder associated with the abnormality of the facet joint. The intervertebral disc may be noneffective because it stresses the shear force due to the prevailing facet joint tropism, which suggests that facet tropism may be related to lumbar disc degeneration as well as degenerative lumbar spondylolisthesis. Besides, posterior lumbar interbody fusion is an important treatment for degenerative spondylolisthesis, and several studies have found that facet tropism is similarly significantly altered after surgical treatment using posterior lumbar spondylolisthesis compared with preoperative values, suggesting that degenerative spondylolisthesis may have an impact on facet tropism.

Our meta-analysis demonstrated a unique link between the facet tropism and the lumbar disk degeneration along with degenerative lumbar spondylolisthesis. This will further guide the treatment of the lumbar disc herniation and degenerative lumbar spondylolisthesis.

2. Materials and Methods

2.1. Search Approach. The Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) checklist was followed for our systematic review (Figure 1). We utilized the instructions for the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) and formed a research-based questionnaire along with a search conducted through the databases Web of Science, EMBASE, PubMed, Cochrane Library, SCOPUS, and CINHAL in the duration of 2001 to 2021 to recognize the related research studies. The associated keywords used to search studies were "facet," "facet joint," "facet tropism," "lumbar disc," "lumbar degenerative disc," "degenerative lumbar spondylolisthesis," "facet degeneration," "lumbar disc herniation," "Degenerative spondylolisthesis," and "Facet joint orientation."Moreover, data from relevant searches were eventually hand searched for further research.

2.2. Inclusion and Exclusion Criteria. The research works that established facet tropism and the facet symmetry as the distinct sagittal positioning of the facets were included in the analysis. Some studies were shortlisted because they comprised the retrospective analysis, the community-dependent radiological research and the cadaverous radiological assessment, and the laboratory and the cadaveric studies. The research that included only the human subjects was incorporated in the analysis along with multiple investigations evaluating the association of facet tropism with the lumbar disc herniation, degenerative lumbar spondylolisthesis, and facet degeneration also covered.

The letters or abstracts, case studies, meta-analysis, or studies with insufficient patient data were disregarded and, thus, were excluded from the eligibility criteria. Studies that defined facet tropism or facet symmetry as an estimate rather than the variation of the sagittal plane angle such as various sizes were also excluded.

2.3. Primary Outcomes. The angle of the facet joint at the MSCT transection site was measured using the PACS workstation angle measurement tool. The reference plane was set to a line made at the two highest points on the posterior border of the vertebral body, the aqueous plane or the vertebral coronal plane, along the anteromedial and posterolateral points of the superior articular facet surfaces on both sides, respectively, and the angle between this articular surface line and the coronal plane of the vertebral body was the facet joint angle.

Facet tropism is the absolute value of the difference between the facet joint angles on both sides, which was suggested to be associated with disc degeneration, facet degeneration, and degenerative spondylolisthesis in the lumbar spine. The facet tropism was choosn as the primary outcome to evaluate the correlation between facet tropism and the level of degeneration in spondylolisthesis. Facet joint asymmetry was defined as a difference of $>7^{\circ}$ between the facet joint angles on both sides according to the measurement method described [8].

2.4. Statistical Analyses. All of the data measurements were carried out with SPSS 16.0 statistical software. Student's t-test was used to compare the means of two groups. $p < 0.05$ was considered to be statistically significant.

3. Results

A total of 117 studies (including the other records) were identified with respect to the inclusion criteria designed for the analysis, as shown in the PRISMA study in Figure 1. From these 117 recognized studies, 41 of them were shortlisted in the screening process while the remaining 76 were observed as duplicate records and, thus, were discarded. In the process of recognizing the eligible studies, only 7 were found to be applicable for performing systematic review and meta-analysis. Here, 34 studies were removed from the selection where they were editorials, abstracts, letters, unidentified or missing data, review papers, or nonclinical studies. The characteristics of the included seven studies are presented in Table 1, with parameters of study year, objective, and conclusion derived.

