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IS THERE ANY RELATIONSHIP BETWEEN LUMBAR INTERVERTEBRAL DISC SPACE HEIGHT AND LUMBAR DISC HERNIATIONS? A STUDY OF RADIOGRAPHIC EVALUATION

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ABSTRACT

Purpose: The main objective of this study was to evaluate the relationship between intervertebral disc space heights and disc pathologies at L4–L5 and L5–S1 levels via lateral lumbar spine radiographies.

Materials and Methods: The 73 patients included in this study were all examined by lateral lumbar spine radiography and lumbar magnetic resonance imaging (MRI). Two specialists re-assessed the MR images and classified the intervertebral discs as normal, bulging, protrusion or extrusion. The researchers also measured the anterior, middle and posterior intervertebral disc space heights at the L4–L5 and L5–S1 levels. The anterior, middle and posterior intervertebral disc heights were statistically compared between normal and herniated discs.

Results: Degenerated discs had significantly lower anterior and posterior intervertebral disc measurements than non-degenerated discs at the L4–L5 level. Herniated discs had significantly lower anterior, middle and posterior height measurements than non-herniated discs at the L4–L5 level. None of these measurements were significantly different for degeneration or herniation when compared with normal discs at the L5–S1 level.

Conclusion: Disc space heights were significantly lower for herniated discs and anterior and posterior disc space heights were significantly lower for degenerated discs at the L4–L5 level. There was no relationship between disc pathologies and intervertebral disc heights at the L5–S1 level.

Key Words: Intervertebral disc degeneration, intervertebral disc displacement, X-rays, magnetic resonance imaging, lumbar vertebrae

Level of Evidence: Retrospective cross-sectional study, Level III

INTRODUCTION

Back pain is a major public health problem[11] with a high prevalence in the adult population. Back pain also imposes a heavy socioeconomic burden [9-10]. Past studies have cited lumbar disc herniation (LDH) as the most common cause of back pain [6].

Magnetic resonance imaging (MRI) is a non-invasive imaging method used in the diagnosis of radiculopathies, disc herniation, and spinal stenosis, in addition to acquiring useful information regarding soft tissues of the lumbar area[7,12,15]. However, compared to lumbar spine radiographies, MRI is an expensive imaging modality with limited accessibility.

The main purpose of this study is to determine the relationship between lower lumbar disc pathologies and intervertebral disc space heights at the L4–L5 and L5–S1 levels. Here, the relationship between disc space height and LDH has been analyzed using lateral lumbar spine radiographies, which are relatively inexpensive and easily accessible, as an initial evaluation method for LDH in patients with back pain.

MATERIALS AND METHODS

Patients

This study was approved by the ethics committee and informed consent was

waived by the committee due to retrospective nature of the study. This investigation was planned as a cross sectional study. Data from patients who were admitted to our hospital between March 2018 and 2019 and had been examined using both lumbar MR imaging and lateral lumbar radiography were retrospectively evaluated (n = 79). Time interval between lateral lumbar radiography and lumbar MR examination was ≤ 15 days for all patients included in the study. Patients classified as grade 3 or grade 4 on the Kellgren-Lawrence classification system for osteoarthritis, were excluded from the study to avoid incorrect measurements of intervertebral disc heights due to difficulties in visualizing the intervertebral disc space on radiographies (n = 4). Patients who were inappropriately positioned for lateral lumbar radiographies were also excluded (n = 2). Exclusion criteria also included scoliosis with a Cobb angle ≥ 20° and other significant vertebral deformities (e.g. vertebral fracture or neoplasms); however, there were no patients with any of these pathologies in the study group. After exclusions, a total of 73 patients were included in this investigation. The mean age of the patients included in the study was 48.34 ± 2.03. The MRI and lateral lumber spine radiographies of 30 male and 43 female patients were evaluated in this study. MRI results were accepted as the "gold standard" against which lateral lumbar spine radiographies were compared.

Lateral Lumbar Spine Radiographies

Lateral lumbar radiographies were obtained by *Silhouette VR* X-ray System, *GE Healthcare*, *USA*. The radiographies were acquired in the standing position for all patients included in the study. All lateral lumbar radiographies were handled by an automatic exposure device with a film focus distance of 100 cm. A tube voltage of 86 kV and current of 25 mA were average values for capturing radiographic images. The mean time interval between initial symptoms and acquisition of lateral lumbar radiography was 9.7 days (range: 1–21 days).

