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PREVALENCE AND ETIOLOGY OF LUMBAR SPINE ABNORMALITIES IN ADULT PATIENTS USING MAGNETIC RESONANCE IMAGING: A CROSS-SECTIONAL STUDY FROM DISTRICT D.I. KHAN, PAKISTAN

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Abstract

Background: Lumbar spine abnormalities comprise a spectrum of degenerative intervertebral disc (IVD) conditions, including disc bulging, disc degeneration, herniation, and annular tears. Magnetic resonance imaging (MRI) is the diagnostic modality of choice for accurately localizing these changes. To determine the prevalence and etiological associations of lumbar spine abnormalities in adult patients using MRI, and to evaluate their distribution across intervertebral disc levels.

Methodology: In this cross-sectional analytical study, 218 adult patients (18–80 years) presenting with low back pain and suspected lumbar spine disease underwent MRI on a 0.3T open MRI system (HITACHI) at MRI departments in D.I. Khan City in collaboration with the Apex Institute of Medical Sciences. T1- and T2-weighted sagittal and axial images were independently evaluated by three radiologists. Data were analyzed using IBM SPSS Statistics version 30, and the chi-square test was applied to assess statistical significance.

Results: Of 218 patients, 123 (56.4%) were male and 95 (43.6%) were female. Disc bulging was the most prevalent abnormality (51.8%, 113/218, $p=0.038$), followed by disc degeneration (28.9%, 63/218, $p<0.001$), herniation (14.2%, 31/218, $p=0.009$), and annular tears (5.0%, 11/218, $p<0.001$). The L4/L5 level was most frequently involved (30.7%), followed by L3/L4/L5 (23.4%), L4 (24.3%), and L5 (9.2%). Heavy weight lifting (21.1%), post-traumatic history (14.7%), and age-related factors (28.4%) were the leading etiological associations, and low back pain was reported by 216 patients (99.1%).

Conclusion: Lumbar disc bulging was the most prevalent lumbar spine abnormality among adults with low back pain in district D.I. Khan, with the L4/L5 and L5/S1 levels most commonly affected. MRI remains the imaging modality of choice for evaluating intervertebral disc abnormalities owing to its non-invasive nature, superior soft-tissue contrast, and diagnostic accuracy.

Keywords: Lumbar Spine; Intervertebral Disc; Magnetic Resonance Imaging; Disc Herniation; Low Back Pain; Disc Degeneration.

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INTRODUCTION

The lumbar spine, situated between the twelfth thoracic vertebra and the sacrum, comprises five mobile vertebrae (L1–L5) that bear axial load and provide the lumbar lordotic curvature.(1) It is composed of vertebral bodies, posterior elements, facet joints, ligaments, nerves, and intervertebral discs (IVDs), each contributing to spinal stability and mobility.(2) The IVD consists of the nucleus pulposus, annulus fibrosus, and cartilaginous end plates; even minor structural alteration of any of these components can compromise disc function and, through its shock-absorbing role, the biomechanics of the entire spine.(3,4)

Lumbar spine abnormalities (LSA) is an umbrella term for a group of degenerative intervertebral disc conditions, namely disc bulging, disc degeneration, herniation, and annular tears.(5) Disc bulging occurs when the annulus fibrosus weakens and extends asymmetrically beyond the disc margin without frank herniation, and may narrow the spinal canal and compress traversing nerve roots.(6,7) Disc degeneration results from combined biological and structural changes in the nucleus pulposus, annulus, and vertebral end plates, culminating in facet joint hypertrophy, disc height loss, and ligamentum flavum thickening.(8,9) Herniation develops when nucleus pulposus material breaches the annulus fibrosus, most frequently at the L4–S1 levels, and can compress the lumbosacral nerve roots, producing radicular pain, sciatica, and sensory or motor deficits.(10,11) Annular tears, visualized on MRI as a high-intensity zone (HIZ) on T2-weighted sequences, alter the disc's biochemical environment and are strongly associated with discogenic low back pain (LBP).(12,13)

