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Morphometric analysis of the spine in patients with single-level lumbar disc herniations: clinical study

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ABSTRACT

Aims: It was reported in the literature that sagittal balance may be impaired in patients with spinal deformities and lumbar degenerative diseases. In this study, we analyzed the relationship between disc herniation and the results of spinal column morphological measurements related to sagittal balance on lumbar direct radiographs and preoperative blood biochemistry results in patients with single-level lumbar disc herniation and healthy subjects.

Methods: Patients who underwent surgery for L4-L5 or L5-S1 intervertebral disc herniation and healthy individuals were included in the study. The participants were then grouped into the control group (n=15) and the LDH group (n=30). Patients were also grouped into the L4-5 HNP group (n=15) and the L5-S1 HNP group (n=15). Age, gender, blood count, and serum C-reactive protein values of all individuals and L1-S1 Cobb angles, T12 and S1 slope angles, L4-S1 Cobb angles, each disc height, and L1-L5 vertebral column height were measured on lumbar direct radiographs.

Results: Age (p=0.035), T12 slope angle (p=0.032), L4-S1 Cobb angle (t=3.649, p=0.001), L1-L2 intervertebral disc height (p=0.032), L5-S1 intervertebral disc height (p=0.033), and eosinophil counts (p=0.039) were different between the control group and LDH group. However, there was no statistical difference between patients with L4-L5 disc herniation and patients with L5-S1 disc herniation in terms of study parameters. ROC-curve and regression analysis revealed that if age over 39 years if the T12 slope angle was less than 21.50 degrees if the L4-S1 Cobb angle was less than 32.43 degrees if L1-L2 disc height was above 7.45 mm and if L5-S1 disc height was below 8.15 mm (p=0.041) these parameters could be used predictive markers for the diagnosis of the lumbar disc herniation (p<0.05).

Conclusion: At the end of the study, it was argued that patient age, T12 slope angle, L4-S1 Cobb angle, L1-L2, and L5-S1 intervertebral disc heights measured on lumbar X-ray images could be used as predictive parameters for the diagnosis of lumbar disc herniation in these patients.

Keywords: Lumbar disc herniation, Cobb angle, T12 slope angle, S1 slope angle

INTRODUCTION

The prevalence of symptomatic lumbar disc herniation (LDH) in the general population ranges from 1% to 3%. Intervertebral disc degeneration is a multifactorial condition, with several factors contributing to its development, including spinal biomechanics, injury, inflammation, and nutrition.[1]

It is well established that a person can maintain a stable standing position with minimal muscular effort through sagittal balance while standing. The extant literature defines sagittal balance as the configuration of the bones (particularly the pelvis and the vertebral column), the mechanical behaviour of the discs and ligaments, the strength and resistance of the muscles, and the capacity to engage compensatory mechanisms.[2,3] When one or more of these factors is disrupted, the sagittal balance has deteriorated. This may have a detrimental effect on the spinal column on a global scale, potentially resulting in conditions such as spinal stenosis or intervertebral disc degeneration. Indeed, studies have demonstrated that patients with spinal deformities and lumbar degenerative diseases exhibit alterations in spinal pelvic sagittal force lines. However, the extant literature on the subject is inconclusive, with only a few studies investigating the effects of these force lines on LDH in patients with LDH.[3-7]

The present study evaluated the relationship between spinal column morphometric measurement results on lumbar X-ray, blood count results, and disc herniation in patients with LDH.

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METHODS

Ethics

This study was approved by the Kırıkkale University, Faculty of Medicine, Non-interventional Clinical Trials Ethics Committee (Date: 29.01.2025, Decision No: 2025.01.10). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Patient Groups

After retrospective screening from the hospital digital record system, patients who had undergone surgery for L4-5 or L5-S1 intervertebral disc herniation between January 2024 and December 2024 were included in this study. In addition, individuals without any metabolic and rheumatologic disease who presented to the outpatient clinic with low back pain but whose lumbar radiologic images did not reveal pathologic images requiring surgical treatment were also included.

The individuals were then divided into two groups as follows:

- Control group (healthy individuals, n=15)
- LDH group (patients operated for L4-L5 or L5-S1 intervertebral disc herniation, n=30)

After excluding the control group individuals, the patients (LDH group) were then divided into two groups as follows:

- L4-L5 HNP group (n=15)
- L5-S1 HNP group (n=15)

The patients were divided into two groups as follows:

- Male patients (n=13)
- Female patients (n=17)

The patients who had congenital spinal anomalies (such as scoliosis, spondylolisthesis), who had lumbar spinal deformities detected on coronal or sagittal X-ray images, who had a history of previous spine surgery, who had disc herniation at more than one level, who had infection, tumor, or rheumatologic involvement at the spine or intervertebral disc level, who had spine fracture or slippage, and patients at pediatric age group were excluded from the study.

