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ORIGINAL RESEARCH

Role Of Magnetic Resonance Imaging In Evaluation Of Lumbar Canal Stenosis

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ABSTRACT

Introduction: Lumbar canal stenosis is a spinal canal narrowing by osseous and non- osseous factors, leading to nerve roots compression. The following are the clinical symptoms seen in patients of lumbar stenosis i.e. radicular pain or atypical leg pain, neurogenic claudication, weakness and bowel/ bladder abnormalities. In this study we used MRI to evaluate lumbar canal stenosis and degenerative changes in spine. **Materials And Methods:**Patients who came to the Radiodiagnosis department, MMC, Muzaffarnagar with low back pain with/without radiculopathy were studied. MRI lumbo-sacral spine was performed and images of the lumbar spine were interpreted, to locate the degenerative findings and degree of spinal canal stenosis. Study population included 150 patients in age of 20-60 years of both male and female gender. **Results:**Lumbar central canal stenosis was seen in 97.3% (146 out of 150) participants and 42.6% (64 out of 150) participants had lateral foraminal stenosis.The mean age of this study group is 43± 6 years, and an explanation to this is degenerative changes. Around42.6% (64 out of 150) participants had lateral foraminal stenosis and 97.3% (146 out of 150) participants had central canal stenosis. **Conclusion**:MRI is non-invasive with no known morbidity, and no radiation exposure. It‘s role in detection, localization and characterization of various degenerative pathologies of spine is commendable and also helps in arriving at a correct anatomical diagnosis thereby guiding further workup for the patient. It can evaluate spinal canal morphology, intervertebral foramina and nerve roots.

Keyword: MRI, Lumbar canal stenosis, degenerative changes

INTRODUCTION

The vertebral column is composed of 33 vertebrae, of which 24 are mobile and 9 are immobile. The mobile vertebrae include seven cervical, twelve thoracic, and five lumbar vertebrae, while the immobile vertebrae consist of five sacral vertebrae that fuse to form the sacrum and four coccygeal vertebrae that fuse to form the coccyx.[1,2] The lumbosacral spine includes various structures such as vertebral bodies, intervertebral (IV) discs, pedicles, articular processes, ligaments, and facets, along with neural components like the conus medullaris, cauda equina, and nerve roots in the lumbar region. [3] The lumbar canal diameter decreases from L1 to L5, with the widest point at L1. This narrowing can compress structures within the canal, leading to symptoms such as back pain and neurological issues.[4]

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The vertebral bodies in the lumbar spine are large and square-shaped, with end plates covered by fenestrated cartilage that provides attachment points for intervertebral discs. These discs function as fibrocartilaginous joints, enabling slight movements and acting as shock absorbers.[5] The intervertebral discs consist of the nucleus pulposus, a gel-like core resistant to compression, and the annulus fibrosus, which helps distribute mechanical stresses. [6] The discs lack blood vessels and nerves, obtaining nutrients through diffusion. [7] Vertebral endplates, composed of bone and hyaline cartilage, form a connection between the vertebral body and the disc, playing a crucial role in bearing pressure and maintaining disc hydration.[8]

The strength of the lumbar spine improves from the lumbar to sacral levels, with the endplates being more rigid than the vertebral body, aiding in load-bearing and protection from compression forces.[9] The spinal cord resides within the vertebral canal, giving rise to spinal nerve roots that exit through vertebral foramens. These roots include dorsal roots for sensory signals and ventral roots for motor signals.[10] Lower back pain is a significant concern, often leading to disability. Risk factors include severe pain, obesity, heavy lifting, poor posture, and depression.Disc degeneration and displacement are major causes of lower back pain, with advanced degeneration leading to disc prolapse and annular fissure, triggering inflammatory reactions and pain.[11]

Lumbar canal stenosis, characterized by narrowing of the spinal canal, results from degenerative changes in facet joints, discs, and ligaments, leading to symptoms like neurogenic claudication, radiating leg pain, and lower back pain.[12,13] The condition is often diagnosed using MRI, which is an effective tool for assessing spinal disorders.[14] Signs of nerve root compression, including clumping of nerve roots and changes in cerebrospinal fluid (CSF) signal intensity, can be observed on MRI.35 However, there is variability in the correlation between MRI findings and clinical symptoms, posing challenges for diagnosis and treatment.[15,16 This study aims to further explore these correlations and associations.

METHODOLOGY

Study Design: This was a hospital-based descriptive study conducted over a period of 18 months.

