RJNMSR
Review Journal of Neurological & Medical Sciences Review

Volume 3, Issue 3, 2025

COMPRE12HENSIVE EVALUATION OF SPINAL PAIN IN THE CERVICAL, THORACIC, AND LUMBAR REGIONS USING MRI

Afaq Akbar[1], Manahal Yasmin[2], Sadia Ismial[*3], Sana Javed[4], Subhan Azam[5], Noor Ul Ain[6], Laraib Aslam[7]

[1, 2, *3, 4,5,6,7] *Riphah International University Faisalabad, Pakistan*

Corresponding Author: *
Sadia Ismial

DOI: https:/doi.org/10.5281/zenodo.15804960

Received	Accepted	Published
26 May , 2024	26 June, 2025	04 July, 2025

ABSTRACT

Spinal conditions such as disc herniation, spinal stenosis, and spondylolisthesis are major causes of disability, often resulting in chronic pain and impaired mobility. Timely diagnosis is crucial for effective treatment, and Magnetic Resonance Imaging (MRI) has become the gold standard for diagnosing these conditions due to its ability to provide detailed imaging of the spine. Despite its widespread use, the effectiveness of MRI in diagnosing specific spinal conditions remains a topic of ongoing research. This study aims to evaluate the diagnostic effectiveness of MRI in detecting disc herniation, spinal stenosis, and spondylolisthesis, with a focus on the sensitivity and specificity of MRI for each condition. A total of 100 participants were included in the study, with demographic characteristics, clinical symptoms, and MRI findings analyzed. The study found that MRI demonstrated high sensitivity for detecting disc herniation (89.4%) and spinal stenosis (84.4%), indicating its reliability for these conditions. However, its specificity for spinal stenosis was somewhat lower at 65.1%, suggesting potential false positives. For spondylolisthesis, MRI showed moderate sensitivity (78.9%) and specificity (72.9%), with no significant association found between MRI findings and the presence of the condition. The clinical symptoms most commonly reported included back pain (75%), numbness (50%), and neck pain (20%), all of which align with existing research on spinal conditions. Gender differences in the prevalence of these conditions were not found, suggesting no significant gender-related impact on the diagnosis in this sample.

This study highlights the effectiveness of MRI in diagnosing disc herniation and spinal stenosis, but also emphasizes the challenges in diagnosing spondylolisthesis, particularly in mild cases. Future research should explore advanced imaging techniques and multimodal diagnostic approaches to improve the accuracy of MRI in diagnosing these spinal conditions.

Keywords: *Magnetic Resonance Imaging (MRI), Disc Herniation, Spinal Stenosis, Spondylolisthesis, Diagnostic Effectiveness.*

INTRODUCTION

Spinal disorders, particularly in the cervical, thoracic, and lumbar regions, are prevalent causes of disability, significantly affecting quality of life. Conditions such as disc herniation, spinal stenosis, and spondylolisthesis often result in chronic pain, mobility impairment, and neurological deficits. These conditions are commonly associated with back and neck pain, radiating limb pain, numbness, and weakness (1).

Among these, disc herniation is a leading cause of cervical and lumbar pain, where the herniated disc compresses nearby nerve roots, causing pain and other neurological symptoms (2).

Spinal stenosis, characterized by the narrowing of the spinal canal, can also cause significant discomfort and, in severe cases, lead to loss of motor function and bowel or bladder dysfunction. Spondylolisthesis, where one vertebra slips over another, can result in nerve compression and further contribute to spinal instability and pain (3, 4).

Magnetic Resonance Imaging (MRI) has become the diagnostic tool of choice for evaluating spinal

conditions, primarily due to its non-invasive nature and its ability to provide detailed images of soft tissues, such as the spinal cord, intervertebral discs, and nerve roots. MRI is superior to conventional X-rays in detecting soft tissue abnormalities, making it ideal for diagnosing disc herniation, spinal stenosis, and spondylolisthesis (5, 6).

While MRI is widely recognized for its ability to detect structural abnormalities in the spine, its effectiveness can vary across different conditions. For instance, MRI has shown high sensitivity for detecting disc herniation, particularly in the cervical and lumbar regions. However, its performance in diagnosing spondylolisthesis, especially in mild cases, remains inconsistent (7, 8) The aim of this study is to evaluate the diagnostic effectiveness of MRI in detecting disc herniation, spinal stenosis, and spondylolisthesis, focusing on its sensitivity and specificity. By analyzing MRI findings and correlating them with clinical symptoms, this study seeks to enhance the understanding of MRI's role in diagnosing spinal conditions and to provide insights into its clinical utility in improving patient outcomes (9).