In Figure 2, we observe pooled standard mean difference comparative assessment between the lumbar degenerative spondylolisthesis and the normal group. Here, the study by Kundakci et al. was observed to be towards high heterogeneity. The test for overall effect $Z = 10.97$, where $P < 0.00001$. It can be seen that there is a significant difference in the pooled standard mean difference between the

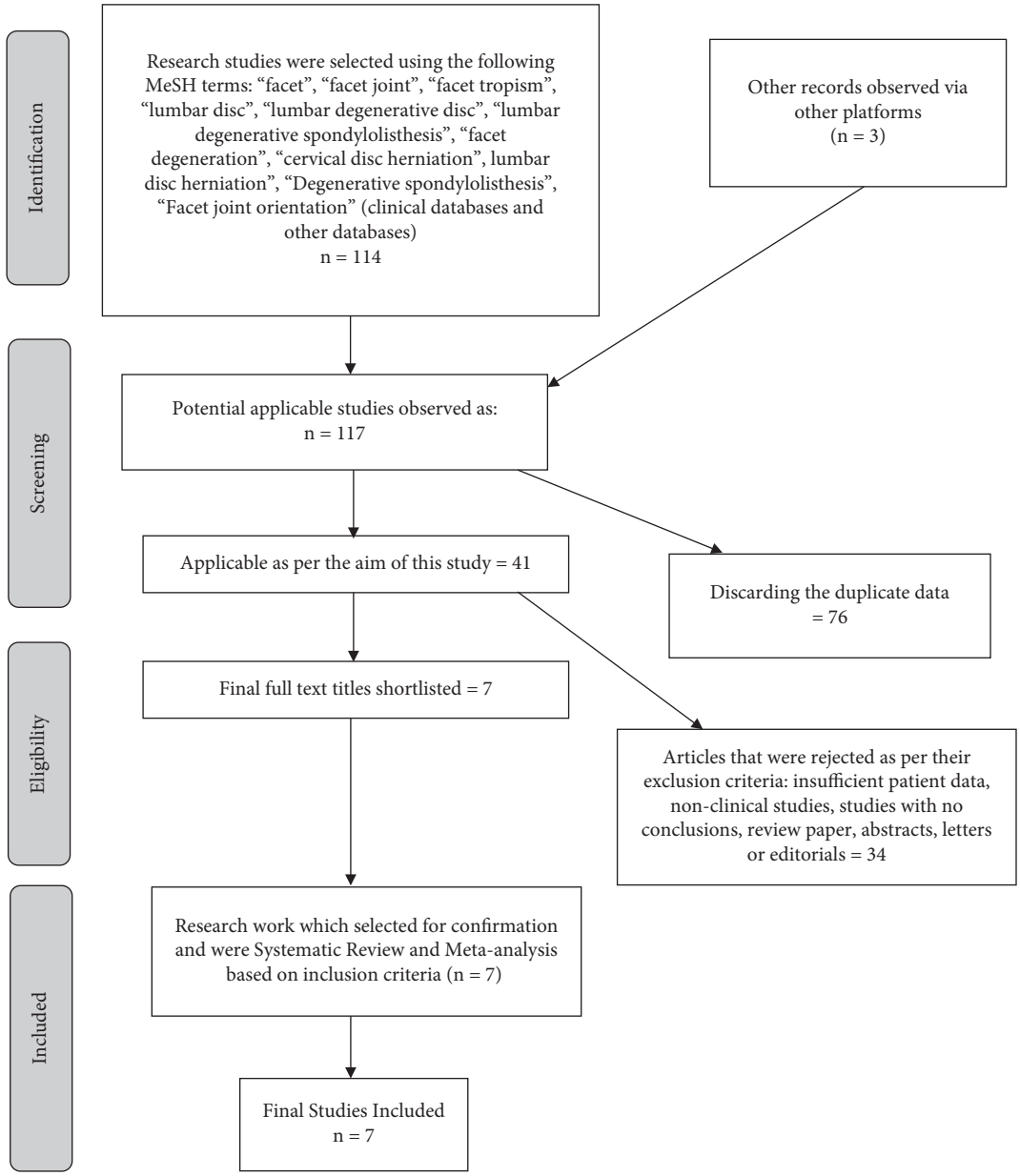

Figure 1: PRISMA study over the study methods.

lumbar degenerative spondylolisthesis and the normal group, suggesting that there is a positive correlation between facet tropism and lumbar degenerative spondylolisthesis. The greater the facet tropism, the higher the possibility of lumbar degenerative spondylolisthesis.

There were four studies included in comparative assessment, and Figure 3 represents the funnel plot, which is determined for the comparative degenerative spondylolisthesis; thus it shows the distribution of studies included.