Study Setting: The study was carried out in the Department of Radiodiagnosis & Imaging at Muzaffarnagar Medical College, Muzaffarnagar, Uttar Pradesh.

Study Population: The study included all outpatient department (OPD) and inpatient department (IPD) patients aged 20-60 years, who presented with symptoms of lower backache and were referred to the Department of Radiodiagnosis for Magnetic Resonance Imaging (MRI). These patients were clinically suspected of having lumbar canal stenosis. The total study duration was 18 months, with 12 months allocated for data collection and 6 months for data analysis.

Sample Size: A total of 150 patients were included in the study. The sample size was determined based on the number of cases referred to the Department of Radiodiagnosis for MRI to assess lumbar canal stenosis over the past three years. Simple random sampling was employed to select the participants for the study, ensuring that every patient meeting the inclusion criteria had an equal chance of being selected.

Inclusion and Exclusion Criteria: The study included patients aged 20-60 years of both genders, referred to the radiodiagnosis department with clinical findings suggestive of lumbar canal stenosis, including lower back pain, radiculopathy (pain radiation, paresthesia, and weakness in the lower limbs), and neurogenic complaints, with confirmed radiological findings of lumbar stenosis. Exclusion criteria were a history of spine surgery, vascular claudication, absolute contraindications to MRI (such as cardiac pacemakers, aneurysm surgical clips, or metallic foreign bodies/body implants), congenital and traumatic causes of backache, and patients unwilling to participate in the study.

Procedure: All patients referred to the Department of Radiodiagnosis with clinical suspicion of lumbar canal stenosis underwent MRI for diagnosis and evaluation. The MRI scans were performed using the SEIMENS MAGNETOM ESSENZA 1.5 T MRI machine. The imaging sequences included axial and sagittal T2, T1, and STIR sequences. Prior to the procedure, informed consent was obtained from each patient. A brief clinical history was also documented. The assessment of central canal stenosis was done using the Miskin Mandell grading system, while lateral foraminal stenosis was graded using the Lee et al. system.

Statistical Analysis: The data collected was analyzed using SPSS version 17. Chi-square test was employed to interpret the data, providing insights into the correlation between clinical symptoms and MRI findings.

RESULT

In this study, the distribution of disc herniation and central canal stenosis was thoroughly analyzed across various age groups, genders, and specific anatomical locations. The study involved 150 participants, with the majority being in the 50-60 years age group, and females constituting 53.3% of the sample.Disc herniation was present in 55.3% of the participants, with disc protrusion being more prevalent than disc extrusion. The data revealed that 38.6% of the participants had disc protrusion, with the highest occurrence in the central location (21.3%), followed by subarticular (right and left combined at 28%). Disc extrusion was less common, affecting 16.6% of the participants, predominantly in the subarticular regions. This distribution highlights the significant

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involvement of the central and subarticular regions in disc herniation.The grading of central canal stenosis was evaluated based on gender and age. Among the participants, 46.5% were classified as Grade 2 stenosis, making it the most common grade. Grade 1 stenosis was observed in 45.8% of the participants, while Grade 3, the most severe form, was noted in only 7.5% of cases. The prevalence of central canal stenosis increased with age, with the highest incidence observed in the 50-60 years age group, accounting for 38.3% of the cases.

When assessing the etiological factors contributing to central canal stenosis, it was found that multiple-level disc bulge was the most consistent finding across all grades of stenosis, present in 90.0% of Grade 3 cases. Ligamentum flavum hypertrophy and facetal arthropathy were also prominent, particularly in Grade 2 stenosis, affecting 80.8% and 67.6% of participants, respectively.Lateral foraminal stenosis was graded separately, with Grade 1 being the most prevalent, observed in 76.5% of the cases. This type of stenosis was more common in the 50-60 years age group, similar to central canal stenosis. The data suggest a strong correlation between age and the severity of both central and lateral stenosis.

In terms of clinical symptoms, pain intensity was closely correlated with the severity of central canal stenosis. Mild pain was most frequently associated with Grade 1 stenosis, occurring in 62.7% of those cases. Moderate pain was more common in Grade 2 stenosis, affecting 61.8% of these participants. Severe pain was predominantly linked to Grade 3 stenosis, observed in 63.6% of these cases. These findings emphasize the relationship between the severity of stenosis and the level of patient discomfort, underscoring the need for targeted pain management strategies in more severe cases.