Material

The age, gender, and duration of stay in the hospital were recorded. In addition, preoperative leukocyte (normal range 4400-11300/uL), neutrophil (normal range 1.100-9600/uL), lymphocyte (normal range 500-6000/uL), monocyte (normal range 0.12-1.2 10^3uL), basophil (normal range 0-300 10^3uL), eosinophil (normal range 0.02-0.5 10^3uL) and platelet (normal range 150-500 10^3/uL) counts and serum C-reactive protein (CRP) levels (normal range 0-5 mg/L) were recorded in the venous blood samples.

In addition, the following measurements were made on the standing lateral lumbar X-rays of the control group without disc herniation and on the preoperative standing lateral lumbar X-rays of the patients (**Figure 1**):

- L1-S1 Cobb angle: The angle between the upper end-plate of the L1 vertebra and the upper end-plate of the sacrum.

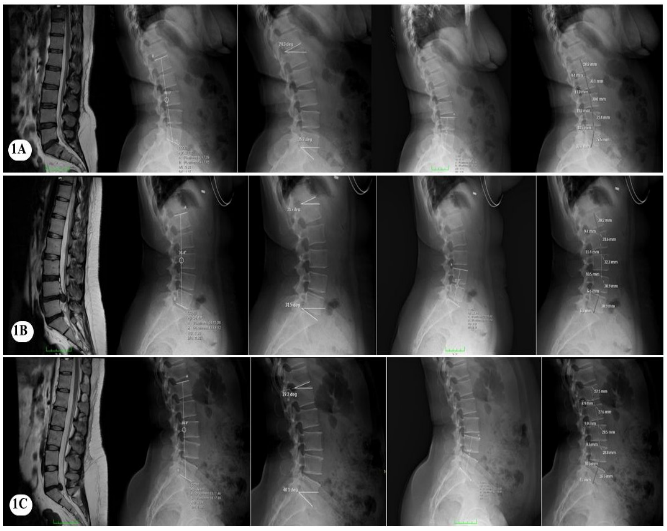

Figure 1. Photographs show sagittal T2-weighted MR images and morphometric measurements on lateral lumbar radiographs of healthy individuals (**1A**), individuals with L4-5 intervertebral disc herniation (**1B**), and individuals with L5-S1 intervertebral disc herniation (**1C**)

- T12 slope angle: The angle between the lower end-plate of the T12 vertebra and the line drawn parallel to the ground.
- S1 slope angle: Angle between the upper end-plate of the sacrum and a line drawn parallel to the ground.
- L4-S1 Cobb angle: The angle between the upper end-plate of the L4 vertebra and the upper end-plate of the sacrum.
- Intervertebral disc height: The height of the widest distance between the upper end-plate and the lower end-plate of each vertebra for each disc size.
- L1-L5 vertebral column height: Sum of the sagittal height of each intervertebral disc height and vertebra height.

In addition, the side (right, left), location (central, foraminal, mixed), extension of the herniated disc into the spinal canal (protrusion, extrusion, sequestration), and the orientation of the herniated disc in the sagittal plane (no migration, down migration, up migration) were recorded on the lumbar MR images of each individual included in the study.

Using posterior-anterior X-ray images, postural scoliosis (lateral bending) was assessed and recorded for all participants. In addition, all participants' lumbar spines were classified based on their sagittal X-ray images, according to Roussouly et al.[12]

Statistical Analysis

The data analysis was conducted using SPSS v20.0, a statistical program. The Kolmogorov-Smirnov test was utilized to analyze the normal distribution of data. Categorical data were evaluated using the Pearson Chi-square test ($p<0.05$). The Mann-Whitney U test was employed to compare non-parametric data between groups, and the Independent Samples t-test was used to compare parametric data ($p<0.05$). Spearman's rho correlation test was used to ascertain the correlations among the parameters ($p<0.05$). The ROC-curve test was used to investigate which study parameters could predict the diagnosis of LDH, and the sensitivity and specificity rates of the parameters were determined by obtaining "cut-off" values. The logistic regression test was also utilized to ascertain the most effective predictive parameters (p<0.05). The model validity was tested using Factor analysis, and a reliability test was performed to assess the reliability of the predictive parameters.

RESULTS

Age (t=-2.174, p=0.035), T12 slope angle (t=2.213, p=0.032), L4-S1 Cobb angle (t=3.649, p=0.001), L1-L2 intervertebral disc height (t=-2.401, p=0.021), L5-S1 intervertebral disc height (t=2.201, p=0.033), and eosinophil counts (Z=-2.061, p=0.039) were different between the control and LDH groups (**Table 1**).

