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Original Article

Radiology Section

Correlation of Magnetic Resonance Imaging findings with Clinical Grading in Lumbar Disc Degeneration: A Cross-sectional Study

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ABSTRACT

Introduction: Low Back Pain (LBP) is the most common musculoskeletal symptom encountered on a daily basis in clinical practice and has a significant impact on healthcare resources. Magnetic Resonance Imaging (MRI) is the most sensitive tool for diagnosing spinal degenerative disease and has proven to be a standard imaging modality for its evaluation. Assessment of the correlation between clinical and radiological severity of lumbar disc degeneration will help in better management of the LBP patients.

Aim: To determine the correlation between the clinical and radiological severity of lumbar disc degeneration in non surgical LBP patients.

Materials and Methods: This observational, cross-sectional study was conducted at the Department of Radiology and Imaging, Sagar Hospitals, Bengaluru, Karnataka, India, from December 2019 to June 2021. A total of 90 patients with LBP who were referred for MRI evaluation were included. Modified Oswestry questionnaire was given to the patients and the clinical severity of the LBP was quantified. Patients with disc degeneration were evaluated on MRI based on six parameters viz., T2-signal intensity, Disc Extension Beyond Interface (DEBIT), annular fissure, modic changes, endplate integrity and osteophytes. Fisher's exact test was used for qualitative data to look into the association between clinical and MRI grades of severity. Correlation was assessed for continuous variables using Pearson correlation analysis.

Results: The study included a total of 90 patients with LBP, with a mean age of 57±13.75 years with equal sex preponderance (45 (50%) male and 45 (50%) female). Clinically, 51 (56.7%) of the study population revealed moderate disability. On quantifying the MRI total score of disc degeneration, 65 (72.3%) of the patients were found to show mild degeneration. In terms of involvement of all the evaluated six MRI parameters, the L4-L5 disc was most commonly affected, followed by the L5-S1 disc. Disc desiccation 353 (78.45%) and osteophytes 336 (74.67%) were the most consistently observed variations. Disc bulges 251 (55.78%) were the next most frequently observed parameter in disc degeneration.

Conclusion: The correlation between the clinical and radiological severity of disc degenerative disease was found to be weakly positive and statistically insignificant. Disc desiccation, osteophytes and disc bulges were the most commonly observed parameters that contributed to lumbar degenerative disease.

Keywords: Disc bulge, Lumbar degenerative disease, Osteophytes

INTRODUCTION

The LBP is one of the most common musculoskeletal symptoms encountered on a daily basis in clinical practice globally, and it affects all age groups with a peak incidence in the third decade of age [1]. It is noted that 75-84% of the general population experiences LBP at some point in their lifetime [2]. LBP is attributed to Intervertebral Disc Degeneration (IVDD) in the majority of LBP cases [3,4].

Advancing age, smoking, obesity, trauma, heavy weight lifting, height, and hereditary variables are the risk factors for lumbar disc degenerative disease. It is also associated with certain occupations such as machine drivers, carpenters, and office workers [5,6]. Ageing, axial disc loading, abnormal posturing, vascular in-growth, collagen and proteoglycan abnormalities are some biophysical factors that contribute to this degeneration [4]. Although the exact pathogenesis of IVDD is unknown, it is primarily caused by the decrease in water and extracellular matrix content in the nucleus pulposus, as well as the loss of collagen structure, which eventually leads to morphological and biomechanical changes [7]. Both the severity of IVDD and the prevalence of LBP increases with age, implying that IVDD may be the principal cause of LBP [8].

In evaluating imaging findings in the degenerative spine, a pathophysiology-based approach can precisely distinguish the process in the affected segment and recognise the pattern of degenerative changes and predict more such pathologies. Identifying subtle abnormalities based on indirect signs can assist clinicians in identifying the source of pain or neurological symptoms and to determine the best options for treatment [9]. MRI has proven to be a standard imaging modality for identifying and characterising intervertebral disc changes due to its multiplanar image acquisition capability, excellent soft tissue contrast, lack of radiation exposure and precise localisation of intervertebral disc changes [10].

Since LBP is extremely common, any change to the diagnostic and treatment approach has a significant impact on healthcare resources. Many research studies have been done using MRI to assess lumbar disc degeneration, with some attempting to quantify the same [5,11-24]. However, limited studies [18-24] are available that compare the clinical severity of LBP with the radiological severity of disc degeneration. Despite the fact that these studies used correlation analysis, they did not provide a comprehensive and quantitative measure of clinical pain severity and radiological degeneration severity.

Hence, the present study was conducted to assess and quantify lumbar disc degeneration using MRI, compare it with the clinical severity of LBP and also determine the correlation between them. To achieve the same, this study included a clinical questionnaire for LBP quantification and an MRI grading system for radiological quantification. Consequently, an assessment of the degree of correlation between these two factors helps clinicians decide the line of management for their patients at an early stage to avoid further complications.

MATERIALS AND METHODS

This observational cross-sectional study was conducted at the Department of Radiology and Imaging, Sagar Hospitals, Bengaluru, Karnataka, India, from December 2019 to June 2021. The study was approved by the institutional review board (ethical committee approval No. EC/NEW/INST/2021/1992). Written informed consent was obtained from the eligible patients to participate in the study.

Inclusion criteria: Patients aged 40 years and older, with a history of LBP, referred to the Department of Radiology and Imaging, for MRI scan were included in the study.

Exclusion criteria: Patients with a history of trauma, prior surgery, spinal infections, congenital abnormalities, spinal tumours and patients with absolute indications for spine surgery were excluded from the study.

Sample size: The sample size (n) was calculated using the following formula:

$$n=\frac{z^2pq}{d^2}$$

where, z is the test statistic (at 95% confidence level)=1.96; p (estimated prevalence of lumbar disc degeneration)=0.193 [25]; q=(1-p)=0.807 and d (precision taken/error margin)=10%=0.1.

Using this formula, the minimum sample size calculated was 60. For better inference, n=60+30 (50% of 60)=90 patients were included in this study. Consequently, the power of this pursued study turned out to be 80%. In 90 patients, a total of 450 discs were studied.