Table1: -Distribution of participants according to gender & age

Gender age Group	Female		Male		Total	
	Number	%	Number	%	Number	%
20-29 Yr	4	5.0%	14	20.0%	18	12.0%
30-39 Yr	13	16.2%	19	27.1%	32	21.3%
40-49 Yr	20	25.0%	19	27.1%	39	26.0%
50-60 Yr	43	53.7%	18	25.7%	61	40.6%
Total	80	53.3%	70	46.6%	150	100.0%

Table 2. Distribution of disc herniation according to age and gender

Age group	Protrusion [no. (%)] - female	Protrusion [no. (%)] - male	Extrusion [no. (%)] - female	Extrusion [no. (%)] - male	Disc herniation total no. (%)
20-39	14(9.3%)	13(8.6%)	5(3.3%)	3(2.0%)	35(23.3%)
40-60	17(11.3%)	14(9.3%)	10(6.6%)	7(4.6%)	48(32.0%)
Total	**31(20.6%)**	**27(18.0%)**	**15(10%)**	**10(6.6%)**	**83(55.3%)**

Table 3: Frequency distribution of disc herniation by location

Location	Disc protrusion no. (%)	Disc extrusion no. (%)	Total no. (%)
Central	32(21.3%)	8(5.3%)	40(26.6%)
Right sub articular	14(9.3%)	7(4.6%)	21(14%)
Left sub articular	12(8%)	9(6%)	21(14%)
Sub articular (r & l)	26(17.3%)	16(10.6%)	42(28%)
Foraminal	0	1(0.6%)	1(0.6%)
Total	**58(38.6%)**	**25(16.6%)**	**83(55.3%)**

Table 4: Grading and distribution of central canal stenosis by gender

Grading of central canal stenosis	No. Of male participants	No. Of female participants	Total	Percentage
Grade 1	33 (22.6%)	34 (23.2%)	67	45.8%
Grade 2	32 (21.9%)	36 (24.6%)	68	46.5%
Grade 3	5 (3.4%)	6 (4.1%)	11	7.5%
Total	70 (47.9%)	76 (52.0)	146	100.0

Table 5: -Frequency distribution of grading of central canal stenosis by age

Age (years)	Grade 1		Grade 2		Grade 3		Total	
	N	%	N	%	N	%	N	%
20-29	8	5.4%	8	5.4%	2	1.3%	18	12.3%
30-39	14	9.5%	15	10.2%	3	2%	32	21.9%
40-49	17	11.6%	18	12.3%	5	3.4%	40	27.3%

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50-60	28	19.1%	27	18.4%	1	0.6%	56	38.3%

Table 6: Distribution of etiological factors according to central canal stenosis grade

Etiological factors	Grade 1 no. (%)	Grade 2 no. (%)	Grade 3 no. (%)	Total participants with central canal stenosis
Bulge single level	12(17.9%)	8(11.7%)	1(9.0%)	21
Bulge >= two levels	55(82.0%)	60(88.2%)	10(90.0%)	125
Disc herniation	36(53.7%)	37(54.4%)	10(90.0%)	83
Ligamentum flavum hypertrophy	45(67.1%)	55(80.8%)	7(63.6%)	107
Facetal arthropathy	44(65.6%)	46(67.6%)	5(45.4%)	95

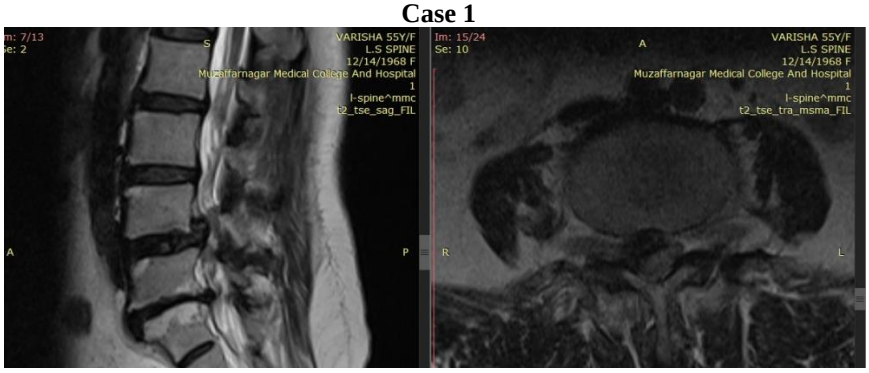
Table 7: Grading of lateral foraminal stenosis by age