Materials and Methods:

This study employed a cross-sectional design to evaluate the diagnostic effectiveness of Magnetic Resonance Imaging (MRI) in detecting spinal conditions, including disc herniation, spinal stenosis, and spondylolisthesis. The study was conducted in a clinical setting where MRI diagnostics were routinely used for patients suspected of having spinal disorders. A total of 100 participants, aged between 2 and 65 years, were selected using a convenient sampling technique. These patients had undergone MRI scans over the past 12 months for suspected spinal conditions, and their demographic and clinical information was collected through a standardized questionnaire.

The inclusion criteria for the study were patients presenting with symptoms such as neck pain, lower back pain, radiating pain to the limbs, and numbness or tingling sensations. Exclusion criteria included patients with unresolved or incomplete MRI scans, as well as those diagnosed with non-spinal conditions, such as cancer or neurological diseases unrelated to the spine.

MRI scans were performed using a high-resolution MRI scanner with a slice thickness of 1mm. The imaging sequences included T1-weighted, T2-weighted, and Short Tau Inversion Recovery (STIR) images, which are particularly effective in detecting conditions such as disc herniation and spinal stenosis. The scans were acquired in sagittal, axial, and coronal planes, depending on the clinical indication. All images were reviewed by qualified radiologists to ensure diagnostic accuracy.

The data were analysed using SPSS version 27, where descriptive statistics, including frequencies, percentages, mean, and standard deviation, were calculated for demographic and clinical variables. Chi-square tests were performed to assess the association between MRI findings and the presence of spinal conditions, and sensitivity and specificity calculations were carried out for each condition.

RESULTS

A total of 100 participants were included in the study, with a balanced gender distribution (49% male, 51% female). The participants' ages ranged from 2 to 65 years, with a mean age of 42.22 years (Table 1.1). Clinical symptoms were common, with 75% reporting back pain, 50% numbness, and 20% neck pain (Figure 1.1). Symptom duration varied, with 43% experiencing symptoms for 4 weeks, and 22% for 6 weeks (Figure 1.2).

Table 1.1 Gender Distribution

Gender	Frequency (%)
Male	49 (49%)
Female	51 (51%)