LBP affects a large proportion of the population at some point in life and is a leading cause of years lived with disability worldwide, yet its precise aetiology often remains elusive.(14,15) MRI is the imaging modality of choice for evaluating the lumbar spine

because it is non-invasive, avoids ionizing radiation, provides superior soft-tissue contrast, and reliably localizes structural change within the IVD.(16,17) Advanced MRI-derived parameters have further refined the non-invasive characterization of disc degeneration, herniation, and annular pathology.(18)

Regional data on the burden and etiological correlates of lumbar spine abnormalities in adult Pakistani populations, particularly those engaged in physically demanding occupations, remain limited. Given that district D.I. Khan has a predominantly labour-based population subject to considerable occupational and traumatic spinal stress, characterizing the local burden of disease is of direct clinical relevance. This study was therefore undertaken to determine the prevalence of lumbar disc bulging, degeneration, herniation, and annular tears, and to evaluate their etiological associations and intervertebral level distribution, in adult patients referred for MRI in district D.I. Khan.

METHODOLOGY

Study Design and Setting: This cross-sectional analytical study was carried out in the MRI departments of DHQ, Bio-Med, and Al-Shifa (Ali) Hospitals, D.I. Khan, in collaboration with the Apex Institute of Medical Sciences, from 1st August to 10th December.

Sample Size and Sampling Technique: A total of 218 patients were enrolled using a non-probability convenience sampling technique.

Inclusion Criteria: Male and female patients aged 18–80 years with low back pain and suspected lumbar spine abnormalities were included, including those with titanium stents, pacemakers, or rods, and those with a history of post-traumatic lumbar spine injury.

Exclusion Criteria: Patients with pacemakers, stents, or rods made of ferromagnetic material, patients undergoing cervical or thoracic spine MRI, and paediatric patients were excluded.

Data Collection: T1- and T2-weighted (axial and sagittal) images of 218 adult patients with suspected lumbar spine disease were evaluated. Patient history — including low back pain, falls, slips, athletic activity, and traumatic history — was recorded via a structured questionnaire prior to MR imaging. The study was approved by the Ethical Review Committee of the Apex Institute of Medical Sciences, and written informed consent was obtained from all participants.

MRI Protocol: MRI examinations were performed using a 0.3T open MRI system (HITACHI), with a resolution of approximately 256×256 and 128×128 pixels. Images were acquired using a spin echo pulse sequence, with time-to-echo (TE) and repetition time (TR) varied according to scanner type and intended image weighting. T1- and T2-weighted sagittal and axial images were obtained with patients in the supine position, with a minimum of 12 sagittal slices of 3 mm thickness per patient. Each MR image was independently assessed by three radiologists with 16, 15, and 18 years of experience, respectively, blinded to patient history.

Statistical Analysis: Data were analyzed using IBM SPSS Statistics version 30. Categorical variables were expressed as frequencies and percentages, and the chi-square test was used to determine statistical significance, with $p<0.05$ considered significant.

RESULTS

In this study, 218 patients were investigated; 123 (56.4%) were male and 95 (43.6%) were female. All 218 patients were diagnosed with lumbar spine abnormalities based on their MR images. Different p values are mentioned in Table 4.

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Prevalence of Lumbar Spine Abnormalities

Common Abnormalities	Frequency	Percent	Cumulative Percent
Lumbar disc bulging	113	51.8	51.8
Lumbar disc degeneration	63	28.9	29.0
Lumbar disc herniation	31	14.2	14.2
Annular tear	11	5.0	5.0
Total patients	218	100%	100%

Table 1: *Prevalence of lumbar spine abnormalities in different aged patients. It was noted that peak prevalence was related with lumbar disc bulging with 51.8% (113/218 patients) and (p 0.038). Other diagnosed diseases was that lumbar disc degeneration 28.9% (63/218), herniation 31% (31/218) and annular tear was lowest prevalence 5% (11/218).*

