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Is Facet Tropism Associated with Increased Risk of Disc Herniation in the Lumbar Spine?

Hassan Ghandhari[1], Ebrahim Ameri[1], Habib Hasani[1], Mir Bahram Safari[2], Ali Tabrizi[2]

[1]Bone and Joint Reconstruction Research Center, Shafa Orthopedic Teaching Hospital, Iran University of Medical Sciences, Tehran, Iran
[2]Department of Orthopedics, Imam Khomeini Hospital, Urmia University of Medical Sciences, Urmia, Iran

Study Design: Retrospective case control study.

Purpose: In current study, we compared the incidence of facet tropism (FT) in patients with lumbar disc herniation and normal controls.

Overview of Literature: It has been suggested that FT can be associated with increased risk of lumbar disc herniation.

Methods: A total of 66 and 63 patients with L4/L5 and L5/S1 disc herniation, respectively, were evaluated in the present study. The control group comprised 61 normal subjects. Facet joint angle was measured using axial magnetic resonance images. The FT was defined as a difference of >10° between the right and left facet joints. The incidence of FT was compared between patients and controls. We also investigated the relationship between facet orientation (sagittal or coronal) and side of disc herniation.

Results: The incidence of FT at the L4/L5 level was significantly higher in patients with disc herniation (48.5% vs. 26.2%, p=0.01), while it was found to be the same at the L5/S1 level in patients and controls (50.8% vs. 36%, p=0.098). Among the 64 patients with FT, intervertebral disc herniation occurred significantly toward the more sagittally oriented facet joint in 41 patients (p<0.05).

Conclusions: FT is associated with increased risk of L4/L5 intervertebral disc herniation, but not at the L5/S1 level. In addition, disc herniation occurred toward the more sagittally oriented facet joint.

Keywords: Facet joint orientation; Intervertebral disc; Biomechanical phenomena; Tropism

Introduction

Facet joints lie in the transverse plane at an angle relative to the sagittal plane. In many vertebral motion segments, the angle between the right and left facet joint orientation and the sagittal plane are not the same; this is known as facet tropism (FT) [1,2]. The incidence of FT >10° has been reported in 14%–28% of lumbar motion segments. FT is reportedly associated with increased shearing forces or decreased resistance in opposing the shearing forces [3-5] and consequently increases risk of spinal disorders, such as spondylolisthesis, osteoarthritis, and other degenerative changes and disc herniation [6-14].

Despite previous attempts to investigate whether facet orientation and tropism influence the risk of lumbar disc herniation, the results remain controversial. Some authors have demonstrated the relationship between FT and lumbar disc herniation [4,5,7,9,15-18], while others have found no association between them [1,9,16,17,19-24]. Consequently, the clinical importance of FT and orienta-

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Corresponding author: Mir Bahram Safari
Department of Orthopedics, Imam Khomeini Hospital, Urmia University of Medical Sciences, Moderres Ave, Urmia, Iran
Tel: +98-9143407811, Fax: +98-4433457277, E-mail: mirbahramsafari30@gmail.com

tion is not yet understood. Therefore, in the present study, we investigated whether FT is associated with increased risk of intervertebral disc herniation at L4/L5 and L5/S1 levels. We also evaluated the potential relationship between facet orientation (sagittal or coronal) and side of disc herniation in these levels.

Materials and Methods

In 2013, 752 patients with low back pain (LBP) and symptoms of radiculopathy were admitted to our referral center. Physical examination was carefully performed in all patients and magnetic resonance imaging (MRI) was requested as part of our routine investigation. Diagnosis of lumbar disc herniation was made based on the clinical and MRI findings. Clinical findings suggesting disc herniation included radicular pain and/or paresthesia, positive straight leg raising, and one of the following: dermatomal hypesthesia, depressed deep tendon reflexes, or weakness in the region of the affected nerve root. A total of 623 cases were excluded due to disc herniation at other levels, multi-level disc herniation, degenerative changes, concomitant spinal deformities, such as degenerative kyphoscoliosis, spina bifida, spinal infection, spinal stenosis, spondylolisthesis, previous history of spinal surgery, and tumor or metastatic disease. A total of 66 patients with L4/L5 and 63 patients with L5/S1 disc herniation were included in the present study. The control group comprised 61 patients who underwent MRI because of suspected spinal fracture or infectious or malignant diseases. These patients showed no signs or symptoms of LBP and radiculopathy and had normal MRI findings. All participants gave written informed consent for use of their MRI data.

