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Original Research

Spectrum Of MRI Image Findings In Lumbar Degenerative Disc Disease In A Tertiary Care Hospital Of Eastern India

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ABSTRACT

Introduction: Lumbar degenerative disc disease (LDDD) is a prevalent cause of chronic low back pain and disability, particularly in aging populations. Magnetic Resonance Imaging (MRI) serves as the gold standard for non-invasive assessment of spinal degenerative changes. This study aimed to evaluate the spectrum of MRI findings in LDDD and analyze their association with demographic variables in patients presenting to a tertiary care hospital in Eastern India.

Methods: A hospital based cross-sectional observational study was conducted on 150 patients at department of Neurosurgery of NRS Medical College, Kolkata with clinically suspected LDDD who underwent lumbar spine MRI. Sociodemographic characteristics, including age and gender, were recorded. MRI findings were evaluated and statistical analysis was performed to assess associations with age and gender.

Results: The most common MRI findings were disc desiccation (90%), disc bulge (74.7%), and osteophyte formation (61.3%). Males exhibited a significantly higher prevalence of facet joint arthropathy ($p = 0.041$) and osteophyte formation ($p = 0.049$). Age-wise analysis revealed that patients aged ≥40 years showed a significantly higher frequency of most degenerative features, including disc desiccation, Modic changes, and multi-level degeneration ($p < 0.001$ for each), while single-level involvement was more common in those under 40 years. This study showed that L4L5 and L5S1 are most commonly involved in LDDD.

Conclusion: MRI reveals a wide spectrum of degenerative changes in LDDD, with notable variations based on age and gender. These findings reinforce the role of MRI in early detection and stratification of degenerative spinal pathology, aiding in more tailored patient management.

Keywords- disc degeneration; low back pain; magnetic resonance imaging.

INTRODUCTION

The most prevalent cause of low back pain worldwide is lumbar degenerative disc diseases [1–3].Low back pain is the predominant symptom linked to musculoskeletal spinal disorders. Discogenic pain resulting from degeneration induces alterations in functional spinal motor instability. [4-7] Lumbar degenerative disc disease comprises many pathologies like disc degeneration, disc displacement, Modic changes, etc.[8]

Risk factors for lumbar degenerative disc disease encompass advancing age, socioeconomic status, torsional stress, smoking, obesity, heavy lifting, vibration, trauma, immobilisation, psychosocial factors, gender, height, hereditary influences, genetic predispositions, and occupations such as machine operators, carpenters, and office workers. The primary diagnostic instrument and imaging modality for assessing disc degeneration is magnetic resonance imaging (MRI) [9,10].

Recent studies have demonstrated the potential advantages of magnetic resonance imaging (MRI) as a diagnostic tool for low back pain (LBP). MRI is recommended as a crucial diagnostic tool for people with lower back pain. The safety and potential advantages of MRI-based diagnosis stem from its precise localisation and superior soft-tissue resolution for illustrating pathology in instances of lumbar disc degeneration. [11]

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Prior literature indicates that MRI is an effective tool for diagnosing degenerative disc disease (DDD), the predominant cause of lower back pain (LBP), and it can play a crucial role in formulating a preventive approach. Magnetic Resonance Imaging (MRI) is the preferred diagnostic method for identifying specific conditions in patients with potentially serious underlying issues (The Red Flags), such as malignancy, vertebral infection, severe or progressive neurological deficits, and other critical conditions, as outlined in the 2007 Guidelines by the American College of Physicians and the American Pain Society for the Diagnosis and Treatment of Low Back Pain. [12-17]

Various diagnostic modalities are employed for the assessment of low back pain, including conventional radiography, computed tomography (CT) scans, bone scans, and ultrasound. According to FDA standards, MRI provides distinct and enhanced information regarding bodily structures compared to standard X-ray, ultrasound, or CT imaging. MRI does not utilise ionising radiation, which refers to high-energy radiation capable of causing possible DNA damage, as seen in X-rays and CT scans. McNally et al [18] have demonstrated the advantages of MRI compared to traditional radiography in the assessment of LDD. Hence the present study was done to assess the spectrum of MRI image findings in lumbar degenerative disc disease in a tertiary care hospital of Eastern India.