Data collection: The patients were provided with a Modified Oswestry LBP disability questionnaire, as it is demonstrated to provide superior measurement properties for assessing the severity of LBP [26]. The score for each patient is evaluated using the following formula:

Formula: {Patient's score/(number of sections completed×5)}×100=% of Disability

and is interpreted as follows [27]:

0%-20%: minimal disability-The patient can cope with most of daily activities.

21%-40%: moderate disability- The patient experiences more pain and difficulty with sitting, lifting and standing. Travel and social life are more difficult and they may be disabled from work. Personal care, employment/homemaking and sleeping are not grossly affected.

41%-60%: severe disability-Pain remains the main problem in this group but activities of daily living are affected.

61%-80%: crippled-Back pain impinges on all aspects of the patient's life.

81%-100%: These patients are either bed-bound or exaggerating their symptoms.

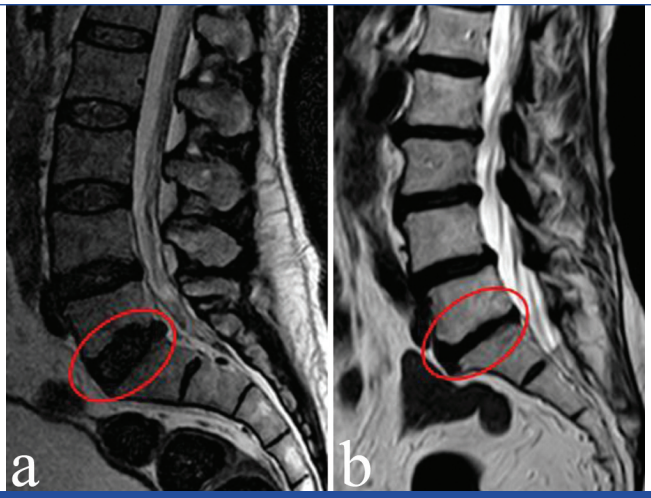
Radiological evaluation and quantification: Patients underwent MRI performed on Philips Achieva 1.5T 16-channel scanner. In all patients, sagittal (T1, T2 sequences), axial (T1, T2 sequences) and coronal (SPAIR (SPectral Attenuated Inversion Recovery) sequence) images were taken. All MRI data were reviewed using Philips extended window software with a 3 mm image thickness and a 0.4 mm slice gap. The MRI data of 5 lumbar discs (L1-L2, L2-L3, L3-L4, L4-L5 and L5-S1) were evaluated based on six parameters viz., T2-signal intensity (T2-SI), DEBIT, annular fissure, modic changes, endplate integrity and osteophytes which were assigned to each disc level and quantified by labeling the scores in the range 0-3 for each parameter [15]. The total score of disc degeneration on MRI at all levels was calculated with a minimum score of "0" upto a maximum score of "90" [Table/Fig-1]. The grading on MRI was done based on the total score [15]. The severity of lumbar disc degeneration on MRI is defined based on the following four grades viz., 1-23: Mild; 24-45: Moderate; 46-67: Severe and 68-90: Very severe.

Scores/Parameters	0	1	2	3
T2-signal intensity (T2-SI)	Normal	Intermediate loss	Marked loss	Absent signal
Disc Extension Beyond Interspace (DEBIT)	Intact	Bulge	Protrusion	Extrusion/ sequestration
Annular fissure	Intact	Concentric tear	Radial tears	Transverse tears
Modic changes	Normal	Type I	Type II	Type III
Endplate integrity	Intact	Isolated defects	Schmorl's node ≤5 mm	Schmorl's node >5 mm
Osteophytes	Absent	Marginal	Discontinuous	Continuous, Table osteophyte

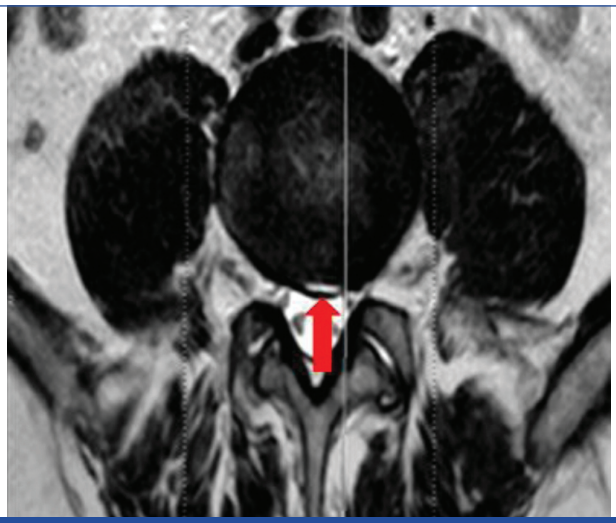
[Table/Fig-1]: MRI parameters and scores.

Categorisation of a disc as "Normal" means that the disc is fully and normally developed and free of any changes of disease, trauma, or ageing [28].

Disc desiccation and annular fissure: Loss of hydration results in desiccation of the nucleus pulposus and tears in the annulus fibrosus. Disc desiccation manifests as loss of T2 signal in the nucleus pulposus [Table/Fig-2a,b] [28]. Annular fissures are classified by their orientation. A "Concentric fissure" is a separation of annular fibers parallel to the peripheral contour of the disc [Table/Fig-3] [28]. A "Radial fissure" is a vertically, horizontally or obliquely oriented separation of annular fibres that extends from the nucleus peripherally to or through the annulus [28]. A "Transverse fissure" is a horizontally oriented radial fissure, limited to the peripheral annulus, that may include separation of annular fibres from the apophyseal bone [28]. Annular fissures are small areas of T2 hyperintensity in the posterior annulus fibrosus.

