INFLUENCE OF FACET JOINT TROPISM ON THE FORMATION OF INTERVERTEBRAL DISC HERNIATION IN THE LUMBOSACRAL SPINE

V.A. Byvaltsev[1–4], I.A. Stepanov[1], A.K. Okoneshnikova[1]
[1]*Irkutsk State Medical University, Irkutsk, Russia;*
[2]*Road Clinical Hospital at «Irkutsk-Passazhirskiy» station of JSCo «Russian Railways», Irkutsk, Russia;*
[3]*Irkutsk Scientific Center of Surgery and Traumatology, Irkutsk, Russia;*
[4]*Irkutsk State Medical Academy of Continuing Education, Irkutsk, Russia*

Objective. To evaluate the influence of facet joint tropism on the formation of intervertebral disc hernias in the lumbosacral spine, and to determine the relationship between facet joint asymmetry and the type of hernia of the lumbar intervertebral discs.
Material and Methods. Sixty-four patients aged 23–47 years with herniated lumbar intervertebral discs at one level (L3–L4, L4–L5 or L5–S1) were examined. Calculation of facet angles was performed on MRI axial slices. Tropism was verified when the difference between the angles of the right and left joints exceeded 10°.
Results. When calculating the facet joint angles, tropism was detected in 22 (34.3 %) cases. One-factor analysis of the effect of facet joint tropism on the intervertebral disc hernia formation at all three levels revealed its significant influence (p = 0.0017; OR 7.416; 95 % CI 3.11–22.64). Analysis of the effect of facet joint tropism on the formation of intervertebral disc hernias at each level has shown that statistically significant effect is exerted only on L5–S1 intervertebral discs (p = 0.0224; OR 13.537; 95 % CI 2.419–98.475).
Conclusion. Facet joint tropism significantly influences the formation of intervertebral disc hernias at all three levels of the lumbosacral spine as a whole but does not affect the type of lumbar intervertebral disc hernia.
Key Words: facet joints, tropism, asymmetry, intervertebral disc, intervertebral disc herniation.

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For many years, tropism, or asymmetry of facet joints (FJs), has been the object of special attention of spinal neurosurgeons because of its influence on spinal column biomechanics. As is known, the changes in the normal biomechanics of the spine induce degeneration of FJs and intervertebral discs (IVDs), which is the most common cause of pain in the lower back [1, 2].

The term "FJ tropism" was first used by Brailsford [7] in 1928 to refer to the asymmetry between the right and left FJs or more sagittal orientation of one of the FJs. To date, several clinical studies on the relationship between FJ tropism and degeneration are available [5]. Farfan et al. [12] were the first who found the correlation between FJ tropism and lumbosacral IVD herniation [13]. Moreover, the authors concluded that lumbar IVD herniation occurs on the side of FJ with the smallest angle, since FJ is not capable of reducing torsion loads acting on the annulus fibrosus during movements in this orientation. Nevertheless, many authors disagree with this statement [15–16, 22].

Masharawi et al. [20] clearly demonstrated that FJ tropism is one of the normal biomechanical characteristics of the thoracic spine. The presence of FJ tropism in the lumbosacral spine may cause the development of degenerative processes.

According to the literature [4, 6, 8, 14, 17, 23], the incidence of FJ tropism of the lumbosacral spine varies within a wide range, from 10 to 70 %. This is mostly due to the fact that different methods are used to calculate FJ angles, which leads to an ambiguous assessment of the effect of this parameter on the degeneration of both FJs and IVDs. The lack of a unified method for determining FJ tropism leads to contradictions between the available studies. In our opinion, the original technique of Karacan et al. [17] is the most accurate method for determining FJ tropism. This opinion is shared by other researchers [17, 18, 21].

The study was aimed at assessing the effect of FJ tropism on lumbosacral IVD herniation and determining the relationship between FJ asymmetry and the type of lumbar IVD hernias.

Material and Methods

The study included 64 patients (36 males, 28 females) ages 23–47 years (mean age 36.7 ± 5.9 years) with herniated lumbar IVDs at one of the levels (L3–L4, L4–L5, L5–S1). All patients underwent operative treatment for the underlying disease in the form of isolated decompression of neural structures at the Neurosurgical Center of the Road Clinical Hospital at the Irkutsk-

Passazhirskiy station between September 2016 and May 2017. Exclusion criteria were as follows: multiple hernias of the lumbosacral IVDs, recurrent herniation of lumbar IVDs, signs of instability in the spinal motion segment, various types of spondylolisthesis, spine trauma, history of spinal surgery, and ankylosing spondylitis (Bekhterev's disease).

All patients who were admitted to the hospital with clinical and neurological manifestations of herniated lumbar IVDs underwent conventional T1 and T2-weighted MRI of the lumbosacral spine using a 1.5T MRI scanner with slice thickness of 4 mm.

FJ angles were calculated based on axial MRI slices using the RadiAnt DICOM Viewer software according to the original technique proposed by Karacan et al. [17] (Fig.). FJ tropism was verified by the difference between the angles of the right and left FJs of more than 10°.