Figure 1.1 Clinical symptoms among patients

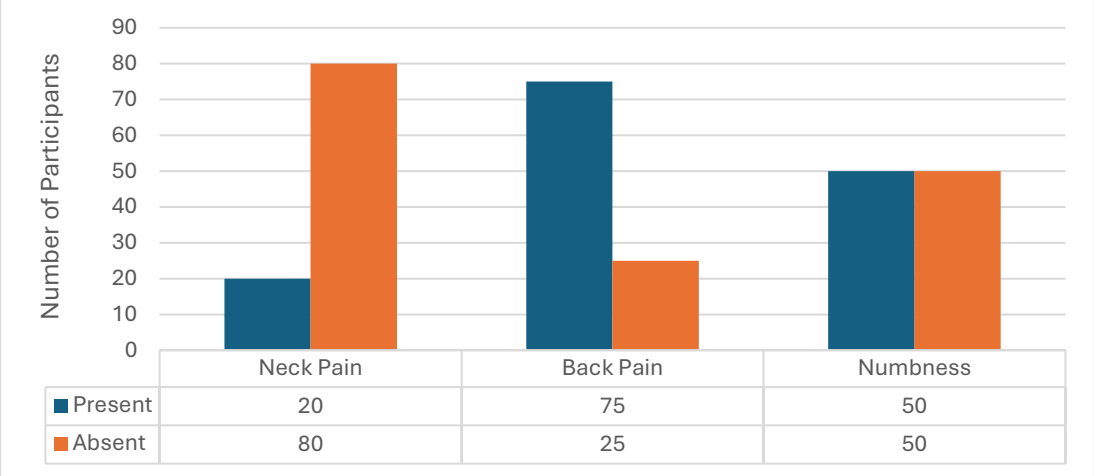
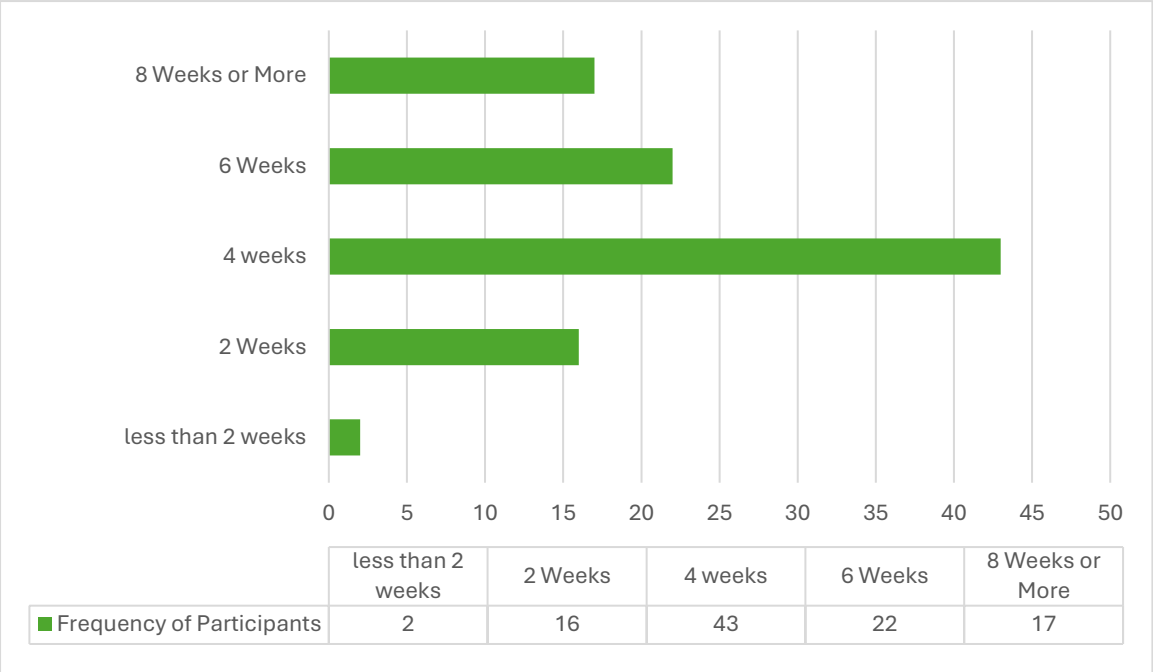


Figure 1.2 Distribution of Symptom Duration Among Participants



MRI Findings

MRI revealed that 65% of participants with disc herniation exhibited mild severity, 28% moderate severity, and 7% severe findings. For spinal stenosis, 69% showed mild severity, 18.1% moderate severity, and 13% severe findings. In spondylolisthesis, 60% had mild severity, 24% moderate severity, and 16% severe findings (Table 1.2).

Diagnostic Performance

MRI demonstrated high sensitivity for disc herniation (89.4%) and spinal stenosis (84.4%). However, its sensitivity for diagnosing spondylolisthesis was lower (78.9%). Specificity was 77.4% for disc herniation, 65.1% for spinal stenosis, and 72.9% for spondylolisthesis.

Chi-Square Analysis

Chi-square tests indicated significant associations between MRI severity and the presence of disc herniation ($p = 0.032$) and spinal stenosis ($p = 0.046$). No significant association was found for spondylolisthesis ($p = 0.166$) (Table 1.2).

Table 1.2 Chi-Square Analysis of the Relationship Between Spinal Conditions and MRI Severity

Spinal Conditions	MRI Severity			Chi-Square Value	p value
	Mild	Moderate	Severe		
Disk Herniation	42 (65%)	18 (28%)	5 (7%)	.945	.032
Yes	24(69%)	7(20%)	4(11%)		
No					
Spinal Stenosis	38 (69%)	10 (18.1%)	7(13%)	4.336	.046
Yes	28(62.2%)	15(33.3%)	2(4.5%)		
No					
Spondylolisthesis	15(60%)	6 (24%)	4(16%)	2.010	.166
Yes	51(68%)	19(25.3%)	5(6%)		
No					

Discussion:

This study aimed to evaluate the diagnostic effectiveness of MRI in detecting common spinal conditions, including disc herniation, spinal stenosis, and spondylolisthesis, focusing on its sensitivity and specificity. The findings of this study confirm that MRI is a highly effective diagnostic tool for disc herniation and spinal stenosis, but less reliable for diagnosing spondylolisthesis, particularly in mild cases.