MRI Interpretation

Disc degeneration was evaluated on T2-weighted images using the Pfirmann grading [14] If there was no clear border between nucleus pulposus and annulus fibrosus (from grade 3 to grade 5), the disc was accepted as a "degenerated disc". Bulging of the disc was defined as the displacement of the outer edges of the intervertebral disc beyond the margins of the adjacent vertebral bodies. More than one-quarter of the circumference of an intervertebral disc should be displaced to accept the disc as "bulging". An intervertebral disc was said to have a "protrusion" if the edges of the herniated part of the disc were less than the measured distance at the base of the herniation. A disc "extrusion" was determined if the distance measured between the edge of the herniated part of the disc and the edge of the non-herniated part of the disc was greater than the length at the base of the herniation in at least one plane of the MR image.5 If no continuity existed between the herniated disc material and the disc itself (a "sequestration"), it was also accepted as an "extrusion" in this study. Bulging was not accepted as a disc herniation in the current study.

Measurements

Three measurements were made for the L4–L5 and L5–S1 intervertebral disc spaces. At each of these levels, the height of the intervertebral disc was measured as the distance between the most anterior parts of the vertebral articular plateau, the distance between the most posterior edges of the articular plateau and the distance between two consecutive vertebral bodies at the midpoint of the anterior and posterior measurements (Figure-1).

The intervertebral disc space height was determined by the consensus of two reviewers (one radiology specialist with 14 years of experience and one orthopedist with 24 years of experience). The measurements were recorded to two digits after the decimal.

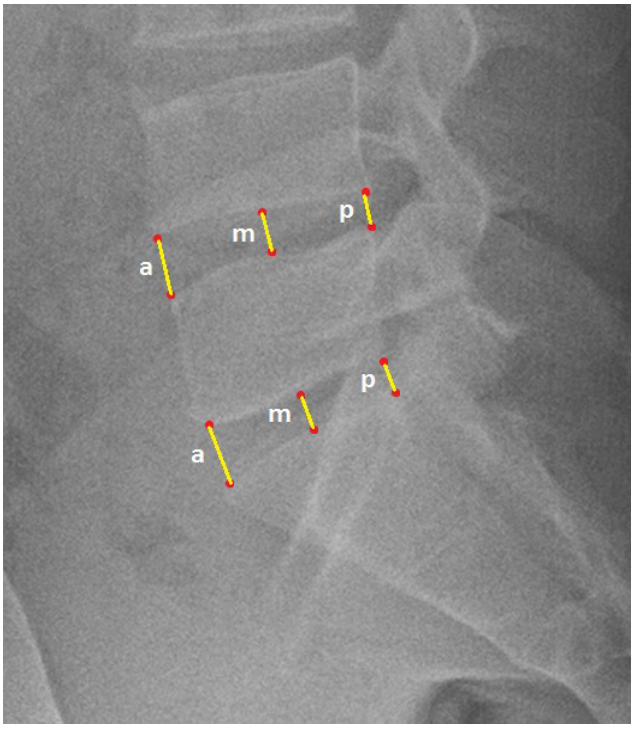

Figure-1. The anterior (a), middle (m), and posterior (p) measurements of intervertebral disc space heights on lateral lumbar spine radiographies

Statistical Analysis

All statistical analyses were performed using IBM SPSS statistics for Windows V.20 (IBM Corp). The homogeneity of data distribution was determined by performing the Kolmogorov–Smirnov test. Receiver operating characteristics (ROCs) were used to specify a cutoff value of intervertebral disc space to determine the presence of disc herniation. Mann Whitney-U test was used to determine the relationship between intervertebral disc space measurements and disc degeneration or herniation. In all statistical calculations, *p*-values < 0.05 represented a significant difference.

RESULTS

The number of herniated discs for each herniation type is presented in Table-1. According to this classification, the anterior and posterior L4–L5 intervertebral disc space height measurements showed a significant difference between degenerated and non-degenerated discs (p = 0.002 and p = 0.011 for anterior and posterior height measurements, respectively). Although the middle height measurements were not statistically significant, there was a trend towards significance (p = 0.051) between degenerated and non-degenerated discs at the L4–L5 level. Significant statistical differences were observed for the anterior, middle and posterior height measurements of intervertebral disc spaces between herniated and non-herniated discs at the L4–L5 level (Table-2).

Table-1. Results of MRI examinations

Disc level	*MRI result*	*n*	*Herniation*	*n*
L4–L5	**Normal disc**	34	Herniation (-)	49
	Bulging	15		
	Protrusion	21	Herniation (+)	24
	Extrusion	3		
L5–S1	**Normal disc**	37	Herniation (-)	58
	Bulging	21		
	Protrusion	11	Herniation (+)	15
	Extrusion	4		

There was no significant difference in anterior, middle and posterior disc space height between degenerated and non-degenerated discs or between herniated and non-herniated discs at the L5–S1 level (Table-3).