Correlation test results revealed a positive correlation between the study group and age (r=0.307, p=0.040), between the study group and herniation type (r=0.367, p=0.046), between age and the direction of herniated disc migration (r=0.413, p=0.023), between the direction of disc migration and L1-S1 Cobb angle (r=0.448, p=0.013), between the direction of disc migration and S1 slope angle (r=0.422, p=0.020), between the direction of disc migration and L4-S1 Cobb angle (r=0.489, p=0.006), between the direction of disc migration and L5-S1 disc height (r=0.429, p=0.018), between L1-S1 Cobb angle and T12 slope angle (r=0.398, p=0.007), between L1-S1 Cobb angle and S1 slope angle (r=0. 605, p<0.001), between L1-S1 Cobb angle and L1-L2 disc height (r=0.348, p=0.019), between T12 slope angle and L4-S1 Cobb angle (r=0.425, p=0.004), between T12 slope angle and L5-S1 disc height (r=0.425, p=0.004), between S1 slope angle and L4-S1 Cobb angle (r=0.442, p=0.002), between S1 slope angle and "Roussouly classification" (r=0.498, p=0.001), between L4-S1 Cobb angle and L4-L5 disc height (r=0.359, p=0.015), between L4-S1 Cobb angle and L5-S1 disc height (r=0.606, p<0.001), between L1-L2 disc height and L2-L3 disc height (r=0.797, p<0.001), between L1-L2 disc height and L3-L4 disc height (r=0.470, p=0.001), between L1-L2 disc height and L1-L5 vertebral column height (r=0.424, p=0.004), between L2-L3 disc height and L3-L4 disc height (r=0.666, p<0.001), between L2-L3 disc height and L1-L5 vertebral column height (r=0.466, p=0.001), between L3-L4 disc height and L4-L5 disc height (r=0.380, p=0.010), between L3-L4 disc height and L1-L5 vertebral column height (r=0.458, p=0.002), between L4-L5 disc height and L5-S1 disc height (r=0.441, p=0.002), between L5-S1 disc height and L1-L5 vertebral column height (r=0.305, p=0.041) (**Table 2**).

On the other hand, there was a negative correlation between the study group and T12 slope angle (r=-0.300, p=0.045), between the study group and L5-S1 disc height (r=-0.330, p=0.027), between gender and L2-L3 disc height (r=-0.326, p=0.029), between gender and L3-L4 disc height (r=-0.370, p=0.012), between gender and L1-L5 vertebral column height (r=-0.651, p<0.001), between L4-S1 Cobb angle and the direction of disc migration (r=0.428, p=0.003), and between disc herniation type and L1-L5 vertebral column height (r=-0.402, p=0.028) (**Table 2**).

ROC-curve analysis applied to all participants' data showed that if the age is >39 years (area=0.688, p=0.042, 73% sensitivity and 60% specificity, 95% CI 0.494-0.881) if the T12 slope angle measured on lumbar X-ray images is <21.50 degrees (area=0.282, p=0.018, 63% sensitivity and 68% specificity, 95% CI 0.136-0.428) if the L4-S1 Cobb angle measured on lumbar X-ray images is <32.43 degrees (area=0.184, p=0.001, 73% sensitivity and 80% specificity, 95% CI 0.055-0.313) if the L1-L2 disc height is >7.45 mm (area=0.732, p=0.012, 70% sensitivity and 60% specificity, 95%CI 0.580-0.885), and if the L5-S1 disc height is <8.15 mm (area=0.311, p=0.041, 60% sensitivity and 60% specificity, 95%CI 0.160-0.463), these parameters could be predictive markers in decision-making for LDH on lumbar X-ray images. In addition, Logistic regression analysis revealed that age (B=0.053, Wald=4.109, p=0.043, OR=1.055, 95% CI 1.002-1.110), T12 slope angle (B=-0.122, Wald=4.022, p=0.045, OR=0.885, 95% CI 0.785-0.997), L4-S1 Cobb angle (B=-0.142, Wald=7.737, p=0.005, OR=0.868, 95% CI 0.785-0.959), L1-L2 disc height (B=0.576, Wald=4.711, p=0.030, OR=1.780, 95% CI 1.058-2.995) and L5-S1 disc height (B=-0.346, Wald=4.162, p=0.041, OR=0.707, 95% CI 0.507-0.986) could be used as predictive markers for diagnosis of the LDH on lumbar X-ray images (**Table 3, Figure 2**).

However, Factor analysis applied to test the validity of these parameters showed that these parameters could not be valid parameters for predicting the diagnosis of LDH on lumbar X-ray images (Kayser-Meyer-Olkin test=0.414, Barlett's test of Sphericity=24.553, p=0.006). A Reliability test was performed to test the reliability of these parameters, and it was concluded that they could not be reliably used for diagnosing the disc herniation on lumbar X-ray images (Cronbach's alpha value=-0.115, interclass correlation=-0.115, 95% CI -0.728-0.328, F=0.897, p=0.656).