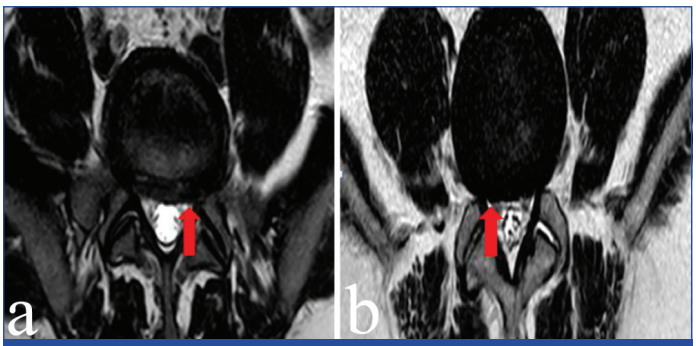


[Table/Fig-2]: Disc desiccation (score 1 and score 3).



[Table/Fig-3]: Annular fissure (score 1).

Disc Extension Beyond Interface (DEBIT): The term "Intact" means no disc material extends beyond the periphery of the disc space [28]. The term "Bulge" refers to a generalised extension of disc tissue beyond the edges of the apophyses. Such bulging involves greater than 25% of the circumference of the disc and typically extends a relatively short distance, usually <3 mm, beyond the edges of the apophyses [Table/Fig-4a] [28]. "Protrusion" is present if the greatest distance, in any plane, between the edges of the disc material beyond the disc space is less than the distance between the edges of the base, in the same plane. Disc protrusions are focal or localised abnormalities of the disc margin that involve less than 25% of the disc circumference [Table/Fig-4b] [28]. The "Base" is defined as the cross-sectional area of disc material at the outer margin of the disc space of origin, where disc material displaced beyond the disc space is continuous with disc material within the disc space. In the cranio-caudal direction, the length of the base cannot exceed, by definition, the height of the intervertebral space [28]. "Extrusion" is present when, in atleast one plane, any one distance between the edges of the disc material beyond the disc space is greater than the distance between the edges of the base, or when no continuity exists between the disc material beyond the disc space and that within the disc space [28]. Extrusion is further specified as "Sequestration", if the displaced disc material has lost continuity completely with the parent disc [28].



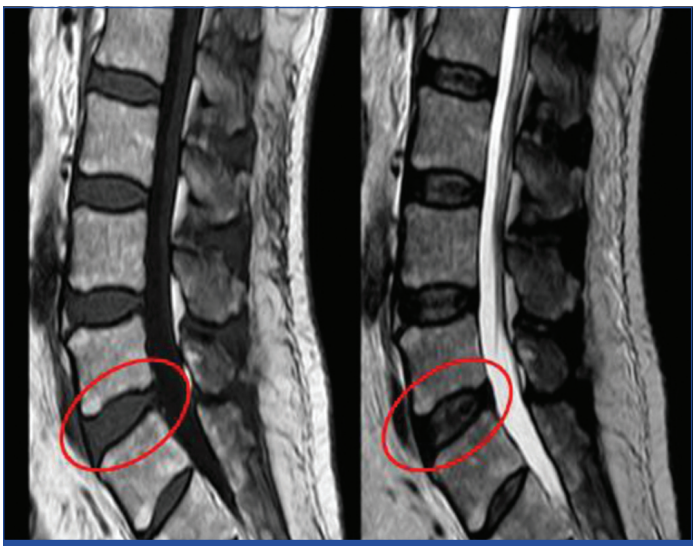
[Table/Fig-4]: Disc bulge (score1) and Protrusion (score 2).

Modic type changes: Modic changes represent vertebral body endplate changes on MRI. They were assessed using the original classification by Modic MT et al., which consists of three types [29]:

Type I: hypointense on T1 and hyperintense on T2 images;

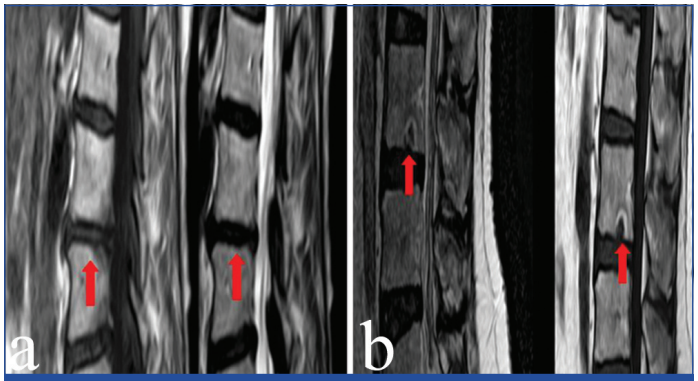
Type II: hyperintense on T1 and iso/hyperintense on T2 images [Table/Fig-5];

Type III: hypointense on both T1 and T2 images.



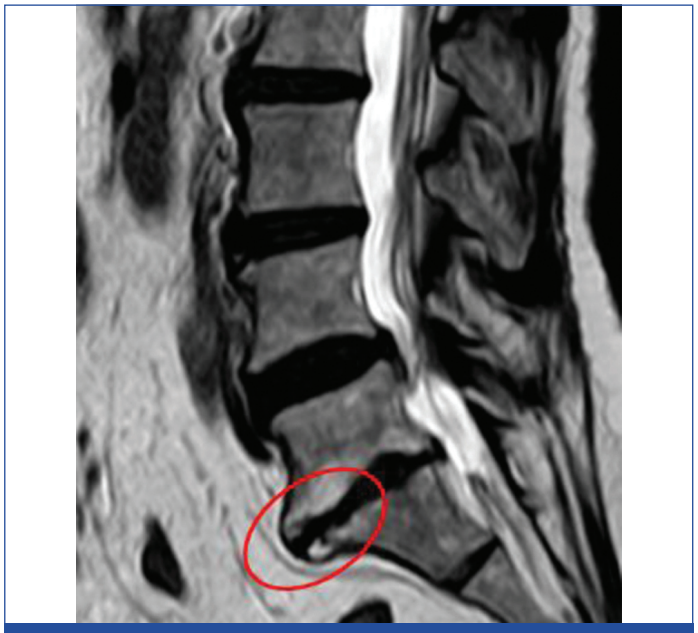
[Table/Fig-5]: Type II modic changes (score 2).

Endplate changes: Vertebral endplate changes might be "Isolated defects" (non specific/non Schmorl's nodes- [Table/Fig-6a]) or Schmorl's nodes. "Schmorl's nodes" have been described as a disc displacement in which a portion of the disc projects through the vertebral endplate into the centrum of the vertebral body [Table/Fig-6b] [28].