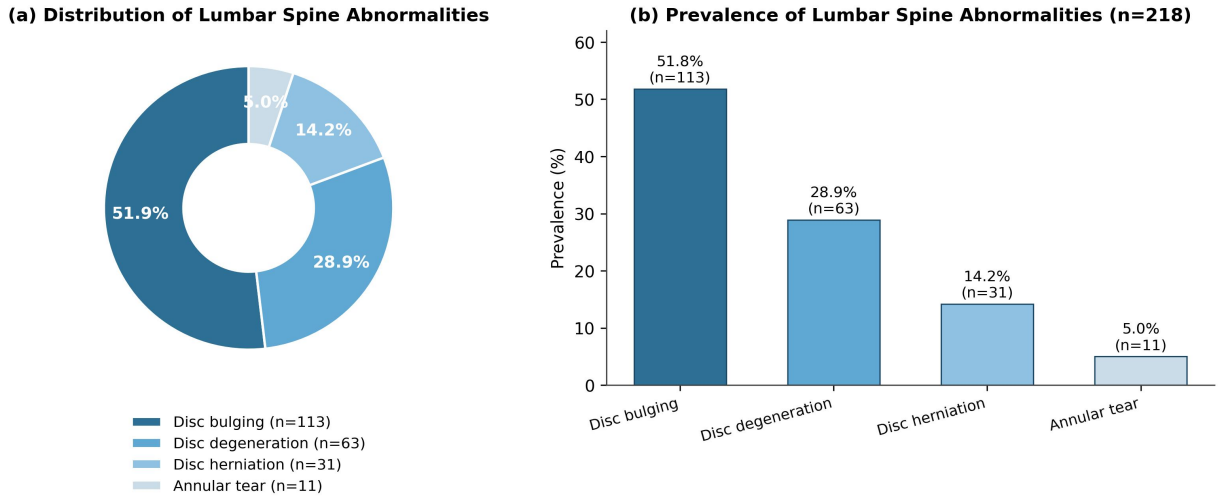

Figure 1: *(a) Pie chart and (b) bar chart showing the prevalence of lumbar spine abnormalities among 218 patients. The most common condition is lumbar disc bulging*

(51.8%), followed by lumbar disc degeneration (28.9%), disc herniation (14.2%), and annular tear (5%).

Table 2 shows the prevalence of participants with abnormalities of the lumbar spine (%) divided by the different etiological reasons. Based on their clinical characteristics, the patients were categorized into various groups and compared to one another, revealing notable differences. The prevalence of patients with age-related etiology was statistically higher than that of patients with other variables. The history of heavy lifting is the second most significant risk factor (21.1%), whereas a family history of lumbar spine disorders is the least significant factor (3.2%). Patients with a record of lumbar spine post-accident (14.7%) and slipping down (13.4%) are likewise more common than those who fall down (5.0%). In Figure 2, the low back discomfort is also highlighted. 216 patients, or 99.1%, experienced LBP, which was linked to the abovementioned histories. Every p-value for those specific physical and historical parameters is mentioned in Table 4.

Prevalence of LSA Regarding Patient's Historical and Physical Parameters

Etiology	Frequency	Percentage	Cumulative Percent
Athlete	9	4.1	4.1
Fall down	11	5.0	5.0
Slipped down	30	13.8	13.8
Post-trauma	32	14.7	14.7
Family history	7	3.2	3.2
Heavy weight lift	46	21.1	21.1

Etiology	Frequency	Percentage	Cumulative Percent
Low back pain	216	99.1	99.1
Age related	62	28.4	28.4
Total patients	218	100%	100%

Table 2: *Etiology of LSA among 218 patients. The most common cause is LBP (99.1%), followed by heavy weight lifting (21.1%) and age-related factors (28.4%). Other cases include post-trauma (14.7%), slipping down (13.8%) and minor contributions from athletic activities, falls down and family history.*