MATERIAL AND METHODS: The present hospital based cross-sectional study was conducted at Department of Neurosurgery of NRS medical college, Kolkata during the study period of 1.5 year from July 2023 to December 2024. Ethical clearance was taken from institutional ethics committee of college and hospital and patients participating were asked to sign an informed consent form after explaining them the complete procedure of the study.

The sample size was determined using the equation

$N = (Z\alpha 2 * p(1-p)) / MOE$.

$Z\alpha/2$ represents the critical value of the normal distribution at $\alpha/2$ (at a 95% confidence level, α equals 0.05, yielding a critical value of 1.96), MOE denotes the margin of error, and p signifies the sample proportion. A finite population correction has been incorporated into the sample size formula. A previous study indicated that the prevalence of degenerative spinal stenosis in patients with low back pain (LBP) is 11%. Given this incidence, the sample size was determined to be 150.Patients were selected on the basis of inclusion and exclusion criteria

Inclusion criteria-

1. Patients above the age of 18 years.
2. Patients referred from clinicians suspecting degenerative disease of the lumbar spine and patients with a lumbar degenerative disease with bowel and bladder involvement.

Exclusion criteria

1. Patients with a history of acute trauma, surgical intervention infection, tumors and tumor-like condition.
2. Patients with MRI unsafe devices
3. Patients with ferromagnetic foreign bodies.
4. Patients having claustrophobia.

A pre-designed questionnaire was used to collect data. MRI was done using Siemen Magnetom-C 3 Tesla. A trained radiographer performed imaging. The scan consisted of sagittal, axial, and coronal T1-weighted, T2-weighted spin echo, and short tau inversion recovery sequences.

Each level from L1−S1 was assessed for disc degeneration, us ing the latest international nomenclature for describing disc pathology. The signal intensity changes of the disc in sagittal sections on T2-weighted images was graded using a scale from 0 to 3 where 0=homogeneous hyper-intense (white), 1=hyper-intense with visible intranuclear cleft (white with a dark band in the equator plane of the disc), 2=intermediate signal intensity (all colors between white and black), and 3=hypo-intense (dark disc without visible nuclear complex). Changes in the disc contour were described on a nominal scale: 0=normal, 1=bulge, 2=focal protrusion, 3=broad based protrusion, 4=extrusion, and 5=sequestration. Defects in end-plates were graded: 0=normal endplates, 1=defects and 2=large defects. Lum bar disc degeneration was diagnosed if there was either a signal intensity change (grade 2 or 3) or a change in disc contour (grade 2 or higher) at one or more lumbar levels. Those with normal signal intensity (grade 0 and 1); normal disc contour (grade 0 or 1), no annular tears, normal endplates and no other pathology in MRI were classified as subjects without disc degeneration [19,20]. Spondylolisthesis was measured and diagnosed by the method of Meyerding [21]. The anteroposterior (AP) di ameter of the superior surface of the lower vertebral body is divided into quarters and a grade of I–IV is assigned to slips of one, two, three or four quarters of the superior vertebra, but we could not divide our data according to the grades of spondylolisthesis; we simply noted whether spondylolisthesis was present. If not we labeled the patient as free from spondylolisthesis.

Data analysis was done using the Statistical Package for the Social Sciences version 25.0. Point estimate at 95% Confidence Interval was calculated along with frequency and proportion for the binary data and mean with standard deviation for continuous data.

RESULTS: The age of the participants ranged from 21 to 80 years. The majority of patients (70%) were in the age group of above 40 years.There was a male predominance in the study population (61.3%). The distribution of occupation indicated that manual laborers constituted the largest group (37.3%).Most patients hailed from rural and semi-urban areas of Eastern India. Most of the patients were low educated

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and belongs to lower middle class (31.3%) as shown in table 1.