Differences in the values of FJ angles at the level of herniated IVDs were compared to those at the level of the control IVDs. FJs at level of IVDs adjacent to the herniated IVDs were used as the control group (i.e. L4—L5 was the control level for IVDs of L3—L4, the level L3—L4 or L5—S1 for L4—L5, and L4—L5 for L5—S1).

The study was approved by the ethics committee of the Irkutsk State Medical University. All patients involved in the study gave written informed consent.

Statistical data processing was carried out using the Microsoft Excel 2010 software. Fisher's exact test was used to compare the categorical variables. FJ angles were compared using t-test. The differences were considered to be significant at $p < 0.05$. A univariate analysis was carried out to assess the effect of FJ tropism on the development of hernias. Risk factors with a value of $p < 0.05$ were investigated using the binary logistic regression method.

Results and Discussion

There were the following types of herniated lumbosacral IVDs in the study group patients: paramedian in 17 (26.5 %) cases, lateral left-sided in 28 (43.7 %) cases, and lateral right-sided in 19 (29.6 %) cases. Most of the herniated lumbar IVDs were located at the level of L5—S1 — 38 (59.3 %) cases, at the level of L4—L5 — 18 (28.1 %) cases, and at the level of L3—L4 — 8 (12.5 %) cases.

When calculating the values of FJ angles, tropism was detected in 22 (34.3 %) cases, and only in 6 (9.3 %) cases at the levels of control IVDs.

Univariate analysis of the effect of FJ tropism on IVD herniation at all three levels has confirmed a significant effect: $p = 0.0017$; odds ratio (OR) 7.416; 95 % confidence interval (CI) 3.11—22.64 (Table 1).

Analysis of the effect of FJ tropism on IVD herniation for each level showed that it is statistically significant only for IVDs L5—S1 ($p = 0.0224$, OR 13.537, 95 % CI 2.419—98.475). No significant effect was found for L3–L4 and L4—L5 IVD levels ($p = 0.184$, OR 9.483, 95 % CI 4.627—16.091 and $p = 0.247$, OR 8.063, 95 % CI 6.318—12.074, respectively; Table 2).

When analyzing the relationship between FJ asymmetry and the type of lumbar IVD herniation, the following results were obtained: IVD hernias were oriented toward the FJ with the smallest angle in 17 of 22 cases of FJ tropism. However, statistical processing of the data did not confirm this correlation ($p = 0.619$).

To date, there are several studies focusing on the relationship between FJ tropism and lumbar IVD herniation. Some authors [12, 10, 17, 21, 24] state that FJ tropism is one of the most important factors predisposing to IVD degeneration. Other researchers [3, 8, 11, 14, 23] did not observe such a relationship.

As noted earlier, Farfan et al. [12] have proved the correlation between FJ tropism and lumbar IVD herniation in the clinical series. However, subsequent studies in this area were quite controversial.

Cyron et al. [10] demonstrated the effect of FJ tropism on the development of spinal motion segment instability. Later on, Van Shaik et al. [24] evaluated the effect of FJ tropism on localization of lumbar IVD hernia in the clinical series of 100 patients. The authors came to the conclusion that IVD hernias were located both on the side of FJ with the smallest angle and on the side of the FJ with the largest angle, when the difference in FJ angles was less than 11°. At the same time, lumbar IVD hernias were mostly located on the side of FJ with the largest angle in the case of FJ tropism of more than 11°. Noren et al. [21] noted that FJ tropism is a proven risk factor for degeneration of lumbar IVDs at all levels. These results were supported by the study of Karacan et al. [17], who showed that FJ tropism is significantly more common in patients with herniated lumbar IVDs, and these changes are more characteristic of patients higher than 180 cm.

It is worth noting that other researchers refute the relationship between FJ tropism and IVD degeneration. Thus, Adams et al. [3] found no significant effect of FJ tropism on lumbosacral spine herniation in the study based on biomechanical analysis. Do et al. [11] also concluded that orientation of FJ does not affect degeneration of lumbar IVDs. Moreover, the researchers argue that,

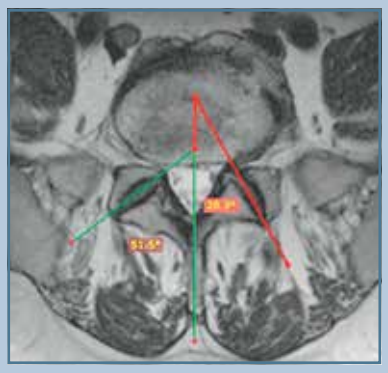

Fig.
The procedure used to calculate the values of the facet joint angles according to the method proposed by Karacan et al. [17] using the RadiAnt DICOM Viewer software: the angle of the facet joint is formed by the intersection of the lines drawn through the middle of the articular cavity of the facet joint and the line drawn through the center of the intervertebral disc and matching the axis of the spinous process

despite any orientation, FJ compensate for the load acting on the annulus fibrosus during movements, preventing its degeneration. This opinion is supported by Hagg et al. [14], Cassidy et al. [8], Vanharanta et al. [23]. There is no statistically significant relationship between FJ tropism and IVD degeneration in adults and adolescents, except for the level of L4—L5 in the group of adult patients. According to our data, FJ tropism significantly influences lumbar IVD herniation at all three levels of IVDs. Nevertheless, when analyzing the effect of this parameter on each lumbosacral IVD, it is statistically significant only for IVDs at L5—S1.