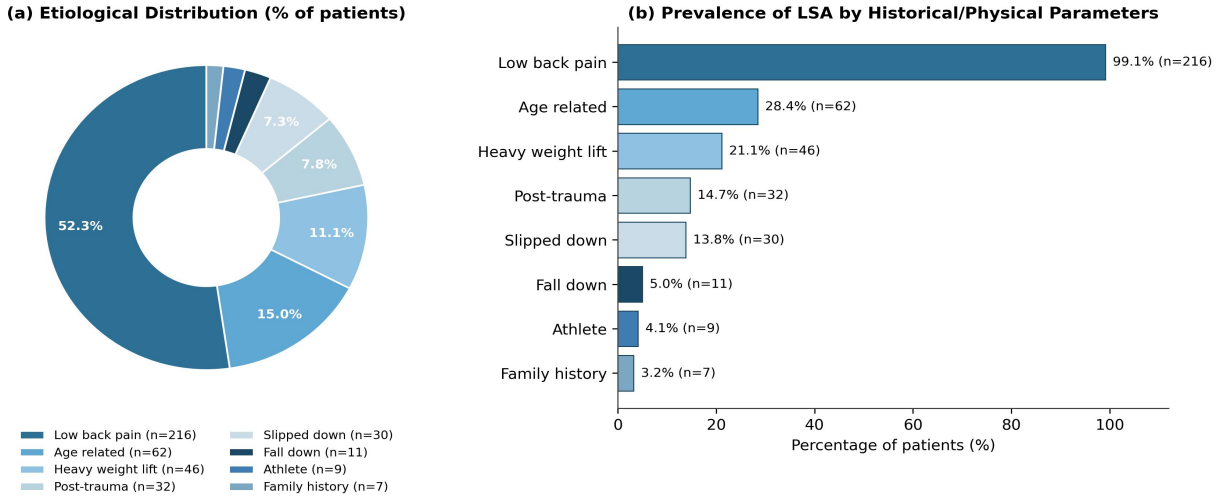

Figure 2: *(a) Pie chart and (b) bar chart showing the prevalence of lumbar spine abnormalities (LSA) regarding patients' historical and physical parameters.*

Some of the investigated patients had lumbar spine abnormalities like disc bulging, degeneration, herniation and annular tear presented on L4/L5 (30.7%) discs has higher prevalence. Other discs are also involved including L3/L4/L5 (23.4%), L4 (24.3%) and L5 (9.2%) are mentioned in Table 3.

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Prevalence of LSA in Various IVD Levels

IVD Level	Frequency	Percent	Valid Percent	Cumulative Percent
L1	1	.5	.5	.5
L2	3	1.4	1.4	1.8
L2-L3-L4	12	5.5	5.5	7.3
L3-L4-L5	51	23.4	23.4	30.7
L4	53	24.3	24.3	55.0
L5	20	9.2	9.2	64.2
L4-L5	67	30.7	30.7	95.0
L1-L2-L3-L4-L5	11	5.0	5.0	100.0
Total	218	100.0	100.0	