Table 1: Sociodemographic data of patients

Variable	Category	Frequency (n)	Percentage (%)
Age Group (Years)	Below 40	45	30
	Above 40	105	70
Gender	Male	92	61.3
	Female	58	38.7
Occupation	Manual laborers	56	37.3
	Office workers	32	21.3
	Homemakers	28	18.7
	Retired personnel	18	12.0
	Students	10	6.7
	Unemployed	6	4.0
Area of Residence	Rural	69	46.0
	Semi-urban	49	32.7
	Urban	32	21.3
Educational Status	Illiterate	22	14.7
	Primary	41	27.3
	Secondary	43	28.7
	Higher Secondary	26	17.3
	Graduate and above	18	12.0
Socioeconomic Status (Modified BG Prasad scale)	Upper	7	4.7
	Upper middle	26	17.3
	Middle	44	29.3
	Lower middle	47	31.3
	Lower	26	17.3

Multiple findings were found in a single patient. The most common finding was disc desiccation, noted in 90% of patients (n = 135). Disc bulge was observed in 74.7% (n = 112), followed by disc prolapse or herniation in 52% (n = 78) of cases. Facet joint arthropathy, was present in 58.7% (n = 88), while osteophyte formation changes, was identified in 61.3% (n = 92) of patients. Modic changes, particularly of Type I and II, were seen in 40.7% (n = 61). Ligamentum flavum hypertrophy was present in 48.7% (n = 73), contributing to spinal canal stenosis, which was observed in 46% (n = 69) of the cohort. Additionally, foraminal stenosis was identified in 42.7% (n = 64). Annular tearswere found in 28% (n = 42) of cases. Spondylolisthesiswas present in 24% (n = 36). Less frequently observed were Schmorl's nodes (12.7%, n = 19) and endplate changes (35.3%, n = 53), indicating vertical disc herniation and endplate degeneration, respectively.Notably, multi-level disc degeneration was more prevalent (67.3%, n = 101) than single-level involvement (32.7%, n = 49) as shown in table 2. (FIGURE:1- 5)

Table 2: Degenerative MRI findings found in patients

MRI Finding	Frequency (n)	Percentage (%)
Disc Desiccation	135	90.0
Disc Bulge	112	74.7
Disc Prolapse / Herniation	78	52.0
Annular Tear	42	28.0
Modic Changes (Type I/II/III)	61	40.7
Facet Joint Arthropathy	88	58.7
Ligamentum Flavum Hypertrophy	73	48.7
Spinal Canal Stenosis	69	46.0
Foraminal Stenosis	64	42.7
Spondylolisthesis	36	24.0
Schmorl's Nodes	19	12.7
Osteophyte Formation	92	61.3
Endplate Changes	53	35.3
Multiple Level Degeneration	101	67.3
Single Level Degeneration	49	32.7

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Figure 1:L4L5 PIVD in Axial MRI

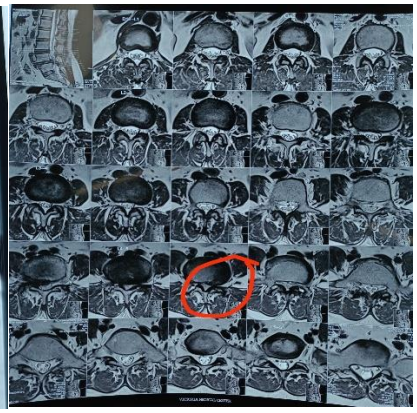

Figure 2:Facet Hypertrophy

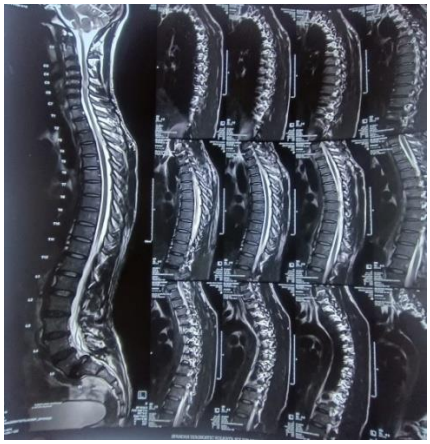

Figure 3: L5S1 anterolisthesis with sacralization

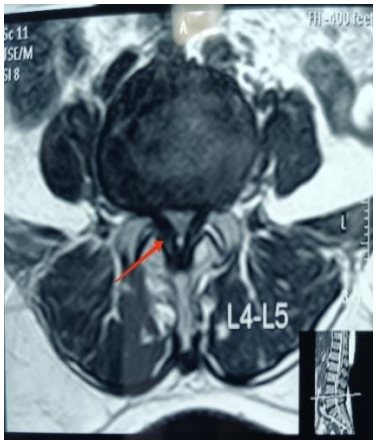

Figure 4: Ligamentum flavum hypertrophy at L4L5

Figure 5:Multi level lumber PVID

The distribution of MRI findings across the lumbar intervertebral disc levels (L1-L2, L2-L3, L3-L4, L4-L5, and L5-S1) across the study cohort. As anticipated, pathological alterations were primarily noted at the lower lumbar levels (L4-L5 and L5-S1), exhibiting increased occurrences of disc desiccation, bulging, herniation, Modic changes, facet joint arthropathy and spinal canal stenosis. Conversely, the upper lumbar levels (L1-L2 and L2-L3) demonstrated a reduced incidence of degenerative alterations, as indicated in Table 3.