T1 and T2 MRI was performed using 1.5 T (MAGNETOM Avanto; Siemens Healthcare, Erlangen, Germany) while the patients were in the supine position. In the axial plane, the slices were parallel to the end plates with 3-mm thickness, enabling us to exactly assess the intervertebral discs and facet joints. Disc herniation was defined as extrusion of the disc material beyond the osseous confines of the vertebral body resulting in the displacement of epidural fat, nerve root, or thecal sac [9]. Normal discs were defined as uncollapsed disc space with no evidence of herniation. Disc signal in the T2 weight was clear white with a smooth border of annulus fibrosus and nucleus pulposus [17].

Measurement of the facet joint angle (FJA) was performed using the method described by Chadha et al. [17], and the axial slice in which both the right and left facet joints were most accurately visualized was selected. A line connecting the anteromedial and posterolateral edges of the superior articular facet was drawn. A midsagittal line crossing the tip of the spinous process and the center of the disc was also drawn. The acute angle between the facet and midsagittal lines was measured as the FJA (Fig. 1). Measurements were performed by an expert neurosurgeon utilizing the radiology PACS software with an accuracy of 0.01. A pilot study showed that the intraobserver

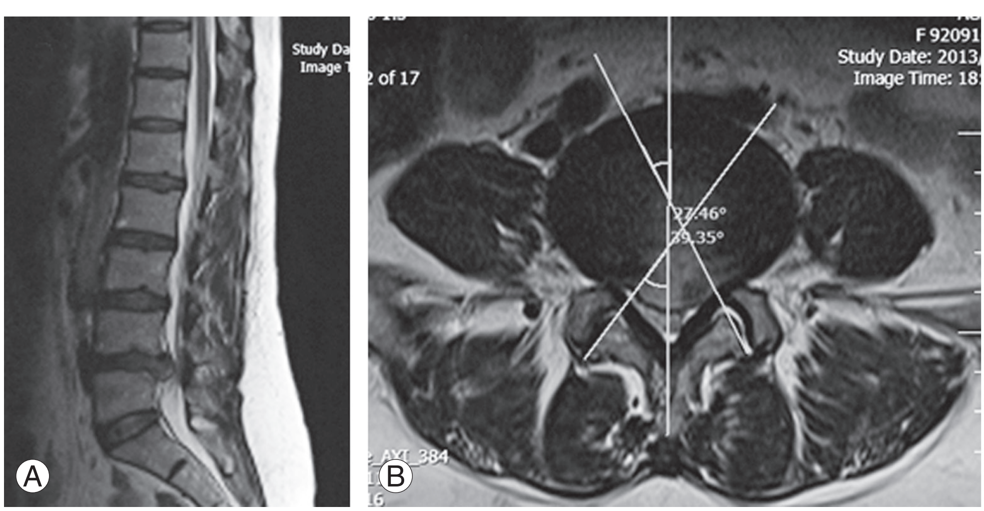

Fig. 1. Lumbar spinal magnetic resonance imaging images of a 43-year-old man with herniation of the intervertebral disc at the L4/L5 level. **(A)** Sagittal view, **(B)** axial view, and the method of measurement of the facet joint angle.

Table 1. Comparison of mean age and sex distribution of patients with L4/L5 disc herniation and controls

Variable	Patients (n=66)	Controls (n=61)	*p*-value
Age (yr)	42.3±14.6 (18–84)	41.5±12.6 (15–73)	0.432
Gender			0.600
Male	43 (65.1)	37 (60.7)	
Female	23 (34.9)	24 (39.3)	

Values are presented as mean±standard deviation (range) or number (%).

Table 2. Comparison of mean of age and sex distribution of patients with L5/S1 disc herniation and controls

Variable	Patients (n=63)	Controls (n=61)	*p*-value
Age (y)	39.1±15.7 (16–98)	41.5±12.6 (15–73)	0.112
Gender			0.969
Male	38 (60.3)	37 (60.7)	
Female	25 (39.7)	24 (39.3)	

Values are presented as mean±standard deviation (range) or number (%).

reliability of the surgeon in measurement of FJA was 0.91. Each angle was measured twice and the average was considered as the FJA. Smaller values indicated greater sagittal orientation of the joint. In the present study, FT was considered as a difference of >10° between the right and left facet joints.