Table 3: *Prevalence of LSA (%) in various IVD level.*

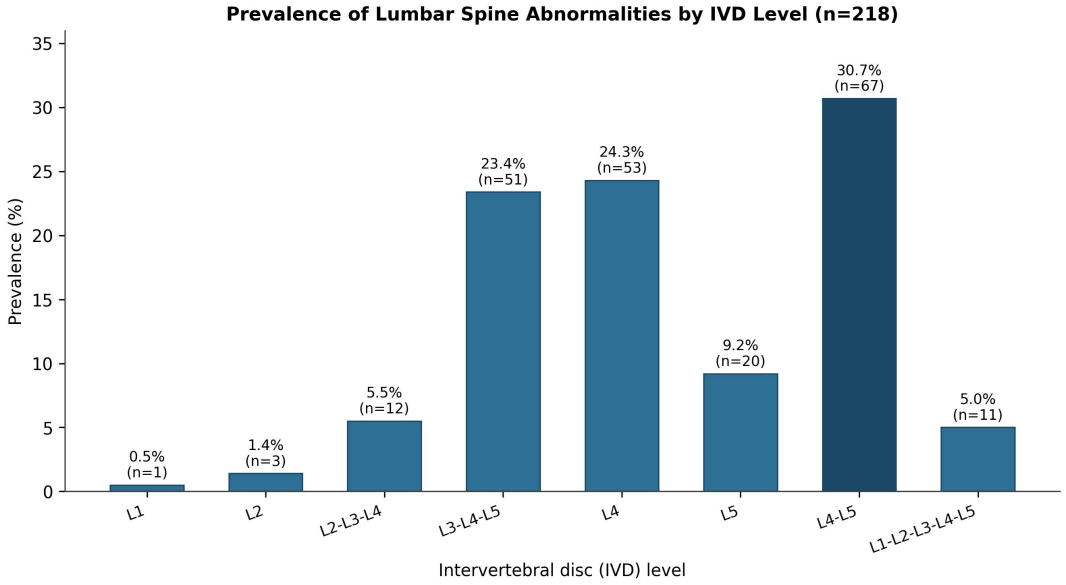

Figure 3: *Bar chart showing the prevalence of lumbar spine abnormalities by intervertebral disc (IVD) level (n=218). The L4/L5 level shows the highest prevalence (30.7%), followed by L4 (24.3%) and L3-L4-L5 (23.4%).*

The MR images and reports of patients under and over 70 years of age were compared in order to assess the frequency of disc abnormalities with respect to the patient's age and gender. The incidence of disc bulging and degeneration in old aged patients group, results was more significant than other type of diseases. Disc herniation (posteriorly to the spinal canal) was more prominent than other sites of IVD. Annular tear (Peripheral and circumferential tear) was also seen on different aged patients.

Statistical p Values of LSA

Lumbar Spine Abnormalities	Frequency	Percentage	p value
Lumbar disc bulge	113	51.8	0.038
Lumbar degenerative disc	63	28.9	<0.001
Lumbar disc herniation	31	14.2	0.009
Annular tears	11	5.0	<0.001

Table 4: *Result of a chi-square test analyzing LSA. Lumbar disc bulging and degeneration are statistically significant p values of 0.038 & <0.001 respectively. Other conditions, like disc herniation and annular tears also show significant associations with p values of 0.009 & <0.001.*

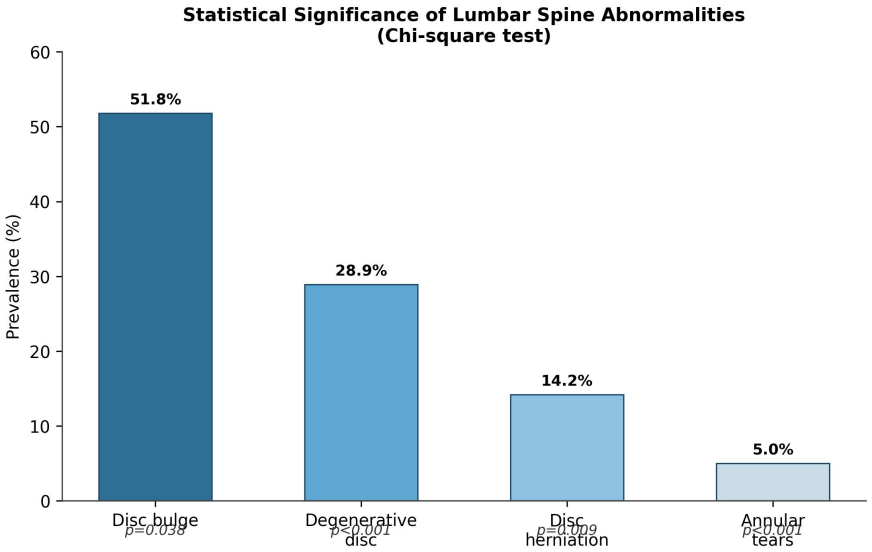

Figure 4: *Bar chart showing the prevalence and statistical significance (chi-square test) of lumbar spine abnormalities among 218 patients.*