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Table 3: Distribution of MRI imaging findings of patients according to disc level

MRI Finding	L1-L2 (n/%)	L2-L3 (n/%)	L3-L4 (n/%)	L4-L5 (n/%)	L5-S1 (n/%)	Total (n/%)
Disc Desiccation	8 (5.3%)	12 (8.0%)	30 (20.0%)	45 (30.0%)	40 (26.7%)	135 (90.0%)
Disc Bulge	5 (3.3%)	8 (5.3%)	24 (16.0%)	42 (28.0%)	33 (22.0%)	112 (74.7%)
Disc Prolapse / Herniation	2 (1.3%)	5 (3.3%)	18 (12.0%)	32 (21.3%)	21 (14.0%)	78 (52.0%)
Annular Tear	1 (0.7%)	3 (2.0%)	10 (6.7%)	18 (12.0%)	10 (6.7%)	42 (28.0%)
Modic Changes (Type I/II/III)	3 (2.0%)	6 (4.0%)	14 (9.3%)	22 (14.7%)	16 (10.7%)	61 (40.7%)
Facet Joint Arthropathy	6 (4.0%)	10 (6.7%)	20 (13.3%)	30 (20.0%)	22 (14.7%)	88 (58.7%)
Ligamentum Flavum Hypertrophy	4 (2.7%)	8 (5.3%)	18 (12.0%)	26 (17.3%)	17 (11.3%)	73 (48.7%)
Spinal Canal Stenosis	3 (2.0%)	7 (4.7%)	14 (9.3%)	27 (18.0%)	18 (12.0%)	69 (46.0%)
Foraminal Stenosis	3 (2.0%)	6 (4.0%)	12 (8.0%)	24 (16.0%)	19 (12.7%)	64 (42.7%)
Spondylolisthesis	1 (0.7%)	2 (1.3%)	6 (4.0%)	17 (11.3%)	10 (6.7%)	36 (24.0%)
Schmorl's Nodes	3 (2.0%)	4 (2.7%)	5 (3.3%)	4 (2.7%)	3 (2.0%)	19 (12.7%)
Osteophyte Formation	5 (3.3%)	8 (5.3%)	20 (13.3%)	34 (22.7%)	25 (16.7%)	92 (61.3%)
Endplate Changes	4 (2.7%)	6 (4.0%)	12 (8.0%)	18 (12.0%)	13 (8.7%)	53 (35.3%)
Multiple Level Degeneration	—	—	—	—	—	101 (67.3%)
Single Level Degeneration	—	—	—	—	—	49 (32.7%)

A markedly elevated prevalence of degenerative alterations was noted in patients aged 40 years and older. Disc desiccation was observed in all patients aged 40 years and older (100%), in contrast to 66.7% in those younger than 40 years ($p < 0.001$). Likewise, disc bulging was markedly more prevalent in the older age group (83.8%) compared to 53.3% in the younger group ($p < 0.001$). Findings including Modic changes, facet joint arthropathy, ligamentum flavum hypertrophy, spinal canal stenosis, and foraminal stenosis were significantly more common in patients aged 40 years and older ($p < 0.05$ for each). Disc prolapse/herniation was more prevalent in elderly persons (57.1% vs. 40.0%), although this difference lacked statistical significance ($p = 0.054$). Annular tears and spondylolisthesis were substantially more prevalent in the ≥40 age group ($p = 0.028$ and $p = 0.037$, respectively). Significantly, multiple level degeneration was observed in 77.1% of older patients, in contrast to 44.4% of younger patients ($p < 0.001$), where single level degeneration was more prevalent. In individuals under 40 (55.6%) ($p < 0.001$), findings, including Schmorl's nodes, exhibited no significant age-related difference ($p = 0.732$), as shown in table 4.