There were three studies identified for assessment of pre- as well as postoperative conditions, while Figure 4 demonstrates the forest plan on the preoperative as well as postoperative conditions. From the forest plot, the pooled mean difference was obtained from the studies as 0.25 [0.06, 0.43], with 95% confidence interval for Z=2.66, where P=0.008. There was significant difference obtained between the two groups, i.e., preoperative and postoperative; the facet tropism after operation was significantly reduced compared with that before operation, suggesting that there is a positive correlation between facet tropism and lumbar degenerative spondylolisthesis. The distribution of studies was demonstrated over a funnel plot as shown in Figures 5 and 6.

There were five study groups analyzed for plot disc herniation as well as the normal group at the L4-L5 level. The pooled mean difference yields a significant difference between the disc herniation and the normal group as 0.60 [0.05, 1.14], and a higher heterogeneity was observed to be as 89% with a test for overall effect as 2.15, where P=0.03 and confidence interval to be 95%, which can be seen that there is a significant difference in the pooled mean difference yield

Table 1: Studies selected for meta-analysis.

S. no.	Author	Year	Objective	Conclusion
1.	Dai [9]	2001	To assess the correlation between facet tropism and the level of degeneration in spondylolisthesis	Compared to the control group, a significant tropism in facet joint was noted in patients suffering from spondylolisthesis. Hence for patients suffering from degenerative spondylolisthesis, a considerable level was correlated with disc degeneration.
2.	Lee et al. [10]	2006	The effect of facet tropism on the adults and adolescents with adults in lumbar discs	The results suggested that tropism did not affect the herniation in lumbar discs in both adults and adolescents
3.	Chen et al. [11]	2014	To assess the relationship between parameters and L4 lumbar degenerative spondylolisthesis	No significant variation in the facet joints L3-L4 and L4-L5 was noted when the control group was compared with degenerative spondylolisthesis
4.	Pichaisak et al. [12]	2015	The difference in facet joint angles was evaluated between the control group, spondylolisthesis group, and lumbar degenerative disc group	The difference in tropism and facet joint angle was noted in the degenerative spondylolisthesis group compared with the normal control group. A distinction was noted in degenerative disc disease in the case of facet tropism
5.	Samartzis et al. [13]	2016	Identifying critical values in tropism and angulation in articulating facets for the development and progression of degenerative spondylolisthesis	The relevance was noted between 16–24 degree angulation
6.	Kundakci et al. [14]	2018	Study on tropism and facet tropism in case of degenerative diseases	In the case of L4-L5, facet tropism is a risk factor for degenerative spondylolisthesis
7.	Mohanty et al. [15]	2018	To assess the link between lumbar intervertebral disc and facet tropism	Severity in the case of facet tropism for patients with the lumbar intervertebral disc was higher than in the patients without the lumbar intervertebral disc. Values of facet tropism were higher with critical values of 5.7° (L4-L5) and increased risks in L5-S1 discs

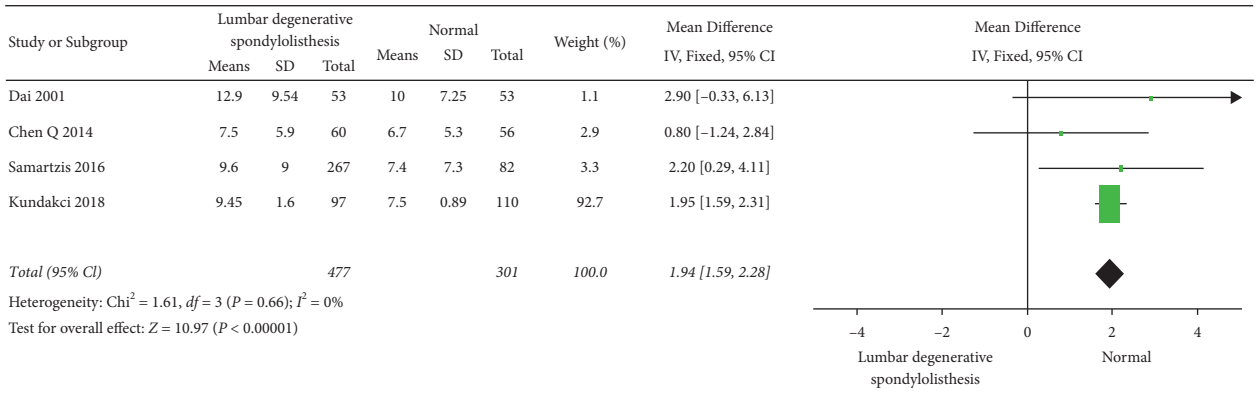

Figure 2: Forest plot comparative assessment between lumbar degenerative spondylolisthesis.