[Table/Fig-6]: Isolated endplate defects (score 1) and Schmorl's nodes (score 3).

Osteophytes: They are focal hypertrophy of the bone surface and/or ossification of the soft tissue attachment to the bone. "Marginal osteophytes" are defined as osteophytes that protrude from and beyond the outer perimeter of the vertebral endplate apophysis [Table/Fig-7] [28]. "Discontinuous osteophytes" are considered as non marginal osteophytes that occur at sites other than the vertebral endplate apophysis [28]. "Continuous, table osteophytes" are considered as bridging osteophytes that form a bony bridge between two vertebrae.



[Table/Fig-7]: Marginal osteophytes (score 1).

STATISTICAL ANALYSIS

Data obtained was entered in Microsoft Excel and analysed using IBM Statistical Package for the Social Sciences (SPSS) software for Windows, version 21.0. Appropriate statistical analysis has been done using the mean, standard deviation and percentages. Fisher's-exact test was used for the qualitative data to look into the association between different parameters and grades. A p-value of ≤0.05 was considered statistically significant. Pearson correlation analysis was used to assess correlation for the continuous variables involved. A correlation coefficient of zero indicates that no linear relationship exists between two continuous variables and a correlation coefficient of -1 or+1 indicates a perfect linear relationship [30].

RESULTS

The study included a total of 90 patients with LBP, with a mean age of 57±13.75 years with equal sex preponderance {45 (50%) male and 45 (50%) female}. There were 24 (26.7%) patients with minimal

disability, 51 (56.7%) with moderate disability, 9 (10%) with severe disability and 6 (6.6%) patients with crippled disability. Majority of the patients were having moderate disability with a mean score of 29.29±6.39 [Table/Fig-8].

Grading	Mean±SD scores	n (%)
Minimal disability	15.75±5.34	24 (26.7)
Moderate disability	29.29±6.39	51 (56.7)
Severe disability	50.22±4.52	9 (10.0)
Crippled	70.33±6.37	6 (6.6)
Total	-	90 (100.0)

[Table/Fig-8]: Clinical grading of severity.

Degenerative changes in the L1-L2 disc were mainly due to disc desiccation (T2-SI changes) and osteophytes. Degenerative changes in the L2-L3 disc were also due to disc desiccation (T2-SI changes) and osteophytes with a slight increase in incidence of disc bulge (DEBIT). Degenerative changes in the L3-L4, L4-L5 and L5-S1 discs were generally due to disc desiccation, DEBIT and osteophytes. Out of the total 450 discs evaluated, 353 (78.45%) discs showed disc desiccation, 336 (74.67%) levels revealed osteophytes, 251 (55.78%) discs exhibited disc bulges/protrusions, 66 (14.67%) discs revealed endplate integrity changes, 44 (9.78%) discs had modic changes and only 10 (2.23%) discs showed annular fissure [Table/Fig-9].

The mean changes in T2-SI and modic changes show an increasing trend from upper to lower lumbar levels. The mean score of endplate integrity remains almost constant from L2-L3 to L4-L5 levels. However, the mean score of osteophytes and DEBIT increases from L1-L2 to L4-L5 level and slightly decreases at L5-S1 level. T2-SI and modic changes have the highest mean score at the L5-S1 level; osteophytes, DEBIT and annular fissure have their highest mean score at the L4-L5 level and endplate integrity changes has its highest mean score at the L3-L4 level. Variations in standard deviation are most often seen in T2-SI and DEBIT, indicating that these parameters contribute more to the degenerative process [Table/Fig-10].

The patients with mild and moderate disc degenerative changes on MRI are shown in [Table/Fig-11].

Comparison between the clinical grades and corresponding MRI grades of patients is shown in [Table/Fig-12]. None of the patients revealed severe or very severe grades of disc degeneration on MRI.

According to Fisher's-exact test, the p-value was estimated as 0.4. Further, it was found that Pearson's probability was (denoted as P) <0.01, and Pearson's correlation coefficient value (denoted as r) of the involved grades and parameters was found to be 0.396. Statistical analysis thus revealed that there was a low positive correlation between the clinical severity of LBP and the MRI severity of disc degeneration, with a statistically insignificant association at the 5% level of significance, and the same is justified through the scatter diagram displayed in [Table/Fig-13].

	L1-2 level				L2-3 level				L3-4 level				L4-5 level				L5-S1 level			
Scores	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
T2- SI	36 (8%)	23 (5%)	15 (3%)	16 (4%)	32 (7%)	26 (6%)	13 (3%)	19 (4%)	16 (3%)	24 (5%)	26 (6%)	24 (5%)	6 (1%)	24 (5%)	28 (6%)	32 (7%)	7 (1%)	22 (5%)	26 (6%)	35 (8%)
DEBIT	80 (18%)	8 (2%)	2 (0.4%)	0	68 (15%)	17 (4%)	5 (1%)	0	33 (7%)	49 (11%)	8 (2%)	0	2 (0.4%)	69 (15%)	19 (4%)	0	16 (3%)	58 (13%)	16 (4%)	0
Annular fissure	90 (20%)	0	0	0	89 (20%)	1 (0.2%)	0	0	90 (20%)	0	0	0	84 (19%)	6 (1%)	0	0	87 (19%)	3 (0.6%)	0	0
Modic changes	88 (19%)	0	1 (0.2%)	1 (0.2%)	86 (19%)	1 (0.2%)	3 (0.6%)	0	80 (18%)	2 (0.4%)	8 (2%)	0	77 (17%)	2 (0.4%)	11 (2%)	0	75 (17%)	4 (0.9%)	10 (2%)	1 (0.2%)
Endplate integrity	82 (18%)	1 (0.2%)	3 (0.6%)	4 (1%)	76 (17%)	5 (1%)	3 (0.6%)	6 (1%)	75 (17%)	6 (1%)	3 (0.6%)	6 (1%)	77 (17%)	4 (1%)	3 (0.6%)	6 (1%)	74 (16%)	13 (3%)	3 (0.6%)	0
Osteo phytes	52 (11%)	38 (8%)	0	0	36 (8%)	54 (12%)	0	0	12 (3%)	77 (17%)	1 (0.2%)	0	5 (1%)	83 (19%)	2 (0.4%)	0	9 (2%)	81 (18%)	0	0