On the other hand, after the control group individuals were excluded from the study, no statistical difference was found in terms of study parameters between patients with L4-L5 disc herniation and patients with L5-S1 disc herniation (**Table 4**).

When patients with LDH were divided into two groups male and female gender, L1-L2 disc height (t=2.319, p=0.028), L2-L3 disc height (t=2.246, p=0.033), L3-L4 disc height (t=2.351, p=0.026), L1-5 vertebral column height (t=4.103, p<0.001) and monocyte counts (t=2.287, p=0.030) were different between male and female patients (**Table 5**).

DISCUSSION

Research has indicated that patients diagnosed with disc degeneration exhibit a reduced sacral incidence and a diminished sacral slope angle compared to healthy individuals. Therefore, it was argued that patients with disc degeneration tend to have more vertical sacrum, sacral kyphosis, and severe low back pain, thus developing more disc degeneration.[9] In addition, it has been shown that individuals with reduced lumbar lordosis have more axial loading on the vertebral endplates, which leads to more dehydration and degeneration of the intervertebral disc. It has been posited that the L3-L4, L4-L5, and L5-S1 intervertebral discs were subject to these overloads, which led to the onset of degenerative processes.[5,10-12]

The findings of this study indicated that patients afflicted with LDH were characterized by advanced age, elevated L1-L2 disc height and eosinophil counts, and diminished T12 slope angles, L4-S1 Cobb angles, and L5-S1 disc heights

Table 1. Descriptive table of the study groups

		Control	LDH		
Variable		**Mean±SD/median (min-max)/n (%)**	**Mean±SD/median (min-max)/n (%)**	**t/Z/X²**	**p**
Age		38.67±16.38	48.10±12.23	-2.174*	0.035
Sex	Male	7 (15.6%)	13 (28.9%)	0.045‡	0.832
	Female	8 (17.8%)	17 (37.8%)	-	-
Roussouly's classification	Type 1	4 (8.9%)	12 (26.7%)	4.647‡	0.200
	Type 2	8 (17.8%)	15 (33.3%)		
	Type 3	2 (4.4%)	0 (0.0%)		
	Type 4	1 (2.2%)	3 (6.7%)		
Lateral bending	Neutral	15 (33.3%)	23 (51.1%)	4.145‡	0.126
	Right	0 (0.0%)	2 (4.4%)		
	Left	0 (0.0%)	5 (11.1%)		
Herniation site	Right	-	14 (46.7%)	-	-
	Left	-	16 (53.3%)	-	-
Disk migration	No	-	14 (46.7%)	-	-
	Below	-	15 (50.0%)	-	-
	Above	-	1 (3.3%)	-	-
Disk location	Central	-	12 (40.0%)	-	-
	Foraminal	-	4 (13.3%)	-	-
	Mixt	-	14 (46.7%)	-	-
Herniation type	Protruded	-	15 (50.0%)	-	-
	Extruded	-	13 (43.3%)	-	-
	Sequestrated	-	2 (6.7%)	-	-
L1-L5 Cobb angle		44.27±12.43	48.67±12.45	-1.118*	0.270
T12 slope angle		23.53±3.85	18.83±7.73	2.213*	0.032
S1 slope angle		38.87±10.25	33.87±8.67	1.716*	0.093
L4-S1 slope angle		37.90±8.73	26.41±10.50	3.649*	0.001
Intervertebral disk height	L1-L2	6.95±1.27	8.01±1.45	-2.401*	0.021
	L2-L3	8.41±1.10	9.17±1.78	-1.527*	0.134
	L3-L4	9.13±1.31	9.07±2.06	0.102*	0.919
	L4-L5	9.57±1.30	8.90±2.35	1.035*	0.307
	L5-S1	8.86±1.27	7.33±2.53	2.201*	0.033
L1-L5 vertebral column height		161.07±9.45	165.23±8.43	-1.498*	0.141
Leukocyte		7130 (4690-10450)	8350 (5070-17630)	-1.661†	0.097
Neutrophil		4610 (2210-7170)	5120 (2800-15530)	-1.734†	0.083
Lymphocyte		2472.67±547.82	2428.67±804.31	0.190*	0.850
Monocyte		432±121.67	539±200.54	-1.893*	0.065
Basophil		40 (20-70)	30 (10-80)	-0.467†	0.640
Eosinophile		22 (20-70)	75 (19-370)	-2.061†	0.039
Platelet (10^3)		269.47±58.67	278.10±54.38	-0.489*	0.627
C-reactive protein		1.80 (0.10-3.40)	1.95 (0.40-9.40)	-0.530†	0.596
Hospitalization		-	3 (2-9)	-	-

