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MRI EVALUATION OF NEURAL FORAMINAL STENOSIS IN LUMBAR RADICULOPATHY : A PROSPECTIVE STUDY IN A TERTIARY CARE HOSPITAL

Radio-Diagnosis

Susmita Mahata Assistant Professor, Department of Radiodiagnosis, Jhargram Government Medical College & Hospital, Jhargram, West Bengal, India

Aditi De Assistant Professor, Department of Radiodiagnosis, Bankura Sammilani Medical College & Hospital, Bankura, West Bengal, India

Pradyot Ranjan* 3rd Year Post Graduate Trainee, Department of Radiodiagnosis, Bankura Sammilani Medical College & Hospital, Bankura, West Bengal, India*Corresponding Author

ABSTRACT

Background: Lumbar radiculopathy is a common cause of low back pain resulting from compression of spinal nerve roots, most frequently within the neural foramina. Neural foraminal stenosis is one of the principal cause of radiculopathy, particularly in patients with degenerative lumbar spine disease. Magnetic resonance imaging (MRI) provides excellent soft-tissue contrast and allows accurate evaluation of neural foraminal pathology.[1,2] **Objectives:** To evaluate neural foraminal changes in patients with lumbar radiculopathy using MRI and to correlate imaging findings with clinical features. **Materials and Methods:** This prospective observational study included 60 patients presenting with clinical symptoms of lumbar radiculopathy who underwent MRI of the lumbosacral spine. Foraminal stenosis was graded using the Lee classification system[4]. Associated findings such as disc pathology and nerve root displacement were recorded. Clinical features including dermatomal pain, paresthesia, muscle weakness, and straight leg raising (SLR) test were correlated with imaging findings.**Results:** The mean age of patients was 45.7 ± 11.8 years. Neural foraminal involvement was most frequently observed at L4–L5 (56.7%), followed by L5–S1 (35%). According to Lee grading, Grade 1 stenosis was seen in 56.7%, Grade 2 in 33.3%, and Grade 3 in 10% of cases. Nerve root displacement was observed predominantly in moderate and severe stenosis. No statistically significant gender predilection was identified.**Conclusion:** MRI is a reliable and non-invasive modality for evaluating neural foraminal stenosis in lumbar radiculopathy. The L4–L5 level is most commonly affected (56.7%), and the Lee grading system provides a useful framework for assessing severity and guiding clinical management.[2,9]

KEYWORDS

Lumbar Radiculopathy; Neural Foraminal Stenosis; Magnetic Resonance Imaging (mri); Lee Classification; Degenerative Spine Disease; Lumbar Spine.

INTRODUCTION

Low back pain is one of the leading causes of disability worldwide and represents a significant public health burden. Among the various causes of low back pain, lumbar radiculopathy is a frequently encountered clinical condition characterized by pain radiating from the lumbar region to the lower extremities along the distribution of affected nerve roots. [1,15,21,22]

Lumbar radiculopathy commonly results from compression or irritation of spinal nerve roots due to degenerative changes in the lumbar spine. Intervertebral disc degeneration, disc herniation, osteophyte formation, and hypertrophy of the facet joints may lead to narrowing of the neural foramina and subsequent nerve root compression. Initial evaluation of low back pain should emphasize clinical assessment and identification of red flag signs prior to imaging [2,3,8,24]

Magnetic resonance imaging (MRI) has emerged as the imaging modality of choice for evaluating lumbar spine pathology because of its superior soft-tissue contrast and multiplanar imaging capability. [2,9] MRI allows detailed visualization of intervertebral discs, nerve roots, ligaments, and surrounding structures without exposure to ionizing radiation.[9,19]

Neural foraminal stenosis is an important cause of lumbar radiculopathy. Several grading systems have been proposed for evaluating the severity of foraminal narrowing on MRI. Among these, the classification described by Lee et al. provides a practical and reproducible method for assessing foraminal stenosis based on morphological changes in the exiting nerve root.[4,6]

The present study was undertaken to evaluate neural foraminal changes in patients presenting with lumbar radiculopathy using MRI and to correlate imaging findings with clinical symptoms.

LEE GRADING SYSTEM:[8]

Grade 0: absence of foraminal stenosis;

Grade 1: mild foraminal stenosis showing perineural fat obliteration surrounding the nerve root in the two opposing directions (vertical or transverse). It involves contact with the superior and inferior portions of the nerve root or anterior and posterior portions of the nerve root. No evidence of morphologic change in the nerve root is shown.