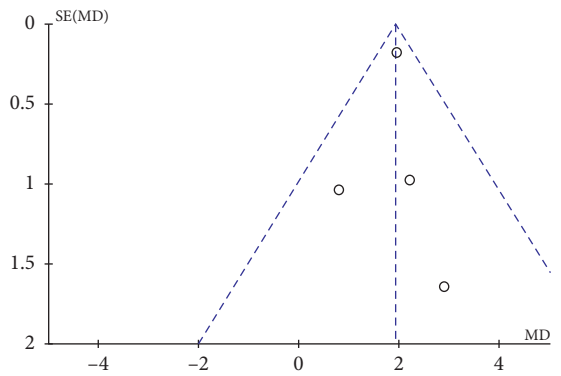

Figure 3: Funnel plot on the comparative assessment between lumbar degenerative spondylolisthesis.

Study or Subgroup	Pre operative Means	SD	Total	Post operative Means	SD	Total	Weight (%)	St.Mean Difference IV, Fixed, 95% CI
Dai 2001	12.9	9.54	53	10	7.25	53	22.2	0.34 [−0.04, 0.72]
Chen Q 2014	7.5	5.9	60	6.7	5.3	56	24.6	0.14 [−0.22, 0.51]
Samartzis 2016	9.6	9	267	7.4	7.3	82	53.1	0.25 [0.01, 0.50]
Total (95% Cl)			*380*			*191*	*100.0*	*0.25 [0.06, 0.43]*

Heterogeneity: $Chi^2 = 0.55$, $df = 2$ ($P = 0.76$); $I^2 = 0\%$

Test for overall effect: $Z = 2.66$ ($P = 0.008$)

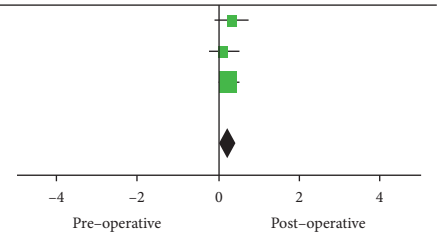

Figure 4: Forest plot on pre- and postoperative conditions.

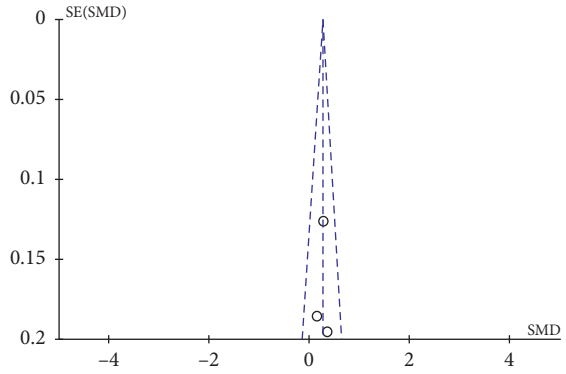

Figure 5: Funnel plot for pre- and postoperative severity conditions.

Study or Subgroup	Disc Herniation Means	SD	Total	Normal Means	SD	Total	Weight (%)	St.Mean Difference IV, Random, 95% CI
Samartzis D 2016	0	0	0	0	0	0		Nol estimable
Lee 2006	6.92	5.46	73	3.58	2.95	23	23.3	0.66 [0.1 9, 114]
Kundakci YE_2018	6.7	6.03	26	7.1	5.6	110	24.2	−0.07 [−0.50, 0.36]
Pichaisak 2015	7.83	5.41	60	4.93	4.67	60	25.2	0.57 [0.20, 0.94]
Mohanly 2018	7.85	3.5	300	4.05	2.62	126	27.2	1.16 [0.94, 138]
Total (95% CI)			*459*			*319*	*100.0*	*0.60 [0.05, 1.14]*

Heterogeneity: $Tau^2 = 0.27$; $Chi^2 = 27.90$, $df = 3$ ($P > 0.00001$); $I^2 = 89\%$

Test for overall effect: $Z = 2.15$ ($P = 0.03$)

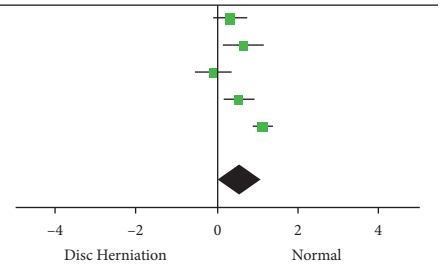

Figure 6: Forest plot of disc herniation versus the normal group in L4/L5.