Table 4: Distribution of MRI imaging findings of patients according to age

MRI Finding	< 40 Years (n = 45)	≥ 40 Years (n = 105)	Total (n)	p-value
Disc Desiccation	30 (66.7%)	105 (100%)	135	**<0.001** *
Disc Bulge	24 (53.3%)	88 (83.8%)	112	**<0.001** *
Disc Prolapse / Herniation	18 (40.0%)	60 (57.1%)	78	0.054
Annular Tear	7 (15.6%)	35 (33.3%)	42	**0.028** *
Modic Changes	10 (22.2%)	51 (48.6%)	61	**0.003** *
Facet Joint Arthropathy	15 (33.3%)	73 (69.5%)	88	**<0.001** *
Ligamentum Flavum Hypertrophy	13 (28.9%)	60 (57.1%)	73	**0.002** *
Spinal Canal Stenosis	10 (22.2%)	59 (56.2%)	69	**<0.001** *
Foraminal Stenosis	11 (24.4%)	53 (50.5%)	64	**0.002** *
Spondylolisthesis	6 (13.3%)	30 (28.6%)	36	0.037 *
Schmorl's Nodes	5 (11.1%)	14 (13.3%)	19	0.732
Osteophyte Formation	20 (44.4%)	72 (68.6%)	92	**0.005** *
Endplate Changes	10 (22.2%)	43 (41.0%)	53	0.022 *
Multiple Level Degeneration	20 (44.4%)	81 (77.1%)	101	**<0.001** *
Single Level Degeneration	25 (55.6%)	24 (22.9%)	49	**<0.001***

Disc desiccation was the most prevalent degenerative change in both males (92.4%) and females (86.2%), with no statistically significant difference ($p = 0.214$). Similarly, disc bulge and disc herniation were common

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findings, noted in 79.3% and 56.5% of males, and 67.2% and 44.8% of females, respectively; however, these differences were not statistically significant ($p > 0.05$). A statistically significant association was observed with facet joint arthropathy, which was more prevalent in males (65.2%) compared to females (48.3%) ($p = 0.041$). Similarly, osteophyte formation showed a significant male predominance (67.4% vs. 51.7%, $p = 0.049$). Other findings such as ligamentum flavum hypertrophy, spinal canal stenosis, Modic changes, foraminal stenosis, and annular tears were observed more frequently in males, but the differences did not reach statistical significance ($p > 0.05$). Spondylolisthesis, Schmorl's nodes, and endplate changes also showed no significant gender association. Multi-level disc degeneration was more common than single-level involvement in both genders, with no significant difference observed ($p = 0.267$) as shown in table 5.

Table 5: Distribution of MRI imaging findings of patients according to gender

MRI Finding	Male (n=92)	Female (n=58)	Total (n)	p-value
Disc Desiccation	85 (92.4%)	50 (86.2%)	135	0.214
Disc Bulge	73 (79.3%)	39 (67.2%)	112	0.098
Disc Prolapse / Herniation	52 (56.5%)	26 (44.8%)	78	0.162
Annular Tear	29 (31.5%)	13 (22.4%)	42	0.229
Modic Changes	41 (44.6%)	20 (34.5%)	61	0.206
Facet Joint Arthropathy	60 (65.2%)	28 (48.3%)	88	0.041 *
Ligamentum Flavum Hypertrophy	50 (54.3%)	23 (39.7%)	73	0.078
Spinal Canal Stenosis	45 (48.9%)	24 (41.4%)	69	0.360
Foraminal Stenosis	43 (46.7%)	21 (36.2%)	64	0.202
Spondylolisthesis	20 (21.7%)	16 (27.6%)	36	0.402
Schmorl's Nodes	13 (14.1%)	6 (10.3%)	19	0.478
Osteophyte Formation	62 (67.4%)	30 (51.7%)	92	0.049 *
Endplate Changes	35 (38.0%)	18 (31.0%)	53	0.371
Multiple Level Degeneration	65 (70.7%)	36 (62.1%)	101	0.267
Single Level Degeneration	27 (29.3%)	22 (37.9%)	49	0.267