DISCUSSION

In this cross-sectional study of 218 adult patients with low back pain, disc bulging was the most prevalent lumbar spine abnormality (51.8%), followed by disc degeneration (28.9%), herniation (14.2%), and annular tears (5.0%). The predominance of disc bulging in our cohort is consistent with the physically demanding, labour-intensive occupational profile of much of the district's population, reflected in heavy weight lifting (21.1%) and slipping-related trauma (13.8%) as leading etiological associations. Comparable occupational associations, including posterior disc bulging and an increased risk of sciatica among machine operators and manual workers, have previously been described.(19) Loss of disc height with lumbar bulging and vertebral end-plate bowing has likewise been attributed to ageing.(7) Consistent with earlier discography-based work, a lumbar bulge with reduced T2 signal intensity or disc-height loss is considered strongly suggestive of an underlying annular tear.(13) In our series, axial T2-weighted

imaging demonstrated both posterior and circumferential bulging, with the highest prevalence at L4/L5 and L5/S1 (30.7%), followed by L3/L4/L5 (23.4%) and the L1–L5 multilevel pattern (5.0%).

Disc degeneration (28.9%) and herniation (14.2%) were most common in patients aged over 50 years, broadly consistent with earlier data reporting degeneration and herniation in 67.3% and 28.2% of discs, respectively, in an asymptomatic Indian cohort, and with Western series describing a prevalence range of 28–84% across age groups.(20) Katewa et al. similarly reported comparable disc-level involvement (L4-L5, L5-S1, L3-L4) in patients with degenerative spinal disease, with a mean age of 48.4 ± 14.9 years and peak involvement in the 51–60-year age group.(21) In our cohort, degeneration was more common in male patients aged 50–70 years with a history of heavy manual work, while affected female patients were somewhat younger (48–65 years); the lack of ionizing radiation, multiplanar capability, and superior soft-tissue contrast of MRI support its continued preference for evaluating these changes.(21) Broader epidemiological data confirm that degenerative spinal disorders, including disc degeneration, spondylosis, osteoporosis, and stenosis, are strongly age- and obesity-associated.(22,23) In our cohort, heavy physical work and post-traumatic history, rather than obesity, emerged as the dominant modifiable etiological correlates, consistent with reports linking spinal trauma to accelerated degeneration.(24,25)

Herniation in our study (14.2%) most frequently involved the L4/L5 and L5/S1 levels, in agreement with a large MRI series reporting L4/5 and L5/S1 as the predominant levels, with male and female prevalence of 58.8% and 52.4%, respectively ($p<0.01$).(26) These findings support a primarily degenerative and occupational-load-related mechanism for herniation in our labour-intensive population.

Annular tears were the least prevalent abnormality in our cohort (5.0%), most often associated with heavy weight lifting (21.1%) and falls (5.0%), a pattern broadly comparable to a cohort in which over 60% of patients with annular tears reported LBP, with post-traumatic history, falls, and elevated body mass index as contributing factors.(27) As in previous series, annular tears in our study clustered at the L4/L5 and L5/S1 levels and were most reliably identified as an isolated high-intensity zone on T2-weighted imaging, whereas signal change on both T1- and T2-weighted sequences was more suggestive of calcification than an acute tear.(12,13) Innervation of the outer annulus fibrosus by the sinuvertebral and ventral ramus branches provides a plausible anatomical basis for annular tear-related LBP, which was reported by 99.1% of our study population, underscoring LBP as the principal indication for lumbar MRI referral in this setting.(6)

CONCLUSION

The prevalence of lumbar spine abnormalities was highest for disc bulging, followed by degeneration, herniation, and annular tears, among adults with low back pain in district D.I. Khan. Disc bulging predominated over other disc pathologies, and the L4/L5 and L5/S1 levels were most frequently involved. The etiological findings, most notably the association with heavy manual labour and post-traumatic history, are consistent with the region's largely occupation-based population. Given its non-invasive nature, absence of ionizing radiation, superior soft-tissue contrast, and reliable localization of intervertebral disc changes, MRI remains the imaging modality of choice for evaluating lumbar spine abnormalities. Lifestyle modification, adequate nutritional support, and, where appropriate, pharmacological or surgical intervention should be considered in the

management of affected patients, and larger multicentre studies are recommended to validate these regional findings.

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AUTHOR'S CONTRIBUTION

[Author 1] conceived and designed the study and drafted the manuscript. [Author 2] performed data collection and MRI evaluation. [Author 3] performed the statistical analysis and critically revised the manuscript for important intellectual content. All authors read and approved the final version of the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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