(*) t value, Independent Samples t-test, (†) Z value, Mann-Whitney U test, (‡) X2 value, Pearson Chi-square test, p<0.05, LDH: Lumbar disc herniation, SD:Standard deviation, min: Minimum, max: Maximum, n: Number of subjects

when compared with the control group. The findings of this study indicated that patients diagnosed with LDH were predominantly of advanced age. Conversely, the T12 slope angle, L4-S1 Cobb angles, and L5-S1 disc heights in these patients were lower than those observed in healthy individuals. It was hypothesized that the thoracic kyphosis angle would be higher in patients with disc herniation, and thus, the load on the vertebral column would be increased, with the L5-S1 disc space being most affected by this excessive load. In addition, although lumbar lordosis (i.e., L4-S1 Cobb angles) at the herniated disc level was decreased in these patients, L1-S1 Cobb angle was not different between the

Table 2. Correlation table showing the relationship between study data

		Age	Disc migration	Herniation type	L1-S1 Cobb angle	T12 slope angle	S1 slope angle	L4-S1 Cobb angle	Roussouly classification	L 1-L2 height	L 2-L3 height	L 3-L4 height	L 4-L5 height	L 5-1 height	L1-L5 vertebral height
Group	r	0.307	-0.092	0.367	0.211	-0.300	-0.204	-0.428	-0.229	0.231	0.058	0.025	-0.056	-0.330	0.132
	p	0.040	0.629	0.046	0.164	0.045	0.180	0.003	0.130	0.127	0.707	0.870	0.717	0.027	0.387
Age	r	1.000	0.413	0.065	0.147	-0.131	0.035	-0.173	0.238	0.189	0.063	-0.145	-0.111	-00.110	-0.127
	p		0.023	0.734	0.337	0.392	0.817	0.255	0.116	0.214	0.679	0.343	0.469	0.473	0.404
Gender	r		0.022	0.240	0.097	0.041	0.002	-0.003	-0.086	-0.226	-0.326	-0.370	-0.271	0.129	-0.651
	p		0.908	0.202	0.528	0.787	0.991	0.982	0.577	0.136	0.029	0.012	0.072	0.398	<0.001
Disc migration	r		1.000	0.141	0.448	0.337	0.422	0.489	-0.090	0.124	0.261	-0.112	-0.022	0.429	-0.147
	p			0.459	0.013	0.069	0.020	0.006	0.637	0.512	0.164	0.554	0.907	0.018	0.439
Herniation type	r			1.000	0.104	0.235	-0.072	-0.041	-0.172	-0.324	-0.339	-0.069	0.029	-0.194	-0.402
	p				0.583	0.212	0.706	0.829	0.363	0.080	0.067	0.716	0.878	0.303	0.028
L1-S1 Cobb angle	r				1.000	0.398	0.605	0.252	0.274	0.348	0.240	-0.014	-0.224	0.061	0.005
	p					0.007	<0.001	0.096	0.069	0.019	0.112	0.928	0.140	0.690	0.976
T12 slope angle	r					1.000	0.240	0.425	-0.009	-0.063	-0.069	-0.102	0.043	0.421	-0.083
	p						0.112	0.004	0.953	0.680	0.651	0.504	0.777	0.004	0.589
S1 slope angle	r						1.000	0.442	0.498	0.103	0.109	-0.133	-0.143	0.152	-0.077
	p							0.002	0.001	0.499	0.474	0.382	0.349	0.318	0.614
L4-S1Cobb angle	r							1.000	0.056	0.155	0.240	0.143	0.359	0.606	-0.062
	p								0.714	0.308	0.112	0.349	0.015	<0.001	0.684
Roussouly classification	r								1.000	0.162	0.132	0.038	-0.200	-0.151	-0.115
	p									0.289	0.386	0.803	0.187	0.323	0.453
L1-L2 disk height	r									1.000	0.797	0.470	0.238	0.248	0.424
	p										<0.001	0.001	0.115	0.101	0.004
L2-L3 disk height	r										1.000	0.666	0.282	00.284	0.466
	p											<0.001	0.060	0.059	0.001
L3-L4 disk height	r											1.000	0.380	0.038	0.458
	p												0.010	0.805	0.002
L4-L5 disk height	r												1.000	0.441	0.305
	p													0.002	0.041