Table-2. Height measurements of intervertebral disc space at L4–L5

	Disc degeneration (-) (n = 22)	Disc degeneration (+) (n = 51)	Disc herniation (-) (n = 49)	Disc herniation (+) (n = 24)
Anterior height (mm) (med-max-min)	13.26-18.34-8.75	11.66-16.62-3.71	12.39-18.34-3.71	10.29-15.27-4.61
Middle height (mm) (med-max-min)	11.20-15.62-8.78	10.93-14.15-3.71	11.75-15.62-5.30	9.91-13.44-3.71
Posterior height (mm) (med-max-min)	8.44-11.70-5.15	7.29-13.55-2.18	8.02-11.70-3.71	6.34-13.55-2.18
p value (anterior-middle-posterior height)	0.002-0.051-0.011		0.001-0.001-0.004	

med: median value, max: maximum value, min: minimum value

Table-3. The height measurements of intervertebral disc space at L5–S1

	Disc degeneration (-) (n = 17)	Disc degeneration (+) (n = 56)	Disc herniation (-) (n = 58)	Disc herniation (+) (n = 15)
Anterior height (mm) (med-max-min)	12.46-17.33-7.21	12.47-17.06-4.25	12.46-17.33-4.25	12.90-16.64-10.29
Middle height (mm) (med-max-min)	9.50-16.49-5.25	9.93-14.76-3.64	9.85-16.49-3.64	9.94-13.40-7.21
Posterior height (mm) (med-max-min)	5.89-10.15-3.97	6.45-11.56-3.62	6.06-11.56-3.62	6.89-10.08-3.71
p value (anterior-middle-posterior height)	0.943-0.700-0.583		0.417-0.571-0.530	

med: median value, max: maximum value, min: minimum value

At the L4–L5 level, 11.81mm of anterior intervertebral disc space height showed 54.9% sensitivity and 54.5 % specificity; 8.01 mm of posterior intervertebral disc space height indicated 41.7 % sensitivity and 63.6 % specificity as a cutoff value based on ROC analysis with AUC value of 0.558 and 0.550, respectively for disc degeneration (Figure-2).

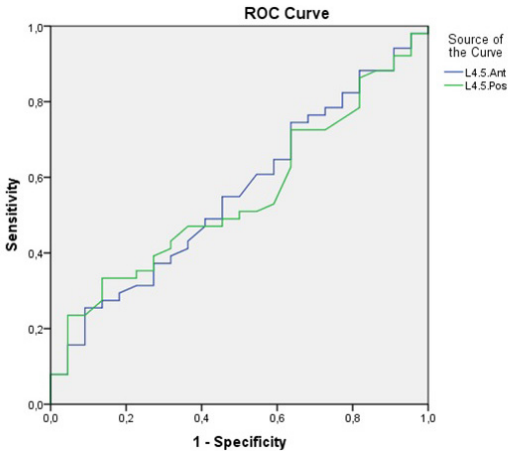

Figure-2. The receiver operating characteristics (ROC) analysis for anterior and posterior intervertebral disc space heights at the L4–L5 level in disc degeneration

For the same intervertebral disc level, 11.67 mm of anterior intervertebral disc height showed 62.5 % sensitivity and 42.9 % specificity; 10.16 mm of middle intervertebral disc height depicted 62.5 % sensitivity and 28.6 % specificity; 8.005 mm of posterior intervertebral disc height showed 37.5 % sensitivity and 53.1 % specificity as a cutoff value with AUC value of 0.493, 0.358 and 0.418, respectively for disc herniation (**Figure-3**).

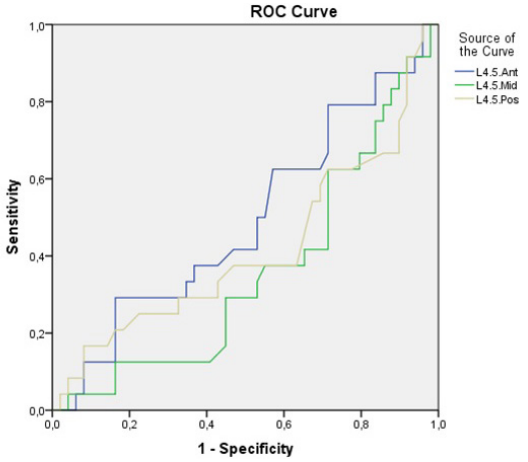

Figure-3. The receiver operating characteristics (ROC) analysis for anterior, middle, and posterior intervertebral disc space heights at L4–L5 level in disc herniation

DISCUSSION

Heights with disc degeneration and disc herniation using lateral lumbar spine radiographies. Our results showed that anterior and posterior intervertebral disc space heights were associated with lumbar disc degeneration, whereas anterior, middle, and posterior intervertebral disc space heights were associated with disc herniation at the L4–L5 level.