Grading of lateral foraminal stenosis	Grade 1	Grade 2	Grade 3	Total
20-29	2(3.1%)	1(1.5%)	0(0%)	3(4.6%)
30-39	8(12.5%)	2(3.1%)	0(0%)	10(15.6%)
40-49	10(15.6%)	4(6.2%)	1(1.5%)	15(23.4%)
50-60	29(45.3%)	4(6.2%)	3(4.6%)	36(56.2%)
Total	**49(76.5%)**	**11(17.1%)**	**4(6.2%)**	**64(100%)**

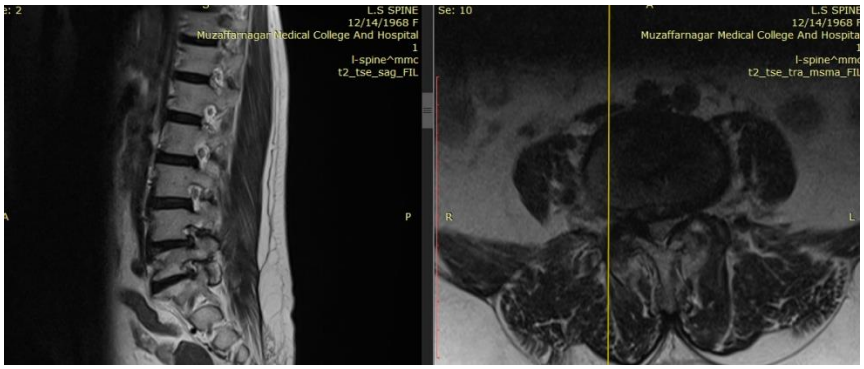
Table 8: Relation of pain intensity with central canal stenosis grading

Grading of central canal stenosis	Grade-1		Grade-2		Grade-3		Total	
Intensity of pain	No.	%	No.	%	No.	%	No.	%
Mild	42	62.7%	21	30.9%	1	9.1%	64	43.8%
Moderate	23	34.3%	42	61.8%	3	27.3%	68	46.5%
Severe	2	3.0%	5	7.3%	7	63.6%	14	9.5%
	67	100%	68	100%	11	100.0%	146	100.0%

Case 1



Sagittal T2 W image **Axial T2 W image**



Sagittal T2 W image **Axial T2 W image**

Imaging findings: Central Canal Stenosis 'Grade 1' Lateral Canal Stenosis 'Grade 1'
L4-L5: disc bulge with central disc extrusion & cranial migration causing slight crowding of nerve roots in thecal sac causing right traversing & right exiting nerve root indentation. Facetal arthropathy also seen

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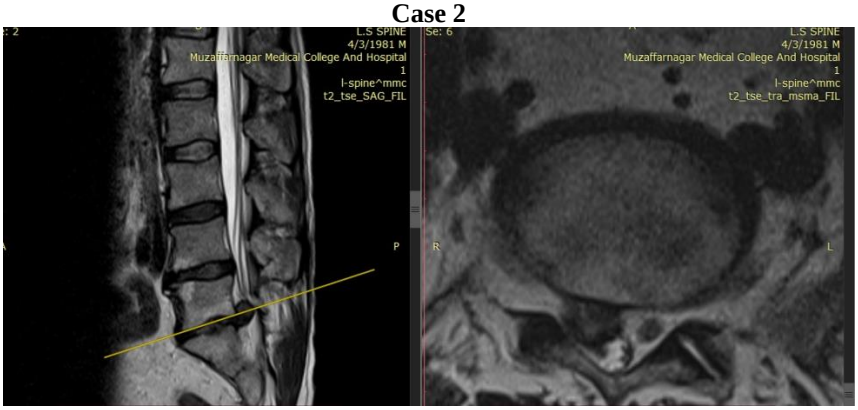
Case 2