[Table/Fig-9]: MRI evaluation score of degeneration at all lumbar disc levels.
*Percentages mentioned inside the brackets are approximate

Disc levels/Parameters		L1-2	L2 -3	L3-4	L4-5	L5-S1
T2-SI	Mean±SD scores	1.12±1.13	1.21±1.14	1.64±1.06	1.96±0.94	1.99±0.97
DEBIT	Mean±SD scores	0.16±0.49	0.3±0.57	0.77±0.7	1.23±0.52	1.16±0.8
Annular fissure	Mean±SD scores	0	0.01±0.1	0	0.07±0.25	0.03±0.81
Modic changes	Mean±SD scores	0.06±0.37	0.08±0.37	0.2±0.58	0.27±0.66	0.3±0.71
Endplate integrity	Mean±SD scores	0.21±0.71	0.32±0.83	0.33±0.83	0.31±0.83	0.21±0.48
Osteophytes	Mean±SD scores	0.42±0.49	0.6±0.49	0.88±0.36	0.97±0.27	0.9±0.3

[Table/Fig-10]: Mean score and Standard Deviation (SD) of the parameters on MRI at all lumbar disc levels.
*In some cells SD is more than mean because of the skewed distribution of data

Grading	Mean±SD scores	n (%)
Mild	14.47±5.11	65 (72.3)
Moderate	28.85±4.68	25 (27.7)
Severe	0	0
Very severe	0	0

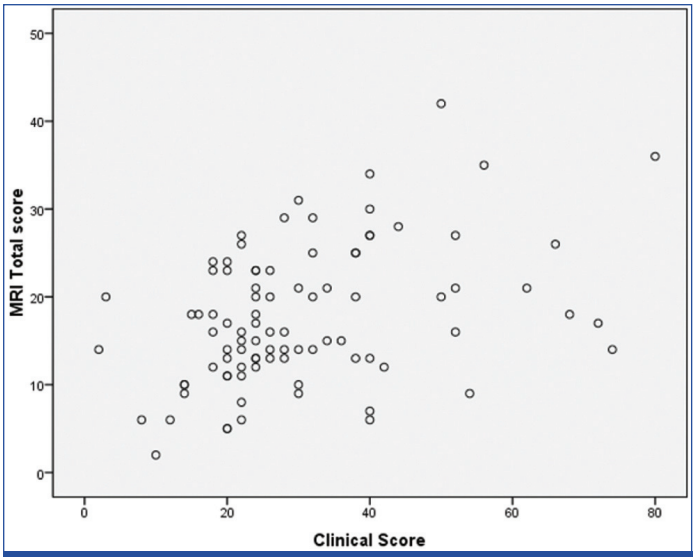
[Table/Fig-11]: MRI total score grading.

Clinical grading of severity	MRI Grading based on total score		Total n (%)	p-value*
	Mild n (%)	Moderate n (%)		
Minimal disability	20 (22.3)	4 (4.4)	24 (26.7)	0.4
Moderate disability	36 (40)	15 (16.7)	51 (56.7)	
Severe disability	5 (5.6)	4 (4.4)	9 (10)	
Crippled	4 (4.4)	2 (2.2)	6 (6.6)	
Total	65 (72.3)	25 (27.7)	90 (100)	

[Table/Fig-12]: Comparison of clinical grading and MRI Total Score grading.
*Fisher-exact test: p-value <0.05 was considered statistically significant, p-value >0.05 was considered statistically insignificant

DISCUSSION

The LBP is an exceedingly common problem that needs to be addressed thoroughly. In this study, the majority, 51 (56.7%) of the patients with LBP had moderate disability clinically. The most commonly affected lumbar levels in this study were found to be L4-L5 and L5-S1. The lumbar spine, particularly at the L4-L5 and



[Table/Fig-13]: Scatter plots showing correlations between clinical and MRI total score.
Pearson's correlation coefficient r=0.396 and Pearson's probability p<0.01

L5-S1 levels, was subjected to more mechanical stress than any other part of the spine, making it more susceptible to degenerative changes. Saleem S et al., conducted a study using MRI on 163 LBP patients and inferred that L4-L5 (64.4%) and L5-S1 (46.6%) levels were most commonly involved in disc degeneration [6]. In a similar study conducted on 165 LBP patients by Kushwah APS et al., it was also inferred that L4-L5 (42%) and L5-S1 (28%) levels were most commonly involved [19]. Further, in an independent study conducted on 109 patients by Suthar P et al., it was inferred that the L4-L5 (42%) level was most commonly involved in degeneration [5]. Similar results were obtained in the studies conducted on 40 patients and 100 patients by Osman N et al., and Rai GS et al., respectively [11,20]. The corresponding results of the present study reveal that the findings were consistent with the aforementioned studies.

Another significant finding of the present study was that the multiplicity of disc level involvement was more common than single disc involvement. This was in agreement with the independent studies conducted on 109, 100, 100 and 588 patients by Suthar P et al., TV Kishan et al., Rai GS et al. and Takatalo J et al., respectively [5,10,20,31].

Disc desiccation (78.45%) was the most common observed MRI parameter in the present study, in which absent T2 signal was more common (28%). Furthermore, intermediate T2 signal loss was more common at upper lumbar levels, while absent T2 signal was more common at lower lumbar levels. Clinicoradiological studies performed on 165 and 100 patients by Kushwah APS et al., and Rai GS et al., respectively, reveal that disc desiccation (83% and 93%, respectively) was the most commonly observed parameter [19,20].

Osteophytes (74.67%) was the next most common finding observed in the present study, in which marginal osteophytes (74%) were more common and more frequent at lower lumbar levels.