The lumbosacral part of the spine is known to be prone to disc herniation because of the mobility of this spinal segment. Previous studies in the literature have shown that the major portion (75 %) of lumbar flexion occurs at the lumbosacral joint and 15-20 % of flexion occurs at the L4–L5 level.[1] In this study, we have analyzed the relationship between L4–L5 and L5–S1 intervertebral disc space heights with disc pathologies since a majority (90-95 %) of clinically significant compressive radiculopathies are known to occur at these levels [4].

Previously, the sum of the disc heights was generally estimated to be a quarter of the total height of the vertebral column [2], leading to the assumption that "disc height was affected by height" [10].

However, some researchers have used converted measurements and ratios based on disc height instead of measuring individual intervertebral disc spaces [8]. Other studies have investigated the shape of end plates and disc heights to determine their relationship with disc pathologies. There are authors in the literature suggested that for degenerated and herniated intervertebral discs, spinal levels with concave-shaped end plates may have significantly higher discs than flat-shaped levels. Flat-shaped levels had significantly higher average disc height than levels with irregular-shaped end plates for degenerated discs but were not significantly higher in herniated discs [13]. In our current research, we were not focused on the specific shapes of end plates; instead, we measured the intervertebral disc space at three positions and analyzed the association between height at each position with disc pathologies.

In a study by Mirab *et al.*, the authors investigated normal intervertebral disc dimensions and found that mean anterior, middle and posterior disc heights were 18.14, 13.82 and 10.14 mm, respectively at the L4–L5 level and 18.71, 12.99 and 8.51 mm, respectively at the L5–S1 level [11]. Hong *et al.* studied the intervertebral disc space in the Korean population and found the anterior, middle and posterior heights to be 10.83, 10.05, and 7.20 mm, respectively at the L4–L5 level and 10.40, 9.58, and 6.02 mm, respectively at the L5–S1 level [8]. Both these studies were performed on MRI. The age range of the Hong *et al.* study population was 15 to 25 years. Our research using lateral lumbar spine radiographies found the anterior, middle and posterior disc heights to be 13.26, 11.20, and 8.44

mm, respectively at the L4–L5 level and 12.46, 9.50, and 5.89 mm, respectively at the L5–S1 level for non-degenerated discs. Besides technical variations, the difference in height measurements may also reflect genetic differences between the various study populations.

In the year 2017, Lee *et al.* published a study in a Korean population of 20 to 25-year-olds (n = 389). The results of this study showed that the anterior and middle height of intervertebral disc spaces were significantly lower for both degenerated and herniated discs, in comparison with normal intervertebral discs at the L4–L5 level [10]. In our research, anterior and posterior heights were significantly lower for disc degeneration. Moreover, anterior, middle and posterior heights were significantly lower for disc herniation at the same level. The difference of middle height of intervertebral disc space was not significant between degenerated and non-degenerated discs at this level in our research; however, the *p* value was remarkably close to statistical significance ($p = 0.051$).

Another aspect of this study showed that intervertebral disc space heights were not related to disc herniation or degeneration at the L5–S1 level. This may be because, at this level, biomechanical factors may play a more dominant role in affecting disc pathologies rather than disc space narrowing. More studies with larger populations may expand our understanding of the exact role of morphological alterations in disc space on disc pathologies at the L5–S1 level.

There are a few limitations of this study. Firstly, a wide range of age groups were included in this study. These measurements should be performed for each age group classified as young adults, adults and elderly, to understand the exact relationship between disc space narrowing and disc pathologies. The peak frequency of intervertebral disc herniation at L4–L5 and L5–S1 levels is known to occur between the ages of 44-50 years [15]. The mean age of our study population was approximately 48 years. This situation should also be considered for the results of this study. Secondly, this study only included a small sample size of the local population. More studies need to be performed on different populations given the possible effects of genetic differences. Thirdly, MRI is accepted as the gold standard in the diagnosis of disc pathologies in this study. However, surgical outcomes of patients may provide more accurate information about the relationship between disc space heights and disc pathologies. Lastly, the data distribution and sample size of our study population did not allow for performance of parametric tests. Much more patients are needed to understand the possible relationship between disc space heights and disc pathologies before the results of this study can be generalized to the entire population.

CONCLUSION

In conclusion, anterior and posterior disc space heights were associated with both disc degeneration and disc herniation, while middle disc space height was associated with disc herniation at the L4–L5 level. In addition, no satisfying cutoff disc space height values were obtained from the results of this study that can reliably be used to indicate disc pathologies on lateral lumbar spine radiographies.

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