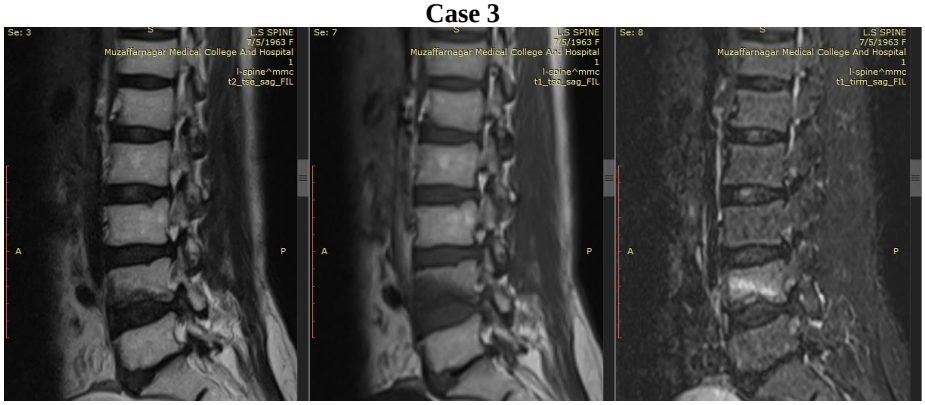


Sagital T2W image **Axial T2 W image**

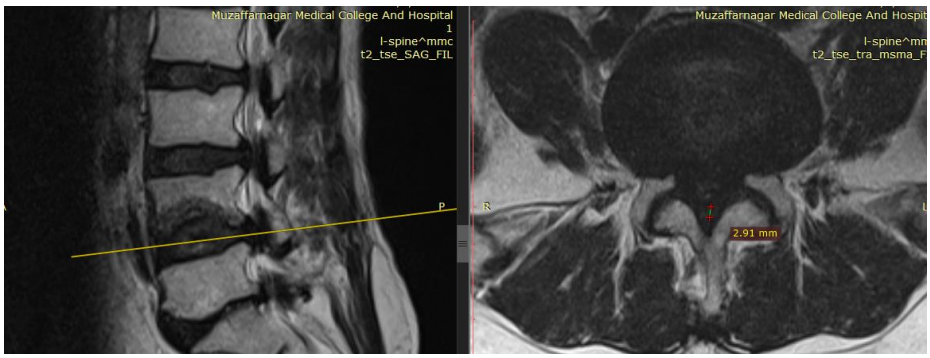
Imaging findings : Central Canal Stenosis 'Grade 1

L5-S1: Diffuse disc bulge with right subarticular extrusion & cranial migration causing compression of right traversing nerve roots and slight crowding of nerve roots in thecal sac

Case 3



Sagittal T2 W image **Sagittal T1 W image** **Sagittal STIR image**



Sagittal T2 W image **Axial T2 W image**

Imaging findings: Central Canal Stenosis 'Grade 3

B/L exiting Nerve Root indentation L4-L5 level: disc bulge with central disc protrusion with complete effacement of CSF in thecal sac and B/L Traversing Nerve Root Compression.Facetal Arthropathy also seen. Type 1 modic change at L4-L5 level. Schmorl's nodes at multiple levels

DISCUSSION

In this study, the mean age is 43±4 years, and a reason for this is the degeneration of the disc, which is commonly seen in participants above 40 years of age. In our study, the age distribution was as follows: 61 out of 150 (40.6%) participants were aged between 50-60 years, 39 out of 150 (26%) were aged 40-49 years, and 32 out of 150 (21%) were aged between 30-39 years.Our findings are comparable to those reported in the literature. In studies Altinkaya et al.,[17] mean ages ranged from 47.8 to 49.3 years among their respective cohorts. The difference in disc degeneration prevalence between younger (20-39 years) and older individuals is likely due to the aging process. Genetic predisposition, repetitive injuries, and physical stress may explain degeneration in younger individuals.

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In our study, 53.3% (80 out of 150) were female participants and 46.6% (70 out of 150) were male participants. This observation is similar to findings reported in the literature. For example, 18.MN, Grooff PN et.al. [18] reported 53.5% female and 46.5% male in their study. Marcus Kin Long Lai et al. [19] reported 61.7% females and 38.3% males. Shiguo Yuan et al. observed 56.2% females and 43.7% males. Lee JW et al.[20] also reported a similar gender distribution.Pregnancy, childbearing, physical stress from child-rearing, weight gain during perimenopause, and post-menopausal changes are causes of lower back pain in women, who generally have a lower pain threshold and response.In our study, the prevalence of lower back pain (LBP) was higher in females (53.7% of 80 female participants) and in the age group 50-60 years. Among males, a prevalence of 27.1% was seen in both the 30-39 and 40-49 years age groups. There were more participants in the 50-60 years age group and more females than males. Lower back pain prevalence significantly increases in women as they age. Postmenopausal women exhibit accelerated disc degeneration, likely due to estrogen deficiency. Disc space narrowing is more pronounced and severe in women compared to age-matched men. In a study by Modic MT et al. [21] the mean age of patients was 56.6 years, and the prevalence of LBP was 55.6% among females and 38.5% among males.Degenerative changes included disc displacement, posterior annular tear, Schmorl‘s nodes, ligamentum flavum hypertrophy, Facetal arthropathy, osteophytes, and Modic changes. The major degenerative changes include disc displacement (disc bulge and disc herniation), followed by ligamentum flavum hypertrophy, Facetal arthropathy, and posterior annular tear.