Grade 2: moderate foraminal stenosis showing perineural fat obliteration surrounding the nerve root in the four directions without morphologic change in both vertical and transverse directions.

Grade 3 : severe foraminal stenosis showing nerve root collapse or morphologic change.

The present study was undertaken to evaluate neural foraminal changes in patients presenting with lumbar radiculopathy using MRI and to correlate imaging findings with clinical symptoms.

MATERIALS & METHODS

Study Design

Prospective observational study.

Study Setting

Department of Radiodiagnosis, IPGME&R–SSKM Hospital, Kolkata.

Study Population

Patients presenting with clinical features suggestive of lumbar radiculopathy who underwent MRI of the lumbosacral spine.

Sample Size

A total of 60 patients were included in the study.

Inclusion Criteria

- Patients with low back pain and radicular symptoms
- Patients referred for MRI of the lumbosacral spine
- Age >18 years

Exclusion Criteria

- History of spinal surgery
- Spinal tumors or infections
- Congenital spinal anomalies
- Contraindications to MRI

MRI Protocol

MRI examinations were performed using standard sequences including:

- Sagittal T1-weighted images
- Sagittal T2-weighted images
- Axial T2-weighted images

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- Axial T1-weighted images

Parameters assessed included:

- Neural foraminal narrowing
- Disc pathology
- Facet joint hypertrophy
- Ligamentum flavum thickening
- Nerve root compression or displacement
- Foraminal stenosis was graded according to the Lee classification.

ETHICS

The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Institutional Ethics Committee of IPGME&R – SSKM Hospital.

RESULTS

Demographic Profile

Total Patients: 60
Male: 29 (48.3%)
Female: 31 (51.7%)
Mean Age: 45.67 Years with Standard Deviation: 11.78
Age Range: 30-70 Years
Most patients fall within the fourth to sixth decade, consistent with degenerative lumbar spine disease.

Involvement of cases according to age distribution

Age wise distribution of cases show female predominance in 41-50 years age group, male predominance in higher age group (61-70yrs), whereas no of cases were same in younger age group (30-40 years) and the mean was 45.67 yrs.

Level of Foraminal Involvement Age Group Wise

In our study it was found out that the L4-L5 level as most frequent narrowest foramen, (right>left) in 30-40 yrs & 40-50 yrs age group. But, left L5-S1 level is most frequent narrowest foramen in 51-60 yrs age group. Whereas all lower three lumbar foramen of both sides are equally involved in 61-70 yrs age group.

Supero-Inferior diameter of Neural foramina at different levels:

Minimum supero-inferior diameter was 2.8 mm, maximum diameter was 17 mm, with a mean of 9.3592 & standard deviation 3.44689.

Moderate neural foraminal narrowing in supero-inferior diameter (within range of 6-12mm) was seen in most of the cases (37 cases out of 60) in our study population. Severe narrowing was distributed between L4-L5(3 cases), & L5-S1 level.(6 cases).

Antero-posterior diameter of neural foramina at different levels:

Minimum anteroposterior diameter was 2.8 mm, and the maximum was 10mm with mean of 6.63 & standard deviation 1.334; Moderate narrowing of antero-posterior diameter was seen in most of the cases(37 cases out of 60), within range of 5-7mm, whereas severe narrowing (<5mm) was more common in L4-L5 level.

Foraminal fat obliteration in different quadrants

Assessment of quadrant wise neural foraminal fat obliteration showed all quadrant involvement in 23 cases (38.3%), superior-inferior quadrant involvement in 21 cases (35%), anterior-posterior quadrant involvement in 16 cases(26.7%).

Severity of Foraminal Stenosis in different age groups

Grade 1 foraminal narrowing was more common in younger age group (30-40 yrs). Frequency of Grade 2 foraminal narrowing increases with age group. Grade 3 foraminal narrowing was maximum in younger age group (30-40 yrs).

Severity of foraminal stenosis (based on LEE classification) with duration of illness

The maximum no of patients presented with grade 1 stenosis (28cases) presented within 1-3 yrs of duration. Severity of foraminal stenosis does not correlate with duration of illness. Patients having Grade 2 stenosis mostly presented within 1-3yrs & 3-5 yrs. Grade 3 cases were seen earlier, mostly within 1-3 yrs, possibly due to early & severe symptoms.