Despite the generally accepted definition of FJ tropism, the threshold value of the difference in FJ angles is interpreted by many authors in different ways. For example, Noren et al. [21] suggest the difference between FJ angles of more than 5° as the threshold value of FJ tropism. Cyron et al. [10] noted that FJ asymmetry is observed when the angles differ by more than 1°. Some authors [9, 17—18, 21, 23] verified FJ tropism when the angles differed by more than 10°. We also use this threshold value in clinical practice.

Farfan et al. [12] and Loback et al. [19] clearly demonstrated the relationship between the location of herniated lumbar IVDs and FJ orientation. Hagg et al. [14] and Cassidy et al. [8] did not observed such a relationship. Kenesi et al. [18] found a reliable relationship between more sagittal orientation of FJs and the side of IVD herniation at the level of L5-S1. The authors observed this relationship in one third of patients. We found no significant correlation between FJ asymmetry and the type of lumbar IVD herniation in our study. Nevertheless, in 17 out of 22 cases of FJ tropism, hernias were orientated towards FJ with the smallest value of the angle.

Of course, this study has some shortcomings. First, it was carried out in a small number of respondents, which affected the results of statistical data processing. Second, the use of MRI scanner with a magnetic field induction of 1.5 T provides low-resolving images in contrast to 3T MRI scanners [9, 25]. Therefore, poor quality of images could affect the calculated difference in FJ angles. Third, the use of FJ at the level of adjacent IVDs in the study group patients as a control is not entirely correct, since the development of IVD degeneration alters biomechanics not only at the level of the involved segment, but rather throughout the whole lumbosacral spine. In this case, the use of FJ in patients without clinical and x-ray signs of FJ degeneration as the control group seems to be the most objective option.

Table 1
The relationship between facet tropism, herniated lumbar intervertebral discs, and normal intervertebral discs for all three levels, n

Intervertebral disc	The presence of facet tropism	The absence of facet tropism
Herniated	22	42
Normal	6	58

p = 0,0017.

Conclusion

The study showed that FJ tropism occurs in 34.3 % of patients with single-level herniation of the lumbosacral spine. FJ tropism significantly affects IVD herniation in the lumbosacral spine at all three levels in general. A statistically significant effect of FJ tropism on herniation was found only for the level of L5—S1. At the same time, it does not affect the type of lumbar IVD herniation.

In summary, this clinical series represents an attempt to evaluate the effect of FJs on degeneration of IVDs as one of the most important biomechanical structures of the spinal column. Undoubtedly, large multicenter studies on a large number of respondents, using a control group of healthy patients are required for a more detailed assessment of the effect of the investigated characteristics.

The study was not sponsored. The authors declare no conflict of interest.

Table 2
The relationship between facet tropism, herniated lumbar intervertebral discs, and normal intervertebral discs for each level, n

Intervertebral disc level	Intervertebral disc herniation		Facet tropism		p
			Present	Absent	
L3—L4	present	8	0	1	0.184
	absent	23	0	5	
L4—L5	present	18	7	14	0.247
	absent	19	5	29	
L5—S1	present	38	15	27	0.0224
	absent	22	1	24	

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Address correspondence to:
Byvaltsev Vadim Anatolyevich
P.O.B. 62, Irkutsk, 664082, Russia,
byval75vadim@yandex.ru

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Vadim Anatolyevich Byvaltsev, DMSc, Chief neurosurgeon of the Health Department of JSCo «Russian Railways», head of the Centre of Neurosurgery, Road Clinical Hospital at «Irkutsk-Passazhirskiy» station of JSCo «Russian Railways»; head of scientific-clinical department of neurosurgery of the Irkutsk Scientific Centre of Surgery and Traumatology, Professor of the Department of Traumatology, Orthopaedics and Neurosurgery of Irkutsk State Medical Academy of Continuing Education; director of the course of neurosurgery, Irkutsk State Medical University, Krasnogo Vosstaniya str., 1, 664003, Irkutsk, Russia, byval75vadim@yandex.ru;
Ivan Andreevich Stepanov, postgraduate student, Irkutsk State Medical University, Krasnogo Vosstaniya str., 1, 664003, Irkutsk, Russia, edmoilers@mail.ru;
Alena Konstantinovna Okoneshnikova, postgraduate student in neurosurgery, Irkutsk State Medical University, Krasnogo Vosstaniya str., 1, 664003, Irkutsk, Russia, alena-okoneshnikova@mail.ru.