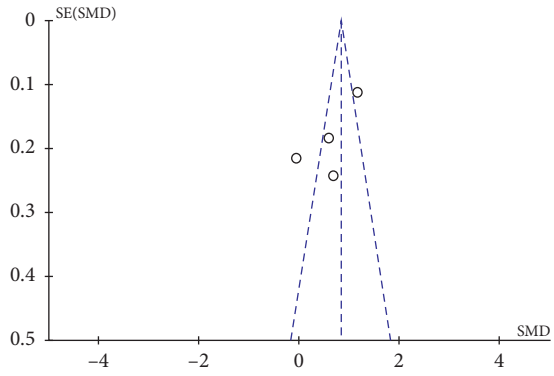

Figure 7: Funnel plot of disc herniation versus the normal group in L4/L5.

between the L4/L5 disc herniation and the normal group, suggesting that there is a positive correlation between facet tropism and L4/L5 disc herniation. The greater the facet tropism, the higher the possibility of L4/L5 disc herniation. Figure 7 demonstrates the funnel plot analysis for the selected study distribution.

From Figure 8, we can observe the forest plot analysis performed over the selected three studies for the comparative analysis on L5/S1 disc herniation in comparison with the normal group. The significant mean difference of the pooled studies was obtained as 0.21 [−0.48, 0.90] with high heterogeneity levels for $Z = 0.60$, where $P = 0.55$ with 95% confidence interval, which can be seen that there is a significant difference in the significant mean difference between the L5/S1 disc herniation and the normal groups, suggesting

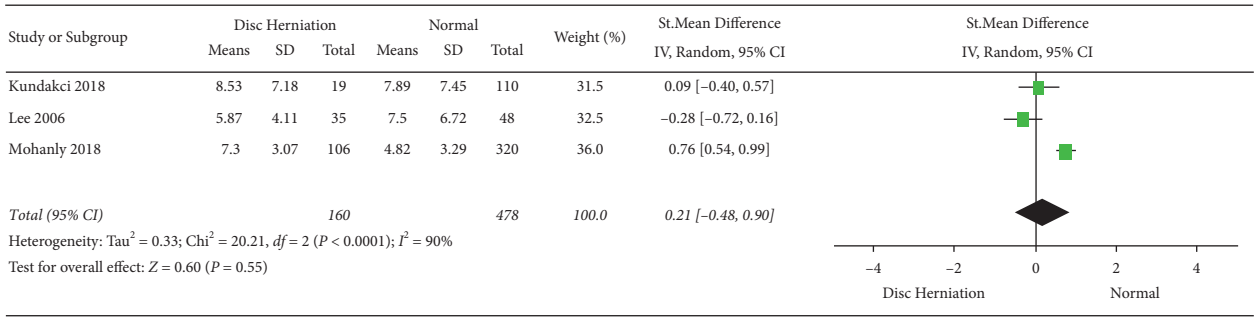

Figure 8: Forest plot on L5/S1 disc herniation compared with the normal group.

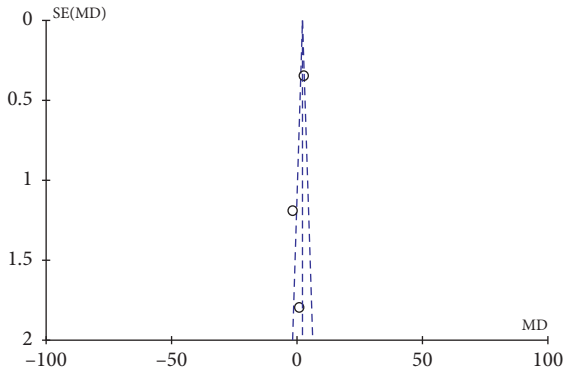

Figure 9: Funnel plot on L5/S1 disc herniation in comparison with the normal group.

that there is a positive correlation between facet tropism and L5/S1 disc herniation. The greater the facet tropism, the higher the possibility of L5/S1 disc herniation. The obtained combined treatment effect was not statistically significant, and the funnel plot for the studies was to demonstrate the bias, as shown in Figure 9.