Table 3. Table describing the patients operated on for lumbar disc herniation

ROC-curve test for decision-making of intervertebral disk herniation							
						95% confidence interval	
Variable	**Area**	**Cut-off value**	**p**	**Sensitivity**	**Specificity**	**Lower**	**Upper**
Age	0.688	>39.50	0.042	73%	60%	0.494	0.881
T12 slope angle	0.282	<21.50	0.018	63%	68%	0.136	0.428
L4-S1 Cobb angle	0.184	<32.43	0.001	73%	80%	0.055	0.313
L1-L2 disk height	0.732	>7.45	0.012	70%	60%	0.580	0.885
L5-S1 disk height	0.311	<8.15	0.041	60%	60%	0.160	0.463
Logistic regression test for decision-making of intervertebral disk herniation							
						95% confidence interval	
Variable	**B**	**Wald**	**p**		**Odds ratio**	**Lower**	**Upper**
Age	0.053	4.109	0.043		1.055	1.002	1.110
T12 slope angle	-0.122	4.022	0.045		0.885	0.785	0.997
L4-S1 Cobb angle	-0.142	7.737	0.005		0.868	0.785	0.959
L1-L2 disk height	0.576	4.711	0.030		1.780	1.058	2.995
L5-S1 disk height	-0.346	4.162	0.041		0.707	0.507	0.986

ROC: Receiver operating characteristic

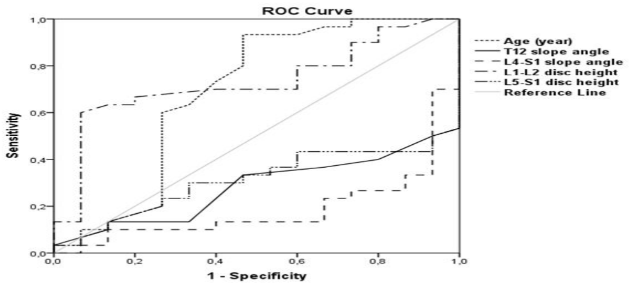

Figure 2. ROC curve plot showing the predictive parameters for the likelihood of lumbar disc herniation
ROC: Receiver operating characteristic

groups. Consequently, it was determined that the lumbar lordosis angle was not associated with an increased risk of disc herniation. However, as the study was retrospective, healthy individuals and patients underwent only routine lumbar X-ray imaging, and measurements were based on these images. As not all individuals included in the study had whole spinal column X-ray images, other parameters that could be used to assess sagittal balance (such as pelvic tilt, pelvic incidence, and thoracic kyphosis angles) could not be measured. Therefore, it was recognized that the risk of bias in the study results could be significant. However, the results

Table 4. Descriptive table of patients operated for lumbar disc herniation

		L4-L5 HNP group	L5-S1 HNP group		
Variable		**Mean±SD/median (min-max)/n (%)**	**Mean±SD/median (min-max)/ n (%)**	**t/Z/X²**	**p**
Age		51.20±14.13	45.00±9.46	1.412*	0.169
Sex	Male	9 (30.0%)	4 (13.3%)	3.394‡	0.065
	Female	6 (20.0%)	11 (36.7%)		
Roussouly's classification	Type 1	5 (16.7%)	7 (23.3%)	3.400‡	0.183
	Type 2	7 (23.3%)	8 (26.7%)		
	Type 3	-	-		
	Type 4	3 (10.0%)	0 (0.0%)		
Lateral bending	Neutral	12 (40.0%)	11 (36.7%)	0.243‡	0.885
	Right	1 (3.3%)	1 (3.3%)		
	Left	2 (6.7%)	3 (10.0%)		
Herniation site	Right	6 (20.0%)	8 (26.7%)	0.536‡	0.464
	Left	9 (30.0%)	7 (23.3%)		
Disk migration	No	6 (20.0%)	8 (26.7%)	1.886‡	0.390
	Below	9 (30.0%)	6 (20.0%)		
	Above	0 (0.0%)	1 (3.3%)		
Disk location	Central	7 (23.3%)	5 (16.7%)	1.333‡	0.513
	Foraminal	1 (3.3%)	3 (10.0%)		
	Mixt	7 (23.3%)	7 (23.3%)		
Herniation type	Protruded	10 (33.3%)	5 (16.7%)	4.359‡	0.113
	Extruded	5 (16.7%)	8 (26.7%)		
	Sequestrated	0 (0.0%)	2 (6.7%)		
L1-L5 Cobb angle		48.73±12.93	48.60±12.41	0.029*	0.977
T12 slope angle		18.53±8.36	19.13±7.33	-0.209*	0.836
S1 slope angle		34.60±9.06	33.13±8.51	0.457*	0.651
L4-S1 slope angle		26.22±9.80	26.60±11.50	-0.099*	0.922
Intervertebral disk height	L1L-2	8.35±1.38	7.67±1.49	1.296*	0.205
	L2-L3	9.65±1.68	8.70±1.80	1.489*	0.148
	L3-L4	8.95±2.58	9.19±1.45	-0.314*	0.756
	L4-L5	8.37±2.47	9.43±2.18	-1.246*	0.223
	L5-S1	7.53±3.04	7.12±1.98	0.441*	0.663
L1-L5 vertebral column height		167.41±6.41	163.05±9.80	1.440*	0.161
Leukocyte		8340 (5070-17630)	8400 (3410-11840)	-0.353†	0.724
Neutrophil		5180 (2800-15530)	4530 (3410-11840)	-0.207†	0.836
Lymphocyte		2348.67±779.06	2508.67±848.16	-0.538*	0.595
Monocyte		510.67±165.77	567.33±232.61	-0.768*	0.449
Basophil		30 (10-50)	30 (10-80)	-0.721†	0.471
Eosinophile		80 (19-260)	70 (20-370)	-0.770†	0.442
Platelet (10^3)		266.87±38.74	289.33±65.99	-1.137*	0.265
C-reactive protein		2.10 (0.40-4.99)	1.80 (0.60-9.40)	-0.581†	0.561
Hospitalization		3 (2-9)	3 (3-4)	-0.089†	0.929