Following the above-mentioned MRI parameters, DEBIT (55.78%) has been found to be the next commonly observed parameter, with disc bulge (45%) being more common compared to protrusion (11.4%). DEBIT was more prevalent at the L4-L5 level, followed by the L5-S1. Raju P et al., conducted a study on 50 patients and found that disc bulge was common at L4-L5 level, followed by L5-S1 [32]. A similar study conducted on 100 patients by Kishan TV et al., also revealed the same results [10]. The studies conducted on 40 and 200 patients by Osman N et al., and De C et al., respectively, found that disc bulge (33.6% and 75%, respectively) was more common at L4-L5 level [11,33]. Angam SS et al., conducted a study on 192 patients and found that disc bulge (85%) was more common compared to protrusion and was mostly seen at L4-L5 level (36.7%), followed by L5-S1 (26%) level [34]. Extrusion or sequestration were not found in this study as they require surgical intervention, and this study only included non surgical patients.

Endplate integrity changes (14.67%) was the next prominent parameter observed in the present study, with isolated defects (6.1%) being the most common, followed by Schmorl's nodes of >5 mm (4%). Isolated defects were common at the L5-S1 level, whereas Schmorl's nodes were common at the L3-L4 level. This is consistent with the studies conducted on 516 and 180 patients by Lee SL and Jin W and Abbas J et al., respectively, where Schmorl's nodes were found to be more common at L3-L4 level (24.9% and 30%, respectively) [35,36].

In this study, 9.78% of the disc levels revealed modic changes. It was observed that type 2 modic changes (7%) were more common than type 1 modic changes (2%). This was in accordance with the clinicoradiological correlation study in LBP patients by Kushwah APS et al., [19]. Further, Modic MT et al., have shown that type 2 is the most frequent compared to other modic changes [29]. Percentage of involvement of all six parameters evaluated on MRI across different scores at all lumbar levels are mentioned in [Table/Fig-9]. In the present study, it was also found that type 2 modic changes were predominantly found at the L4-L5 and L5-S1 levels, which was consistent with the finding in a study conducted by Teichtahl AJ et al., [37].

Annular fissure was the least commonly found parameter in the study, with concentric tears (2%) being the only finding observed, commonly at L4-L5 level. This was in conformity with a study conducted by Kishan TV et al., where it was found that annular fissure was commonly observed at the L4-L5 level (33.33%) [10]. Comparison of the findings of present study with contrast studies are shown in [Table/Fig-14] [5,6,10,11,19,20,29,31-37].

S. No.	Authors name (ref no.)	Place and year of the study	Sample size	Findings	Remark
1.	Present study	Bangalore, India December 2019-June 2021	90	L4-L5 and L5-S1 levels are more susceptible to degeneration. Multiplicity of disc level involvement is more common than single disc involvement. Disc desiccation was the most commonly observed variation. Marginal osteophytes were the next most common finding observed in this study and were more common at lower lumbar levels. Disc bulge was more common compared to protrusion and was more prevalent at L4-L5, followed by L5-S1 level. Type 2 modic changes followed by type 1 were common and found mostly at the L4-L5 and L5-S1 levels. Isolated defects were more common than Schmorl's nodes of > 5 mm. Isolated defects were common at the L5-S1 level, whereas Schmorl's nodes were common at L3-L4 level. Annular fissure was least commonly found in the study, with concentric tears being the only finding observed, commonly at L4-L5 level. There is a low positive correlation between the clinical severity of LBP and the MRI severity of disc degeneration, with a statistically insignificant association at 5% level of significance.	The present study involved quantification of clinical severity and MRI severity of disc degeneration. Correlation between clinical and MRI grades was also determined. All parameters responsible for disc degenerative disease were evaluated.

2.	Suthar P et al., [5]	Vadodara, Gujarat, India 2013	109	L4-L5 (38.59%) level was most commonly involved in degeneration. Multiplicity of disc level involvement is more common than single disc involvement. Disc desiccation was the most commonly observed variation.	No quantitative clinical correlation and no quantification of MRI severity of lumbar degenerative disease.
3.	Saleem S et al., [6]	Karachi, Pakistan January 2012-June 2012.	163	L4-L5 (64.4%) and L5-S1 (46.6%) levels are the most common levels involved in degeneration.	Qualitative correlation of symptoms with MRI findings only. No quantification of the severity of degeneration.
4.	Kishan TV et al., [10]	Nalgonda, Telangana, India 1st April 2017 to 1st August 2017	100	Multiplicity of disc level involvement was more common than single disc involvement. Annular fissure was most commonly involved at L4-L5 level (33.33%). Disc desiccation was the most commonly observed variation. Disc bulge was most common and prevalent at L4-L5, followed by L5-S1 level.	No clinical correlation. No quantification of MRI severity of lumbar degenerative disease.
5.	Osman N et al., [11]	Cairo, Egypt 1st April to 31st May 2017	40	L4-L5 level was most commonly involved in degeneration. The most common site for disc bulges was L4-L5 level (33.6%).	Relatively low sample size. No clinical correlation. No quantification of MRI severity of lumbar degenerative disease.
6.	Kushwah APS et al., [19]	Jabalpur, Madhya Pradesh, India. March 2017-August 2018.	165	L4-L5 (42%) and L5-S1 (28%) levels are more susceptible to degeneration. Disc desiccation was the most commonly observed variation (83%). Type 2 followed by type 1 modic changes were common.	No clinical assessment was done to characterise the severity of LBP. No quantification of MRI severity of lumbar degenerative disease.
7.	Rai GS et al., [20]	Bhopal, Madhya Pradesh, India April 2013-April 2015	100	L4-L5 and L5-S1 levels are more susceptible to degeneration. Multiplicity of disc level involvement was more common than single disc involvement. Disc desiccation (93%) was the most commonly observed variation.	Clinical test concentrates only on disc herniation and radiculopathy. Exclusive non surgical cases are not considered as surgical cases could cause bias in interpretation of LBP severity. No quantification of MRI severity of lumbar degenerative disease.
8.	Modic MT et al., [29]	Cleveland, USA 1987	474	Type 2 followed by type 1 modic changes were common and mostly at the L4-L5 and L5-S1 levels.	Study involved evaluation of modic changes only.
9.	Takatalo J et al., [31]	Northern Finland 2005-2006 and 2008	588	Multiplicity of disc level involvement is more common than single disc involvement.	Diverse age groups are not included in the study. No quantification of MRI severity of lumbar degenerative disease.
10.	Raju P et al., [32]	Siddipet, Telangana, India January 2019-December 2019	50	Disc bulge (60%) was more common compared to protrusion and was more prevalent at L4-L5, followed by L5-S1 level.	Relatively low sample size and also no clinical correlation. No quantification of MRI severity of lumbar degenerative disease.
11.	De C et al., [33]	Bardhaman, West Bengal, India January 2014-June 2015	200	Disc bulge (75%) was more commonly observed compared to protrusion.	Study found positive correlation with severe degree of disc degeneration. No quantification of MRI severity of lumbar degenerative disease.
12.	Angam SS et al., [34]	Warangal, Telangana, India December 2015-November 2016.	192	Disc bulge (85%) was more common compared to protrusion and was more prevalent at L4-L5 (36.7%), followed by L5-S1 (26%) level.	No quantification of clinical correlation. No quantification of MRI severity of lumbar degenerative disease.
13.	Lee SL and Jin W [35]	Kyunggi, Korea May1995-September, 1996	516	Schmorl's nodes were common at L3-L4 level (24.9%).	Study involved evaluation of Schomrl's nodes only.
14.	Abbas J et al., [36]	Haifa, Israel 2018	180	Schmorl's nodes were common at L3-L4 level (30%).	Study was done using Computed Tomography. Study involved evaluation of Schomrl's nodes only.
15.	Teichtahl AJ et al., [37]	Australia 2006-2008 and 2012	72	Type 2 followed by type 1 modic changes were common and mostly at the L4-L5 and L5-S1 levels.	Study involved evaluation of modic changes only.