4. Discussion

The facet tropism follows the disproportionate placing of facet joints, the unfair dispersal of weight, and the biomechanical forces on the intervertebral disc. Such details accompanying other factors guide to degradation of facets and disc. However, disc degradation initiates in the second phase of life and is emphasized in facet tropism. This can ultimately lead to lumbar facet deterioration, disc degradation, or the degradative spondylolisthesis. The facts possess a crucial role in limiting the axial rotation.

It might also result in indefinite scoliosis or situational transition in the sagittal side of the spine. It can result in reducing or even knocking down of lumbar lordosis. The CT (computerized tomography) and MRI (magnetic resonance imaging) can demonstrate the further varied inclination of the facets of either side. The facet block can assure the indications due to the factual degradation peripheral to the facet tropism, which can even be therapeutic for the facet degradation associated symptoms.

The significance associated with facet tropism is beyond playing the role of an image finding, as it can be involved in the pathogenesis of the facet joint degradation followed by degenerative spondylolisthesis and the disk herniation in the lumbar spine pain region. Some general symptoms associated with facet tropism are tenderness over the facet joint, the firmness of the lower back, and the incapability to perform prolonged activities in standing posture. The secondary herniation and spondylolisthesis lead to unilateral foraminal stenosis as well as radiculopathy.

In our meta-analysis, the pooled mean difference with 95% CI was 1.94 (1.59, 2.28), which was noted for lumbar degenerative spondylolisthesis compared with the normal group. There was no heterogeneity (I2 of 0%), as shown in Figure 2 and the funnel plot for Figure 3. The facet tropism associated with the lower back pain was observed in this analysis mainly at the L4-5 level, which was also slightly involved at the L3-4 level. The pooled mean difference with 95% CI was 1.94 (1.59, 2.28), which was noted for lumbar degenerative spondylolisthesis compared with the normal group. The pooled standard mean difference on pre- and postoperative conditions with 95% CI was 0.25 (0.06, 0.43), and there was no heterogeneity noted (I2 of 0%) as shown in Figure 4, and funnel plots for the same are in Figure 5. Most of such recent studies show a positive link between facet tropism and lumbar disk degeneration. This may occur because of the better imaging modal quality, enhanced visibility of facet tropism, and the lumbar disk degeneration. Other causes behind this are that variable researchers have utilized multiple cutoffs for elucidating facet tropism as there is no fundamental definition of facet tropism. However, numerous studies with a small sample might result in a false acceptance of the null hypothesis (a type 2 error).

The advantages of our meta-analysis are that it included seven comprehensive studies where both the continuous and the dichotomous data proposed a remarkable association between the facet tropism and the lumbar disk degeneration. The facet tropism might even have consequences over the patient outcomes after the total disc replacement surgery. The progressive facet arthrosis is recognized as a negative predictor of the clinical results followed by the total disc replacement in the lumbar spine because it might result in disappointing pain relief. Therefore, facet tropism might lead to progressive facet arthrosis, and it can influence the results of the patients going through the total disk replacement.

The limit of our analysis is that it lacks solid experience and further needs verification. Besides, the number of studies incorporated in this meta-analysis is less because the

data needed were not available from multiple studies. Also, the study heterogeneity was comparatively high in the analysis performed of the lumbar disk degenerative. Third, there are a few constraints of our study where it comprises data from the past three decades, and the category of facet tropism and that of the imaging modalities are utilized to identify facet tropism, for facet tropism is not much recognized, and it does not need a special treatment for it. The surgical procedures are saved for the degenerative pathogenesis that gets discarded in facet tropism, and the axial pain occurs because of the facet degradation, and it can be cured with a facet block, which can be further diagnosed.

5. Conclusions

Facet tropism is a well-known but disregarded entity. It has been involved in the process of the pathogenesis of lumbar facet degeneration, the degenerative spondylolisthesis, and the herniation process of the disk. Our meta-analysis demonstrated a unique link between the facet tropism and the lumbar disk degeneration along with degenerative lumbar spondylolisthesis. The spine surgeon has to be cautious about this entity because it might result in the inclination to degenerate, and interventions such as the total disk replacement and the facet blocks are needed. Further studies are needed to verify the opinion of this study.