(*) t value, Independent Samples t-test, (†) Z value, Mann-Whitney U test, (‡) X2 value, Pearson Chi-square test, p<0.05, HNP: Herniated nucleus pulposus, SD: Standard deviation, min: Minimum, max: Maximum

Table 5. Descriptive table of male and female patients operated for lumbar disc herniation

		Male group	Female group		
Variable		**Mean±SD/median (min-max)/n (%)**	**Mean±SD/median (min-max)/n (%)**	**t/Z/X²**	**p**
Age		49.92±13.52	46.71±11.37	0.708*	0.485
Roussouly's classification	Type 1	5 (16.7%)	7 (23.3%)	4.548‡	0.103
	Type 2	5 (16.7%)	10 (33.3%)		
	Type 3	-	-		
	Type 4	3 (10.0%)	0 (0.0%)		
Lateral bending	Neutral	9 (30.0%)	14 (46.7%)	0.767‡	0.681
	Right	1 (3.3%)	1 (3.3%)		
	Left	3 (10.0%)	2 (6.7%)		
Herniation site	Right	5 (16.7%)	9 (30.0%)	0.621‡	0.431
	Left	8 (26.7%)	8 (26.7%)		
Disk migration	No	6 (20.0%)	8 (26.7%)	0.834‡	0.659
	Below	7 (23.3%)	8 (26.7%)		
	Above	0 (0.0%)	1 (3.3%)		
Disk location	Central	5 (16.7%)	7 (23.3%)	0.087‡	0.957
	Foraminal	2 (6.7%)	2 (6.7%)		
	Mixt	6 (20.0%)	8 (26.7%)		
Herniation type	Protruded	8 (26.7%)	7 (23.3%)	2.266‡	0.322
	Extruded	5 (16.7%)	8 (26.7%)		
	Sequestrated	0 (0.0%)	2 (6.7%)		
L1-L5 Cobb angle		47.31±13.36	49.71±12.03	-0.516*	0.610
T12 slope angle		17.92±7.84	19.53±7.81	-0.557*	0.582
L4-S1 Cobb angle		26.41±10.62	26.41±10.74	0.001*	0.999
S1 slope angle		33.23±9.07	34.35±8.60	-0.346*	0.732
Intervertebral disk height	L1-L2	8.67±1.25	7.51±1.43	2.319*	0.028
	L2-L3	9.95±1.73	8.5765±1.61	2.246*	0.033
	L3-L4	10.02±1.55	8.35±2.15	2.351*	0.026
	L4-L5	9.78±2.26	8.22±2.26	1.868*	0.072
	L5-S1	6.52±2.76	7.95±2.23	-1.573*	0.127
L1-L5 vertebral column height		171.04±3.72	160.79±8.37	4.103*	<0.001
Leukocyte		8360 (6120-17630)	8340 (5070-14430)	-0.544†	0.586
Neutrophil		5180 (3530-15530)	4530 (2800-11630)	-0.670†	0.503
Lymphocyte		2496.92±799.96	2376.47±828.18	0.401*	0.692
Monocyte		628.46±232.77	470.59±144.16	2.287*	0.030
Basophil		30 (10-80)	30 (10-80)	-1.027†	0.304
Eosinophile		80 (19-280)	70 (20-370)	-0.063†	0.950
Platelet (10^3)		266.23±42.99	287.18±61.42	-1.047*	0.304
C-reactive protein		2.10 (0.45-4.40)	1.60 (0.40-9.40)	-0.398†	0.691
Hospitalization		3 (3-9)	3 (2-4)	-1.769†	0.077

(*) t value, Independent Samples t-test, (†) Z value, Mann-Whitney U test, (‡) X^2 value, Pearson Chi-square test, $p<0.05$, SD: Standard deviation, min: Minimum, max: Maximum

of this study were still convincing, and it was considered that this research could serve as a preliminary step for further investigations.