DISCUSSION

As life expectancy increases and people age, the incidence and concomitant clinical disabilities of disc degeneration illness are escalating. Lumbar disc degeneration is the predominant cause of low back pain worldwide, with disc herniation identified as a significant element of this degeneration. The contemporary advancement of MRI scans provides an exceptional noninvasive method for imaging the complete lumbar spine. The contrast, sensitivity, and multiplanar pictures elucidate the disc structure within or next to the spine.[22]

In our study the age of the participants ranged from 21 to 80 years. The majority of patients (70%) were in the age group of above 40 years.There was a male predominance in the study population (61.3%). The findings of this study align with other publications from Kenyaand Ethiopia indicating mean age groups afflicted by LBP of 40.9 ± 13.2 and 42.4 ± 13.22, respectively.[22,23] Numerous prior research have indicated a greater prevalence of lower back pain (LBP) in females; however, the discrepancies in the results might be ascribed to the quantity and nature of the tested populations.[24-26]

Magnetic Resonance Imaging (MRI) of the lumbar spine in the study cohort (N = 150) demonstrated a wide array of degenerative alterations. The predominant observation was disc desiccation, identified in 90% of patients, signifying extensive intervertebral disc dehydration and degeneration. Disc bulging was noted in 74.7% of cases, while disc prolapse or herniation occurred in 52%, indicating differing degrees of disc disease. Facet joint arthropathy, signifying degeneration of the posterior elements, was observed in 58.7%, whereas osteophyte development, denoting persistent degenerative alterations, was detected in 61.3% of patients. Modic changes, specifically Types I and II, were observed in 40.7%, indicating modifications in vertebral endplate and marrow signal intensity consistent with inflammatory and fibrotic processes.Hypertrophy of the ligamentum flavum was detected in 48.7%, contributing to spinal canal stenosis, which occurred in 46% of the group. Furthermore, foraminal stenosis was observed in 42.7%, frequently concomitant with disc and osseous alterations resulting in nerve root compression.Annular tears, seen as high-intensity regions on T2-weighted imaging, were identified in 28% of instances. Spondylolisthesis, characterised by spinal displacement resulting from instability, was observed in 24% of cases. Schmorl's nodes were found less frequently (12.7%), as were endplate alterations (35.3%), signifying vertical disc herniation and endplate degeneration, respectively.Multi-level disc degeneration was significantly more common (67.3%) than single-level involvement (32.7%), highlighting the widespread nature of lumbar degenerative disc disease in this population.These findings illustrate the intricate, multivariate characteristics of lumbar degeneration and emphasise the efficacy of MRI in defining the scope and form of

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spinal disease in affected individuals. Our results were similar to previous studies done in the past. [27-31]

In our study degenerative alterations were much more common and severe in persons aged 40 and older. Disc desiccation was observed in all older patients, in contrast to 66.7% of patients under 40 ($p < 0.001$). Likewise, disc bulge, facet arthropathy, Modic alterations, ligamentum flavum hypertrophy, spinal and foraminal stenosis, and osteophyte formation were markedly more prevalent in the age group of ≥40 years ($p < 0.05$).The disparity in prevalence between young and elderly individuals may be attributed to the ageing process.

Degenerative spine disease occurs when the typically elastic discs lose their integrity due to the ageing process, resulting in less protective capacity as the discs degrade. Our study corroborates this finding, indicating that the incidence of DDD is most prevalent among the elderly population. [32-34]

The correlation between gender and degenerative MRI findings in the lumbar spine was examined in a cohort of 150 individuals (92 men and 58 females). Although most degenerative characteristics were noted in both genders, many studies exhibited statistically significant gender-specific differences. In our study changes were more prevalent in male population as compared to females. Some previous studies more prevalence was seen in females which is contrary to our study.[35]

As our investigation was restricted to the centre, a multicentered study would have provided us with a more accurate interpretation. Additionally, causality and connection between the variables could not be established due to the descriptive study methodology.

CONCLUSION

MRI is an effective and safe technique for assessing lumbar spine diseases in patients. The lumbar discs frequently undergo degeneration resulting in herniation and stenosis, particularly at the L4-5 and L5-S1 levels, likely due to a combination of chronic degeneration and a diminished capacity of the disc to withstand applied load. All patients diagnosed with degenerative disc degeneration who exhibit low back pain accompanied by radiculopathy should receive an MRI test according to the literature. It is strongly recommended that MRI scans be conducted for patients suspected of disc herniation and nerve root compression, since this could facilitate early therapy of the condition.

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