Displacement of nerve root

Out of the 60 cases ,14cases(23.3%) showed no displacement of nerve root,26 cases(43.3%) showed superior displacement,17 cases(28.3%) showed postero superior displacement,2 cases(3.3%)showed antero superior displacement and only 1 case(1.7%) show inferior displacement.

Correlation between LEE classification with clinical symptoms

Radicular pain was assessed using pain scale . It was divided into three groups, mild(Pain scale 1-3),moderate(Pain scale 4-6),severe(Pain scale 7-9), to categorize the severity. Patients who had grade 1 MRI findings, all presented with mild pain. Most of the patients who had grade 2&3 MRI findings ,presented with severe pain.

Patients having grade 1 MRI findings showed tingling in 19, numbness in 6, paresthesia in 2, muscle weakness in 21, decreased deep tendon reflex in18 (out of 34 cases).

Patients having grade 2 MRI findings showed tingling in 18, numbness in 11, paresthesia in 4, muscle weakness in 20, decreased deep tendon reflex in 16 (out of 20 cases).

Patients having grade 3 MRI findings showed tingling in 4, numbness in 4, paresthesia in 3, muscle weakness in 5, decreased deep tendon reflex in 4(out of 6 cases).

Ligamentum flavum hypertrophy:

Ligamentum flavum was normal in 45 (75%) cases. In this stud, 25% cases (15 out of 60) showed presence of ligamentum flavum hypertrophy. The prevalence is seen more in 41-50 yrs age group in female with decrease in frequency in higher age group. But in males, frequency was same in all age group except in range of 41-50 yrs age group.

Facet arthropathy:

Facet joint was normal in 31 (51.7%) Facet arthropathy was seen in 29 (48.3%) cases. It was mostly seen (18.3%) in 41-50 yrs age group, followed by 30-40 yrs age group. Female patients of age group 41-50 yrs mostly (10 out of 11cases) showed facet arthropathy. Frequency of facet arthropathy increases with age in male patients.

Nerve Root Changes

Nerve root displacement was observed in several patients and most commonly occurred in cases with Grade 2 or Grade 3 stenosis.
Patterns observed included:

- Superior Displacement (43.3%)
- Posterosuperior Displacement (28.3%)
- Anterosuperior Displacement (3.3%)
- Inferior Displacement (1.7%)
- No Displacement (23.3%)

Statistical Analysis

LEE classification vs MRI Findings

LEE		Foraminal fat obliteration	Displacement of nerve root	Distortion of nerve root	Disc herniation	Ligamentum flavum hypertrophy	Facet arthropathy	others
	Correlation coefficient	-0.474	0.191	0.588	0.111	-0.151	0.059	0.390
	P value	0.000	0.144	0.000	0.400	0.250	0.655	0.002

The study showed positive association of LEE classification with nerve root displacement, nerve root distortion, disc herniation, facet arthropathy, & other MRI findings, but negative association foraminal fat obliteration & ligamentum flavum hypertrophy.

P value is <0.05 (significant) in cases of foraminal fat obliteration(P value 0.000), nerve root distortion (P value 0.000) & in other MRI findings(P value 0.002).

P value is>0.05 (insignificant) in cases of nerve root displacement, disc herniation, ligamentum flavum hypertrophy, facet arthropathy.

Statistical Analysis of LEE classification with pain scale(grading)

There is statistically significant correlation between LEE classification and pain grading (P value 0.013).

Statistical analysis of LEE Classification with clinical findings

Spearman's rho correlation test

The study showed positive association of all clinical findings with Lee classification. The P value signified correlation of Lee classification with Radiating pain (P value 0.000), Tingling (P value 0.041), Numbness (P value 0.001), Paresthesia (P value 0.008), Muscle weakness (P value 0.004), Passive SLR (straight leg raising) test (P value 0.006). Whereas Deep tendon reflex (P value 0.089) did not show statistically significant correlation.