Statistical analyses were performed using SPSS ver. 16.0 (SPSS Inc., Chicago, IL, USA). The mean age was compared utilizing an independent samples *t*-test. Sex and incidence of FT were compared using chi-square test. We also investigated whether the intervertebral disc tends to shift toward the coronally or sagittally oriented facet joint using the one proportion test. All *p*-values <0.05 were considered statistically significant.

The study was confirmed by the Ethics Committee of Iran University of Medical Sciences (approval no., Ir. UMSU. rec. 1395.129). The patients gave full consent to publish this report.

Results

Tables 1 and 2 show the demographic data of the patients and controls. The age and sex distribution in the control group were similar to the two patient groups ($p<0.05$).

The incidence of FT at the L4/L5 level was significantly higher in patients with disc herniation ($p=0.01$) (Table 3), while there was no significant difference between the L5/S1 disc herniation and control groups ($p=0.098$) (Table 4). In patients with FT, discs were herniated toward the more sagittally oriented facet in 22 (68.75%) of the L4/L5 and 19 (59.37%) of the L5/S1 herniated disc groups. In total, disc herniation significantly occurred toward the more sagittally oriented facet joint in 41 out of 64 patients with FT (64%, $p<0.05$).

Table 3. Comparison of the incidence of facet tropism in patients with L4/L5 disk herniation and controls

Variable	Patients (n=66)	Controls (n=61)	*p*-value
With tropism	32 (48.5)	16 (26.2)	0.010
Without tropism	34 (51.5)	45 (73.8)	
Total	66 (100.0)	61 (100.0)	

Values are presented as number (%).

Table 4. Comparison of the incidence of facet tropism in patients with L5/S1 disc herniation and controls

Variable	Patients (n=63)	Controls (n=61)	*p*-value
With tropism	32 (50.8)	22 (36.0)	0.098
Without tropism	31 (49.2)	39 (64.0)	
Total	63 (100.0)	61 (100.0)	

Values are presented as number (%).

Discussion

Synovial facet joints play an important role in spinal stability. Several studies have reported that facet joints are important structures for resisting axial loading [22,23,25,26]. The concept of FT was first proposed by Putti [27] in 1927 as a possible cause of LBP in some patients. He demonstrated that the orientation of the two facet joints at one level can significantly differ in the sagittal plane. In 1967, Farfan and Sullivan [7] showed that FT can result in lumbar disc herniation. They found that discs were herniated toward the more coronally oriented facet joint. Since then, many have investigated whether FT and lumbar disc herniation are related and produced controversial results.

Some studies used biomechanical studies to demonstrate that FT is associated with increased shearing forces and consequently, an increased risk of LBP. Farfan et al. [5] suggested that asymmetrical facet joint orientation leads to greater shearing forces during axial rotation resulting in increased torsional stress at the annulus fibrosus. In a cadaveric investigation of repetitive axial loading, Cyron and Hutton [4] defined FT as a difference of >1° in the right and left facet orientations and suggested that FT is associated with increased shearing forces resulting in an increased risk of degeneration and disc herniation. They also postulated that the coronal orientation of the joint leads to instability under external shear forces and joints rotate toward the more oblique facet joint. Using finite element analysis, Kim et al. [3] showed that facet orientation did not increase disc stress or facet joint stress but that FT could make the corresponding segment more vulnerable to external movements or anterior shear force. In contrast, Ahmed et al. [24] performed a biomechanical study and found that facet orientation does not affect the axial torque-rotation response. Furthermore, they reported that the facet joints stop axial rotation that is not related to their orientation [24,28]. Another biomechanical study by Adams and Hutton [21] showed that axial torsion was not an important factor in the development of lumbar disc herniation.

Van Schaik et al. [18] were the first to use computed tomography (CT) scanning to measure facet orientation and tropism in 100 patients with LBP or sciatica. They reported a correlation between FT and disc herniation at the L4/L5 level and found that if the asymmetry exceeds 11°, the intervertebral disc tends to shift toward the more coronally oriented joint. Noren et al. [15] also reported that FT is related to lumbar disc degeneration and herniation. Performed kinetic MRI in 410 patients with LBP and investigated the association between maximal static and dynamic disc bulging and FT in relation to age. They found that severe FT (≥11°) may be associated with a nearly significant increase in static and dynamic disc bulging in older patients at the L4/L5 level. In a study of 61 patients with lumbar disc herniation, Observed that facet asymmetry at the herniation level was present in 70.5% of patients and concluded that patients with lumbar disc herniation had asymmetry and sagittalization of facet joints, particularly in taller patients. Heliovaara [29] and Bostman [30] found a significant relationship between body height and lumbar disc herniation, and showed that FT and sagittal orientation is associated with increased risk of lumbar disc herniation.