Data Availability

The data used to support this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

References

[1] S. Ke, X. He, M. Yang, S. Wang, X. Song, and Z. Li, "The biomechanical influence of facet joint parameters on the corresponding segment in the lumbar spine: a new visualization method," *The Spine Journal*, vol. 21, no. 12, pp. 2112–2121, 2021.

[2] S. P. Cohen and S. N. Raja, "Pathogenesis, diagnosis, and treatment of lumbar zygapophysial (FACET) joint pain," *Anesthesiology*, vol. 106, no. 3, pp. 591–614, 2007.

[3] R. R. Rai, Y. Shah, S. Shah, N. Sadanandan Palliyil, and S. Dalvie, "A radiological study of the association of facet tropism and facet angulation with degenerative spondylolisthesis," *Neurospine*, vol. 16, no. 4, pp. 742–747, 2019.

[4] G. P. Varlotta, T. R. Lefkowitz, M. Schweitzer et al., "The lumbar facet joint: a review of current knowledge: part 1: anatomy, biomechanics, and grading," *Skeletal Radiology*, vol. 40, no. 1, pp. 13–23, 2010.

[5] Y. Masharawi, B. Rothschild, G. Dar et al., "Facet orientation in the thoracolumbar spine," *Spine*, vol. 29, no. 16, pp. 1755–1763, 2004.

[6] Y. Shi, Y. Z. Xie, Q. Zhou, Y. Yu, and X. H. Fan, "The biomechanical effect of the relevant segments after facet-discectomy in different diameters under posterior lumbar percutaneous endoscopes: A three-dimensional finite element analysis," *Journal of Orthopaedic Surgery and Research*, vol. 16, no. 1, Article ID 593, 2021.

[7] Y. Wang, G. Chen, J. Lin, W. Huang, J. Wang, and H. Teng, "The correlation between facet tropism and intervertebral disc herniation in the subaxial cervical spine," *Spine (Phila Pa 1976)*, vol. 46, no. 5, pp. E310–E317, 2021.

[8] H. Vanharanta, T. Floyd, D. D. Ohnmeiss, S. H. Hochschuler, and R. D. Guyer, "The relationship of facet tropism to degenerative disc disease," *Spine*, vol. 13, no. 8, pp. 1000–1005, 1993.

[9] L. Y. Dai, "Orientation and tropism of lumbar facet joints in degenerative spondylolisthesis," *International Orthopaedics*, vol. 25, no. 1, pp. 40–42, 2001.

[10] D. Y. Lee, Y. Ahn, and S. H. Lee, "The influence of facet tropism on herniation of the lumbar disc in adolescents and adults," *The Journal of Bone and Joint Surgery*, vol. 88, no. 4, pp. 520–523, 2006.

[11] Q. Chen, W. Ding, Y. Shen et al., "Correlation between the 4th lumbar degenerative spondylolisthesis and radiographic parameters," *Zhonghua Wai Ke Za Zhi*, vol. 52, no. 2, pp. 122–126, 2014.

[12] W. Pichaisak, C. Chotiyarnwong, and P. Chotiyarnwong, "Facet joint orientation and tropism in lumbar degenerative disc disease and spondylolisthesis," *Journal of the Medical Association of Thailand = Chotmaihet Thangphaet*, vol. 98, no. 4, pp. 373–379, 2015.

[13] D. Samartzis, J. P. Y. Cheung, S. Rajasekaran et al., "Critical values of facet joint angulation and tropism in the development of lumbar degenerative spondylolisthesis: an international, large-scale m study by the AOSpine Asia pacific research collaboration consortium," *Global Spine Journal*, vol. 6, no. 5, pp. 414–421, 2015.

[14] Y. E. Kundakci, N. Unver Dogan, I. Guler, I. I. Uysal, Z. Fazliogullari, and A. K. Karabulut, "Evaluation of the facet joints with magnetic resonance images in the patients with disc degeneration and spondylolisthesis," *Surgical and Radiologic Anatomy*, vol. 40, no. 9, pp. 1063–1075, 2018.

[15] S. Mohanty, M. Pai Kanhangad, S. Kamath, and A. Kamath, "Morphometric study of the orientation of lumbar zygapophyseal joints in a South Indian population," *Journal of Orthopaedic Surgery*, vol. 25, no. 3, Article ID 230949901773948, 2017.