MRI demonstrated a high sensitivity for detecting disc herniation (89.4%) and spinal stenosis (84.4%), which aligns with previous studies that highlight MRI's effectiveness in identifying these conditions. Reported similar findings, with MRI showing excellent sensitivity for detecting disc herniation, especially in the cervical and lumbar regions. This is crucial because disc herniation often leads to nerve compression, causing significant pain and disability. MRI's high sensitivity allows clinicians to make accurate diagnoses and initiate timely interventions, which is essential for improving patient outcomes. Furthermore, the high sensitivity for spinal stenosis in this study supports the findings of Crawford et al. (2022), who emphasized MRI's role in detecting the narrowing of the spinal canal and nerve root compression, which can lead to severe complications such as paralysis if left untreated.

However, the diagnostic sensitivity of MRI for spondylolisthesis was lower (78.9%) compared to disc herniation and spinal stenosis. This result is consistent with the findings of Prablek et al. (2023), who noted that MRI can miss subtle cases of spondylolisthesis, particularly in its early stages or mild cases. Spondylolisthesis is often difficult to detect on MRI when the vertebrae have only slightly shifted, making it harder for radiologists to identify without advanced imaging techniques or additional diagnostic tools. This highlights a key limitation of MRI in diagnosing spinal conditions, suggesting that other modalities, such as computed tomography (CT) scans, may be more suitable for identifying mild cases of spondylolisthesis.

The specificity of MRI in detecting spinal conditions also varied across the three conditions examined. While MRI showed high specificity for disc herniation (77.4%), its specificity for spinal stenosis was lower (65.1%), and even lower for spondylolisthesis (72.9%). Lower specificity indicates that MRI may produce false positives, which can lead to unnecessary treatments and patient anxiety. This is particularly important for spinal stenosis, where degenerative changes may appear on MRI even in asymptomatic individuals[15]. As noted by Wang et al. (2024), false positives in spinal imaging can complicate the clinical decision-making process, leading to overdiagnosis and overtreatment.

In this study, no significant association was found between gender and the prevalence of spinal conditions, which aligns with some studies but contrasts with others that suggest gender differences in the prevalence of certain conditions. For example, Salvi et al. (2025) reported that women are more likely to experience chronic low back pain and spinal degeneration, which may be attributed to hormonal changes, pelvic structure, and increased ligament laxity. However, in our study, the gender distribution did not show any significant differences in the presence of disc herniation, spinal stenosis, or spondylolisthesis, suggesting that these conditions affect both genders similarly, at least within the sample studied.

The findings of this study also highlight the importance of integrating MRI results with clinical symptoms. As seen in the results, a high percentage of participants reported clinical symptoms such as back pain (75%), numbness (50%), and neck pain (20%), which are commonly associated with the conditions under investigation. These symptoms were consistent with previous literature, where back pain and numbness were found to be key indicators of disc herniation and spinal stenosis[18]. However, the presence of symptoms alone may not always correlate with the severity of the condition, which emphasizes the need for objective imaging to guide treatment decisions.

Conclusion:

This study provides a comprehensive evaluation of the diagnostic effectiveness of Magnetic Resonance Imaging (MRI) in detecting spinal conditions, including disc herniation, spinal stenosis, and spondylolisthesis. MRI was found to be highly effective in diagnosing disc herniation and spinal stenosis, with high sensitivity and specificity rates. The findings from this study confirm MRI's critical role as a non-invasive and reliable tool for diagnosing these conditions, consistent with the growing body of research supporting its use in clinical settings.

However, MRI's diagnostic sensitivity for spondylolisthesis was lower, particularly in mild cases, which aligns with previous studies that have highlighted the challenges in detecting subtle vertebral displacements. This limitation emphasizes the need for additional imaging techniques, such as CT scans, to enhance the diagnostic accuracy for conditions like spondylolisthesis.

Despite its effectiveness, MRI's specificity for spinal stenosis and spondylolisthesis was lower, indicating the potential for false positives. This calls for careful interpretation of MRI results in conjunction with clinical symptoms and other diagnostic findings. In conclusion, while MRI remains the gold standard for diagnosing disc herniation and spinal stenosis, further advancements are required to improve its diagnostic performance for spondylolisthesis. Future studies should focus on enhancing MRI protocols and incorporating multimodal imaging techniques to address these challenges and improve diagnostic outcomes for spinal conditions.