[Table/Fig-14]: Summary of relevant previous studies that have correlations with the present observations [5,6,10,11,19,20,29,31-37].

Based on the analysis of the mean scores of the parameters, it was seen that T2-SI and modic changes were more commonly observed and severely affected at the L5-S1 level; osteophytes, DEBIT and annular fissure at the L4-L5 level and endplate integrity changes at the L3-L4 level. The mean and standard deviation of T2-SI alterations were found to be higher than other parameters, indicating the changes in T2-SI were most affected by disc degeneration. The mean of DEBIT was lower than osteophytes, but the range of the standard deviation was larger for DEBIT. This implies that osteophytes are more common, but the types of osteophytes observed are nearly identical, and DEBIT exhibits wide variations at all disc levels, indicating that DEBIT is more attributable to disc degeneration.

Limitation(s)

The current study involves only non surgical LBP patients without any discussion on demographic factors like height, weight, which are known to influence the degenerative process. In this work, the focus of the study was only on the disc related pathologies of lumbar degenerative disease. The other components that are also responsible for LBP such as facetal arthrosis, spondylolisthesis were not considered in this study.

CONCLUSION(S)

The study results revealed a low positive correlation between the clinical severity of LBP and the radiological severity of disc degeneration, with a statistically insignificant association. Disc desiccation was the most consistently observed variation, followed by osteophytes. Disc bulges revealed wide variations, making it more attributable to disc degeneration compared to osteophytes. The evaluated parameters on MRI exhibited an increasing trend in severity from upper to lower lumbar levels. Clinical objective tests can be performed for a better and more accurate quantification of the clinical severity of LBP. The influence of the demographic features on MRI parameters can be studied individually to explore their impact on disc degeneration. Other disease processes involving lumbar disc degeneration can also be quantified methodically and correlated with various clinical symptoms to identify the disease processes responsible for specific symptoms. Further complications of disc degeneration can also be predicted.