CONCLUSIONS

Lumbar radiculopathy is a common cause of chronic low back pain and lower limb symptoms. Degenerative changes involving the intervertebral discs, facet joints, ligamentum flavum, and neural foramina contribute significantly to nerve root compression and the development of radicular symptoms. MRI provides excellent soft tissue contrast has a high sensitivity for detecting nerve root compression and is therefore considered the imaging modality of choice for evaluating these abnormalities.[1,2,9,23]

In the present study, the majority of patients were between 30 and 50 years of age, with a mean age of 45.67 ± 11.78 years. This finding is consistent with previous reports showing that degenerative lumbar spine disease is most common in middle-aged and elderly individuals.[12,13,14] There was no significant gender predilection, with males constituting 48.3% and females 51.7% of the study population. Similar findings have been reported by Tarulli and Raynor, who noted that lumbar radiculopathy affects both men and women almost equally.[1]

The L4–L5 level was the most frequently affected segment in this study, accounting for 56.7% of cases, followed by L5–S1. This observation is in agreement with previous studies which demonstrated that degenerative lumbar spine disease most commonly affects the lower lumbar segments due to greater mobility and mechanical stress at these levels.[2,3,5,10,11] The predominance of L4–L5 involvement may be explained by the greater load-bearing function and increased susceptibility of this motion segment to disc degeneration, facet arthropathy, and foraminal narrowing.[2,7]

Grade I foraminal stenosis according to the Lee classification was the most common MRI finding, accounting for 56.7% of cases, while Grade II and Grade III stenosis accounted for 33.3% and 10% of cases respectively. The predominance of Grade I stenosis suggests that many patients present during the early stages of degenerative disease. Similar findings have been reported in previous MRI-based studies of lumbar radiculopathy and foraminal stenosis.[4,6,16] Grade II stenosis was more frequent in older age groups, indicating progressive worsening of foraminal narrowing with age.[12,14]

Most patients presented within 1–3 years of symptom onset. Grade I stenosis was predominantly observed in this duration group, whereas Grade II stenosis was more evenly distributed between 1–3 years and 3–5 years of symptoms. Grade III stenosis also tended to present early, likely because severe symptoms prompt earlier clinical evaluation. However, no definite association was observed between the duration of symptoms and severity of foraminal stenosis.

Facet arthropathy was present in 48.3% of patients, while ligamentum flavum hypertrophy was observed in 25% of cases. These findings support the multifactorial etiology of foraminal stenosis, in which disc degeneration, osteophyte formation, facet hypertrophy, and ligamentum flavum thickening collectively contribute to narrowing of the neural foramina.[2,7,8,16] Female patients in the 41–50 year age group showed a higher prevalence of facet arthropathy, whereas ligamentum flavum hypertrophy was more commonly observed in females of the same age group.

Nerve root displacement was observed predominantly in patients with Grade II and Grade III stenosis. Superior displacement was the most common pattern, followed by posterosuperior displacement. Nerve root distortion showed statistically significant correlation with increasing Lee grade (p = 0.000), while nerve root displacement itself did not show statistical significance. Foraminal fat obliteration and other associated MRI findings also showed significant correlation with Lee grade. These findings are in agreement with the observations of Lee et al., who emphasized that nerve root morphology and perineural fat obliteration are important indicators of clinically significant foraminal stenosis.[4]

Clinical findings in the present study correlated well with MRI severity. Patients with Grade I stenosis generally had mild symptoms, whereas patients with Grade II and Grade III stenosis more commonly had severe pain. Statistical analysis demonstrated significant correlation between Lee classification and pain severity (p = 0.013). Lee grade also showed significant positive association with radiating pain, tingling, numbness, paresthesia, muscle weakness, and passive SLR test. However, deep tendon reflexes did not show significant correlation. Similar findings have been described in previous studies, which found that MRI abnormalities correlate better with pain severity and neurological deficits when higher grades of foraminal stenosis are present.[15,18,20]

MRI is particularly valuable because it provides comprehensive assessment of both osseous and soft tissue structures, including intervertebral discs, ligamentum flavum, facet joints, nerve roots, and epidural fat. It allows accurate identification of the cause and severity of nerve root compression without ionizing radiation.[2,9,19] However, abnormal MRI findings may also be present in asymptomatic individuals, and therefore imaging findings should always be interpreted in conjunction with clinical presentation.[3,10,11] MRI is generally preferred over CT for evaluation of lumbar spine pathology, although both modalities have comparable roles in selected cases.[24]

Overall, the findings of this study support the usefulness of the Lee grading system as a practical and reproducible method for evaluating lumbar foraminal stenosis. Current evidence-based guidelines recommend judicious use of imaging in low back pain, particularly in the absence of red flag signs. MRI remains indispensable in the diagnosis of lumbar radiculopathy and helps guide appropriate clinical management and treatment planning.[4,15,25]

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