As observed, multilevel involvement was more predominant than single-level involvement. Single-level disc bulge was seen in 21 (14%) participants, whereas two-level disc bulge was seen in 125 (83.3%) participants. Disc herniation was present in 83 (55.3%) participants, Schmorl‘s nodes in 48 (32%) participants, ligamentum flavum hypertrophy in 107 (71.3%) participants, Facetal arthropathy in 95 (63.3%) participants, posterior annular tear in 92 (61.3%) participants, and type 1 Modic changes were seen in 5 (3%) participants. The maximum disc displacement was observed at L4-L5 levels (91.3%), followed by L5-S1 level (76.6%).Degenerative disc changes commence early in life and are partly due to the natural aging process, though their exact cause remains unknown. Various factors, including autoimmune responses, genetic predispositions, and biochemical alterations, have been suggested as accelerants of this degeneration. The lumbar spine, which endures significant mechanical stress, is particularly prone to these changes. Consequently, such degenerative alterations are a primary contributor to the development of canal stenosis. L4-L5 and L5-S1 are the most affected levels, likely due to experiencing more mechanical forces in the lumbosacral regions and also transitional vertebra.

In our study, central canal stenosis at the lumbar level was observed in 97.3% (146/150) of cases. Among these, the age group most commonly affected was 50-60 years, accounting for 38.3% (56 out of 146 cases). Degenerative changes were identified as the primary cause of stenosis in our investigation. In our study, Grade 1 central canal stenosis was seen in 67 out of 146 participants (45.8%), Grade 2 in 68 out of 146 participants (46.5%), and Grade 3 in 11 out of 146 participants (7.5%).

Similar results were seen in other studies. For example, in a study by Sethi Get al., [22] Grade 1 was seen in 103 out of 357 participants (28.9%), Grade 2 in 127 out of 357 participants (35.6%), and Grade 3 in 42 out of 357 participants (11.8%). Brinjikji W et al. [23] reported Grade 2 in 44 out of 112 participants (39.2%) and Grade 3 in 39 out of 112 participants (34.8%). In a study by Hung IYJ et al.,[24] central canal stenosis was observed in 86.99% (2000 of 2299) of cases, with Grade 1 in 63.3%, Grade 2 in 27.9%, and Grade 3 in 37.5%.

In our study, 64 out of 150 (42.6%) participants had lateral foraminal stenosis. 'Grade 1' foraminal stenosis was seen in 49 out of 64 (76.5%) participants, 'Grade 2' in 11 out of 64 (17.1%), and 'Grade 3' in 4 out of 64 participants (6.2%).In a study by Lee S et al., 46 out of 96 (47.9%) participants had lateral foraminal stenosis. 'Grade 1' was seen in 33 (34.5%), 'Grade 2' in 6 (6%), and 'Grade 3' in 7 out of 96 participants (7.2%). Similar findings were reported by Miskin N et al., Saleem S and colleagues, Tae Seok Jeong et al., Park and colleagues, among others. [25,26]

CONCLUSION

This study utilized Magnetic Resonance Imaging (MRI) to assess lumbar canal stenosis, emphasizing its effectiveness in detecting, localizing, and characterizing spinal degeneration. The findings indicate that lumbar central stenosis is more prevalent than foraminal stenosis, with the most affected age group being 50-60 years and females more commonly involved than males. Disc displacement, particularly multi-level disc bulge, is a significant contributor to stenosis. Ligamentum flavum hypertrophy and facetal arthropathy also play crucial roles in the etiology. Type 1 Modic changes are associated with acute pain, while ligamentum flavum thickening, facetal arthropathy, and Schmorl’s nodes are linked to chronic pain. Pain intensity correlates with the severity of stenosis, with disc bulge, ligamentum flavum thickening, and facetal arthropathy being key factors in Grade 1 and 2 stenosis, and disc bulge and herniation predominating in Grade 3 stenosis.

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