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REFERENCES

[1] Ganesan S, Acharya AS, Chauhan R, Acharya S. Prevalence and risk factors for low back pain in 1,355 young adults: A cross-sectional study. Asian Spine J. 2017;11(4):610-17.
[2] Ramdas J, Jella V. Prevalence and risk factors of low back pain. Int J Adv Med. 2018;5:1120-23.
[3] DePalma MJ, Ketchum JM, Saullo T. What is the source of chronic low back pain and does age play a role? Pain Medicine (Malden, Mass.). 2011;12(2):224-233.
[4] Gaikwad SP, Rote-Kaginalkar V, Badarkhe-Patil P. Magnetic resonance imaging lumbo sacral spine in assessment of low back pain in young adults. Int J Sci Stud. 2016;4(1):25-31.
[5] Suthar P, Patel R, Mehta C, Patel N. MRI evaluation of lumbar disc degenerative disease. J Clin Diag Res. 2015;9(4):TC04-TC9.
[6] Saleem S, Aslam HM, Rehmani MA, Raees A, Alvi AA, Ashraf J. Lumbar disc degenerative disease: Disc degeneration symptoms and magnetic resonance image findings. Asian Spine J. 2013;7(4):322-34.
[7] Ying J, Han Z, Zeng Y, Du Y, Pei S, Su L, et al. Evaluation of intervertebral disc regeneration with injection of mesenchymal stem cells encapsulated in PEGDA-microcryogel delivery system using quantitative T2 mapping: A study in canines. Am J Transl Res. 2019;11(4):2028-41.
[8] Xiong X, Zhou Z, Figini M, Shangguan J, Zhang Z, Chen W. Multi-parameter evaluation of lumbar intervertebral disc degeneration using quantitative magnetic resonance imaging techniques. Am J Transl Res. 2018;10(2):444-54.
[9] Kushchayev SV, Glushko T, Jarraya M, Schuleri KH, Preul MC, Brooks ML, et al. ABCs of the degenerative spine. Insights Imaging. 2018;9:253-74.
[10] Kishan TV, Kisara S, Mounika S, Anusha R, Putta R. Role of MRI in identification, characterization and assessing the sequelae of lumbar disc degenerative changes. MedPulse-International Journal of Radiology. 2018;6(1):01-05.
[11] Osman N, Fawzy F, Lateef H. MRI evaluation of lumbar disc degenerative disease. The Egyptian Journal of Hospital Medicine, 2017;68(2):1202-07.
[12] Beattie PF, Meyers SP, Stratford P, Millard RW, Hollenberg GM. Associations between patient report of symptoms and anatomic impairment visible on lumbar magnetic resonance imaging. Spine (Phila Pa 1976). 2000;25(7):819-28.
[13] Kim BS, Park CH, Lee JH, Chung SG, Park SJ. MRI-based morphological parameters to quantify lumbar disc degeneration. Annals of Physical and Rehabilitation Medicine. 2018;61:e159.
[14] Bechara BP, Agarwal V, Boardman J, Perera S, Weiner DK, Vo N, et al. Correlation of pain with objective quantification of magnetic resonance images in older adults with chronic low back pain. Spine (Phila Pa 1976). 2014;39(6):469-75.
[15] Benneker LM, Heini PF, Anderson SE, Alini M, Ito K. Correlation of radiographic and MRI parameters to morphological and biochemical assessment of intervertebral disc degeneration. Eur Spine J. 2005;14(1):27-35.
[16] Brinjikji W, Diehn FE, Jarvik JG, Carr CM, Kallmes DF, Murad MH, et al. MRI findings of disc degeneration are more prevalent in adults with low back pain than in asymptomatic controls: A systematic review and meta-analysis. AJNR Am J Neuroradiol. 2015;36(12):2394-99.
[17] Brinjikji W, Luetmer PH, Comstock B, Bresnahan BW, Chen LE, Deyo RA, et al. Systematic literature review of imaging features of spinal degeneration in asymptomatic populations. AJNR Am J Neuroradiol. 2015;36(4):811-16.
[18] Chou D, Samartzis D, Bellabarba C, Patel A, Luk KD, Kisser JM, et al. Degenerative magnetic resonance imaging changes in patients with chronic low back pain: A systematic review. Spine (Phila Pa 1976). 2011;36(21 Suppl):S43-53.
[19] Kushwah APS, Bharti RA, Pande S, Lokwani M, Kumar S. Magnetic resonance imaging evaluation of lumbar degenerative disc disease with clinical correlation. Int J Sci Stud. 2018;6(8):165-73.
[20] Rai GS, Mehra A, Gaur TNS. A prospective study of magnetic resonance imaging findings in patients of chronic low back pain: A clinico-radiological correlation. Int J Res Med Sci. 2016;4:47-56.
[21] Jain S, Kumar S. Correlation between clinical features and magnetic resonance imaging findings in lumbar disc prolapse. Indian J Orthop. 2011;45(2):105.
[22] Hicks GE, Morone N, Weiner DK. Degenerative lumbar disc and facet disease in older adults: Prevalence and clinical correlates. Spine (Phila Pa 1976). 2009;34(12):1301-06.
[23] Bertilson BC, Brosjö E, Billing H, Strender LE. Assessment of nerve involvement in the lumbar spine: Agreement between magnetic resonance imaging, physical examination and pain drawing findings. BMC Musculoskeletal Disorders. 2010;11:202.
[24] Sirvanci M, Bhatia M, Ganiyusufoglu KA, Duran C, Tezer M, Ozturk C, et al. Degenerative lumbar spinal stenosis: Correlation with Oswestry disability index and MR imaging. European Spine Journal. 2008;17(5):679-85.
[25] Saxena AK, Jain PN, Bhatnagar S. The prevalence of chronic pain among adults in India. Indian J Palliat Care. 2018;24(4):472-77.
[26] Fritz JM, Irrgang JJ. A comparison of a modified Oswestry low back pain disability questionnaire and the Quebec back pain disability scale. Phys Ther. 2001;81(2):776-88.
[27] Fairbank JC, Pynsent PB. The Oswestry disability index. Spine 2000;25(22):2940-52.
[28] Fardon DF, Williams AL, Dohring EJ, Murtagh FR, Gabriel Rothman SL, Sze GK. Lumbar disc nomenclature: version 2.0: Recommendations of the combined task forces of the North American Spine Society, the American Society of Spine Radiology, and the American Society of Neuroradiology. Spine (Phila Pa 1976). 2014;39(24):E1448-65.
[29] Modic MT, Steinberg PM, Ross JS, Masaryk TJ, Carter JR. Degenerative disk disease: Assessment of changes in vertebral body marrow with MR imaging. Radiology. 1988;166(1 Pt 1):193-99.
[30] Mukaka MM. Statistics corner: A guide to appropriate use of correlation coefficient in medical research. Malawi Med J. 2012;24(3):69-71.
[31] Takatalo J, Karppinen J, Niinimäki J, Taimela S, Näyhä S, Järvelin MR, et al. Prevalence of degenerative imaging findings in lumbar magnetic resonance imaging among young adults. Spine. 2009;34(16):1716-21.
[32] Raju P, Patruni M, Baddam SR. Study to evaluate non traumatic low backache using magnetic resonance imaging, in a tertiary care centre, Siddipet District, Telangana state. Int J Radiol Diagn Imaging. 2020;3(1):192-94.
[33] De C, Ray MK, Chatterjee B, Duttaroy S, Ghosh PK, De C. Correlation between clinical and imaging finding of symptomatic degenerative lumbar spine disease. Saudi J Sports Med 2018;18:79-84.
[34] Angam SS, Ahmed N, Thakkallapelli S, Chouhan S, Routhu M, Babu J. Spectrum and prevalence of degenerative changes seen on MRI of lumbosacral spine in patients with low back pain. IOSR Journal of Dental and Medical Sciences. 2017;16:41-47.
[35] Lee SL, Jin W. MR Imaging of Schmorl's nodes and several factors influencing enhancement of Schmorl's nodes. Rivista di Neuroradiologia. 1999;12(2_suppl):191-92.
[36] Abbas J, Hamoud K, Peled N, Hershkovitz I. Lumbar Schmorl's nodes and their correlation with spine configuration and degeneration. BioMed Research International. 2018;2018:1574020.
[37] Teichtahl AJ, Urquhart DM, Wang Y, Wluka AE, O'Sullivan R, Jones G, et al. Modic changes in the lumbar spine and their association with body composition, fat distribution and intervertebral disc height-a 3.0 T-MRI study. BMC Musculoskelet Disord. 2016;17:92.

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