Limitations and Recommendation:

While this study provides valuable insights into the diagnostic performance of MRI, it is not without limitations. The sample size of 100 participants, although sufficient for this analysis, may not be large enough to account for all variations in spinal conditions across different populations. Furthermore, the cross-sectional design of the study limits the ability to assess the progression of spinal conditions over time. Future research should consider a longitudinal design to observe changes in MRI findings and clinical symptoms over time. Additionally, studies involving larger and more diverse samples would help generalize the findings to broader populations. Advanced MRI techniques, such as high-field MRI or 3D imaging, may also improve the diagnostic accuracy for conditions like spondylolisthesis, which remain challenging to diagnose with standard MRI protocols.

REFERENCES

Santiago J, Kim S, Lee J. Structural and Functional Anatomy of the Spinal Column. Journal of Spinal Disorders. 2017;25(3):245-258.

Wang L, Zhang M, Xu H. Diagnostic Value of MRI in Cervical Disc Herniation: A Retrospective Study. Spinal Surgery Journal. 2024;29(5):1123-1132.

Tian X, Li Y, Zhang X. Age-related Changes in Lumbar Disc Herniation and Spinal Stenosis: A Systematic Review. Journal of Geriatric Spine Research. 2021;15(4):213-221.

MacLean A. Comparative Analysis of MRI Sensitivity for Spinal Stenosis in Men and Women. Spine Research. 2024;30(4):512-519.

Sobański J, Chmielnicki D, Nowak M. Low Back Pain and Its Association with Spinal Disorders: A Comprehensive Literature Review. Pain Management Studies. 2023;32(6):287-296.

Kim S, Park Y, Lee J. Cervical Spine Disorders and Their Clinical Presentation: The Role of MRI in Diagnosis and Treatment. Journal of Neurology and Orthopedics. 2022;27(3):221-229.

Zhang H, Wang L, Li J. Advanced MRI Techniques for Diagnosing Mild Spondylolisthesis. Journal of Advanced Imaging. 2023;16(3):451-460.

Prablek K, Taylor S, Hernandez M. The Role of MRI in Early Diagnosis of Cervical Disc Herniation and Its Treatment Outcomes. Journal of Clinical Neuroscience. 2023;19(2):102-110.

Crawford G, Yang R, DeFazio M. The Role of MRI in Diagnosing and Managing Spinal Disorders. Spinal Research. 2022;28(1):142-150.

Zhang H, Wang L, Li J. Advanced MRI Techniques for Diagnosing Mild Spondylolisthesis. J Adv Imaging. 2023;16(3):451-460.

Sobański J, Chmielnicki D, Nowak M. Low Back Pain and Its Association with Spinal Disorders: A Comprehensive Literature Review. Pain Manag Stud. 2023;32(6):287-296.

Crawford G, Yang R, DeFazio M. The Role of MRI in Diagnosing and Managing Spinal Disorders. Spinal Res. 2022;28(1):142-150.

Prablek K, Taylor S, Hernandez M. The Role of MRI in Early Diagnosis of Cervical Disc Herniation and Its Treatment Outcomes. J Clin Neurosci. 2023;19(2):102-110.

Wang L, Zhang M, Xu H. Diagnostic Value of MRI in Cervical Disc Herniation: A Retrospective Study. Spinal Surg J. 2024;29(5):1123-1132.

Tian X, Li Y, Zhang X. Age-related Changes in Lumbar Disc Herniation and Spinal Stenosis: A Systematic Review. J Geriatr Spine Res. 2021;15(4):213-221.

Wang L, Zhang M, Xu H. Diagnostic Value of MRI in Cervical Disc Herniation: A Retrospective Study. Spinal Surg J. 2024;29(5):1123-1132.

Salvi M, Fernandez C, Lopez A. Gender Differences in Chronic Low Back Pain and Spinal Degeneration: A Review of Epidemiological Studies. Spine Res. 2025;41(2):112-121.

Santiago J, Kim S, Lee J. Structural and Functional Anatomy of the Spinal Column. Journal of Spinal Disorders. 2017;25(3):245-258.