In contrast, Ko and Park [16] did not find an association between FT and lower lumbar disc herniation. Additionally, found that although the average difference in bilateral FJA of patients with lumbar disc herniation was higher than that of controls, there was no statistically significant correlation between FT and lumbar disc herniation. Lee and Lee [1] compared the incidence of FT between levels of herniated and normal adjacent discs in lumbar spine in adolescents and adults and found no significant difference in FT except at the L4/L5 level in adults. In the same study, the degree of facet asymmetry was significantly higher at the L3/L4 level with herniated disc than normal L3/L4 in adults (6.92° versus 3.58°). However, the authors concluded that FT did not influence the development of herniation of the lumbar disc in either adolescents or adults [1]. Furthermore, Hagg and Wallner [17], Cassidy et al. [22], and Vanharanta et al. [23] found no relationship between FT and lumbar disc degeneration or herniation. Moreover, Hagg and Wallner [17] and Cassidy et al. [22] found facet asymmetry in the levels adjacent to herniation.

Due to controversial findings of previous biomechanical and clinical studies, the role of FT in lumbar disc herniation remains to be elucidated and it is currently unclear whether FT is associated with higher risk of lumbar disc herniation. Despite attempts to implicate facet orientation and asymmetry as predisposing factors for lumbar disc herniation, the role of FT remains debatable and inconclusive. These differences may be, in part, related to differences in the methods used to measure facet angles, definitions of FT, and study protocols. In previous studies, FT was defined as a difference >1°, >5°, or >10° [4,9,15]. Furthermore, defined FT as a bilateral angle difference greater than two intraobserver errors. Ko and Park [16] defined it as a difference between bilateral facet angles that was larger than the mean and one standard deviation of the differences between angles at each level. Some studies used CT images to measure the facet angle while others used MR images. Moreover, some studies used the adjacent normal disc as the control, whereas in others, the control group comprised normal subjects.

In the present study, similar to Chadha et al. [9], we defined FT as a difference of >10° between orientation of bilateral facet joints using MRI. However, in contrast to findings of Chadha et al. [9], we found that the incidence of FT was significantly different between patients and controls at the L4/L5 level (48.5% versus 26.2%) while it was similar at the L5/S1 level (50.8% versus 36.0%). Chadha et al. [9] investigated 60 patients with single level lumbar disc herniation and suggested that FT was associated with lumbar disc herniation at the L5/S1 motion segment (37.1% in cases versus 4.8% in controls) but not at the L4/L5 level (24% in cases versus 8.6% in controls). It is of importance to note that Chadha et al. [9] used the normal adjacent disc as the control while in our study the control groups comprised patients without any spinal disease, which may explain the different findings of the two studies. Also, we believe that if there were more subjects in our study, it would have been possible to find a significantly different incidence of FT at the L5/S1 level.

In contrast to some previous studies, Chadha et al. [9] found no relationship between coronal orientation of the facet joint and disc herniation. They observed that in patients with tropism, only 31.6% of discs herniated toward the coronally oriented facet (p=0.11). In the present study, intervertebral discs were significantly herniated toward the sagittally herniated facet joint in patients with FT (64%) which challenges the findings of Farfan and Sullivan [7] and van Schaik et al. [18].

Interestingly, in our study, there was a high incidence of FT in the control group (26.2% in L4/L5 and 36% in L5/S1), which was not associated with any symptoms. This suggests that FT alone cannot increase the risk of lumbar disc herniation and there may be other unknown factors, such as height, type of activity, or other spinal stabilizers, which act in accordance with FT. Further, larger prospective studies are essential to clarify this issue.

Conclusions

Our findings suggest that FT >10° can increase the risk of intervertebral disc herniation at the L4/L5 level, but not at the L5/S1 level; however, this could be related to the small number of patients enrolled in this study and larger studies are required in the future. Additonally, intervertebral discs tend to be herniated toward the more sagittally facet joint in patients with FT at the L4/L5 or L5/S1 levels.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Acknowledgments

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