Conversely, a parallel was observed in the blood count and CRP results between healthy subjects and patients with disc herniation. Consequently, these parameters would not be considered discriminative for disc herniation. Despite the finding of elevated eosinophil count values in patients with disc herniation, these values were found to be within the laboratory's normal range. It was hypothesized that the herniated disc did not induce an inflammatory or immunological response in the patients under consideration.

Following a detailed correlation analysis, it was hypothesized that the probability of disc herniation could be associated with increasing age or decreasing T12 slope angle, L4-S1 Cobb angle, and L5-S1 disc height, as measured on lumbar X-ray images. Conversely, it was observed that disc heights might be higher in males. Furthermore, an observation was made that as the L1-S1 Cobb angle increased, the T12 slope angle, S1 slope angle, and L1-L2 disc height increased concomitantly. This indicated a potential increase in the migration of the herniated disc. It was hypothesized that an increase in the S1 slope angle and the L5-S1 disc height would result in an elevated probability of migration of the herniated disc. Furthermore, in the event of the L4-S1 Cobb angle being measured low, there is the potential for a decrease in both the T12 and S1 slope angles, as well as a reduction in lumbar lordosis. This may result in an increased probability of disc herniation. Conversely, a decrease in the height of the L1-L5 vertebral column has been hypothesized to increase the risk of protruded, extruded, or sequestered disc herniation.

Furthermore, ROC-curve analysis and logistic regression analysis demonstrated that increased patient age and L1-L2 intervertebral disc heights, as well as decreased T12 slope angle, L4-S1 Cobb angle, and L5-S1 intervertebral disc heights, measured on lumbar X-ray images, could be utilized as predictive markers for the diagnosis of LDH in these patients. Consequently, the hypothesis was proposed that lumbar X-rays of patients with low back pain could serve as a valuable diagnostic tool for identifying LDH. However, following the conclusion of the validity and reliability tests, it was determined that none of these parameters could be considered valid or reliable in predicting the diagnosis of LDH. Nonetheless, it was hypothesized that the implementation of these parameters in clinical practice could prove advantageous in predicting diagnoses and risk factors associated with LDH.

Conversely, following the exclusion of subjects in the control group, the study data exhibited no significant differences between the L4-5 HNP and L5-S1 HNP groups. The results indicated that the spinal column morphometric measurement data showed no significant differences between the two patient groups. Furthermore, no discrepancies were observed in blood counts or CRP levels between the two groups.

Finally, when the patients with intervertebral disc herniation were divided into two groups, male and female, it was observed that the disc heights at L1-L2, L2-L3, and L3-L4, along with L1-L5 vertebral column heights and monocyte counts, were lower in female patients compared to male patients. This difference was thought to be due to the larger body mass of male patients compared to their female counterparts. Monocyte counts were not considered a discriminating factor as they remained within the laboratory's normal range values.

Limitations

It should be noted that the study was not without its limitations. Firstly, given the study's retrospective nature, the number of patients was limited. Secondly, the assessment of morphometric parameters, including the C7 plumb line, thoracic kyphosis angle, pelvic incidence, pelvic tilting angle, sacral inclination, and sacro-femoral distance, was not possible due to the absence of whole-body lateral X-ray radiographs in the patient cohort. Thirdly, the long-term follow-up findings of the study groups were not included in the study, as they were considered to fall outside the study remit. Fourthly, the results of the "body-mass index", "visual analog scale", and "Oswestry disability index" of the patients were not included in the study, as they were deemed to be irrelevant to the purpose of the study. Finally, patients with upper LDH were not included in the study because they are rarely encountered in clinical practice (approximately 5% of all LDH patients).[13]

CONCLUSION

The study demonstrated that, despite their inability to be substantiated as reliable and valid parameters, patient age and T12 slope angle, L4-S1 Cobb angle, L1-L2 and L5-S1 intervertebral disc heights, as measured on lumbar X-ray images, could serve as predictive and helpful parameters for the diagnosis of LDH in patients experiencing low back pain. However, further research is required to ascertain whether these parameters can discriminate between patients with and without the condition. It was posited that the conduct of exhaustive investigations encompassing a more substantial patient cohort would be necessary to substantiate the validity and reliability of these parameters.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study was approved by the Kırıkkale University, Faculty of Medicine, Non-interventional Clinical Trials Ethics Committee (Date: 29.01.2025, Decision No: 2025.01.10).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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Author Contributions

All of the authors declare that they have participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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