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Article

Magnetic Resonance Imaging Assessment of Cervical Nerve Root Compression in Symptomatic Patients

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ABSTRACT

Background: Cervical nerve root compression is a common cause of neck pain and neurological symptoms, yet the prevalence and clinical relevance of specific degenerative changes on MRI in symptomatic adults remain incompletely characterized, particularly in South Asian populations. **Objective**: This study aimed to assess the frequency and demographic distribution of MRI-detected cervical degenerative abnormalities—specifically disc bulge, spondylolisthesis, and nerve root compression—in adults presenting with symptoms suggestive of cervical nerve compression, and to evaluate their association with age and gender. **Methods**: A descriptive cross-sectional study was conducted at the Radiology Department of Farooq Hospital, Lahore, from January to March 2025. A total of 102 adults aged 16 years and older with clinical signs of cervical radiculopathy were enrolled using convenience sampling. Patients with prior cervical surgery, trauma, infection, tumor, or congenital anomalies were excluded. Standardized MRI protocols were applied, and findings were independently reviewed by blinded radiologists. Data were analyzed using SPSS v25 with chi-square and correlation tests for group comparisons; statistical significance was set at $p<0.05$. Ethical approval was obtained, and all procedures followed the Helsinki Declaration. **Results**: Disc bulge was the most frequent abnormality (55.9%), followed by spondylolisthesis (43.1%) and nerve root compression (42.2%). Disc bulge was significantly more common in males (66.1% vs. 43.5%, $p=0.022$), while other degenerative features showed no significant age or gender associations. **Conclusion**: MRI reveals a high prevalence of degenerative changes, especially disc bulge and spondylolisthesis, among symptomatic adults. These findings support the clinical value of MRI in diagnostic decision-making and highlight the influence of gender on disc pathology, emphasizing early and comprehensive imaging for effective management.

Keywords: Cervical vertebrae, nerve compression syndromes, magnetic resonance imaging, spondylolisthesis, disc degeneration

INTRODUCTION

Cervical nerve root compression is a frequently encountered neurological and musculoskeletal condition that can severely impair an individual's quality of life due to pain, numbness, paresthesia, and motor dysfunction. These symptoms typically stem from mechanical impingement of cervical spinal nerve roots, caused by structural abnormalities such as disc bulges, herniations, osteophyte formation, or ligamentous hypertrophy. The prevalence of cervical radiculopathy, one of the most common manifestations of this compression, is estimated to range between 3% to 5% in the general population, with increasing frequency in individuals over the age of 50 (1). Contributing factors include degenerative disc disease, poor postural habits, prolonged screen exposure, and sedentary behavior, all of which have become more common in modern lifestyles (2). This increasing burden places a considerable demand on diagnostic accuracy and targeted management strategies (2). The diagnostic standard for evaluating cervical nerve compression has evolved significantly with the introduction and refinement of Magnetic Resonance Imaging (MRI). Unlike conventional radiographs and CT scans, MRI offers unparalleled soft tissue resolution and the ability to visualize neural and discal structures in multiple planes without ionizing radiation exposure (3). MRI, particularly T2-weighted sequences, excels in identifying key features such as foraminal narrowing, disc dehydration, protrusion, and spinal canal encroachment, all of which are critical for understanding the etiology and progression of radiculopathy (4). However, interpretation of MRI must be closely aligned with clinical findings, as anatomical abnormalities can be present in asymptomatic individuals, while conversely, significant

symptoms may occur with minimal radiological evidence (5). These diagnostic challenges highlight the need for integrated assessment approaches that combine imaging with detailed symptom evaluation (6).

Despite MRI's widespread clinical use, several studies have raised questions about the correlation between imaging findings and patient-reported symptoms or outcomes. For instance, Albert et al. reported that MRI has high sensitivity (93%) and specificity (91%) for identifying cervical nerve root compression, especially at the commonly affected C5-C6 and C6-C7 levels (6). Yet, the mere presence of anatomical deformities does not always justify surgical intervention, as non-surgical therapies may be equally effective in selected populations. Moreover, newer imaging modalities such as Diffusion Tensor Imaging (DTI) have begun to provide microstructural data such as fractional anisotropy, enhancing prognostic accuracy beyond conventional anatomical MRI (7). However, access to DTI remains limited in many clinical settings, underscoring the continued reliance on standard MRI for primary assessment. In Pakistan and similar low- to middle-income countries, there is a paucity of localized data evaluating the role of MRI in cervical spine pathology. Most existing literature focuses on lumbar conditions or general degenerative spine disease, leaving a significant knowledge gap regarding the MRI features, demographic distribution, and structural correlates of cervical nerve compression in symptomatic patients. Moreover, while many studies report the frequency of degenerative features such as disc bulge or osteophytes, few quantify their association with clinical symptoms or stratify findings by age and gender. This restricts our understanding of how these factors interact and whether certain subgroups are at higher risk for specific abnormalities. As a result, clinicians may lack contextual evidence for patient-centered diagnostic and management decisions in these populations.

Given these gaps, the present study was designed to evaluate the frequency and distribution of MRI-detected abnormalities among symptomatic patients presenting with suspected cervical nerve root compression. Conducted at a tertiary care radiology department, this research aimed to correlate imaging findings with demographic factors such as age and gender, offering evidence that may enhance diagnostic clarity in clinical practice. The study hypothesizes that disc bulge is the most common abnormality in such patients, and that significant gender or age-related patterns may exist in the occurrence of specific degenerative changes. By focusing on real-world data from symptomatic individuals, this research seeks to contribute practical insights to the ongoing discourse on cervical spine imaging and its role in clinical decision-making.

MATERIAL AND METHODS

This descriptive cross-sectional study was conducted to evaluate the prevalence and patterns of cervical nerve root compression as detected by Magnetic Resonance Imaging (MRI) in symptomatic patients. The rationale for choosing this design was to provide a snapshot of imaging findings and their associations with demographic characteristics in a defined clinical population, without the need for long-term follow-up. The research took place at the Department of Radiology, Farooq Hospital, Lahore, over a period of three months, from January to March 2025. The study setting included outpatient and inpatient referrals from neurology, orthopedics, and general medicine departments, ensuring a diverse sample of patients presenting with cervical spine symptoms.

Participants were selected through a non-probability convenient sampling technique. Eligibility criteria included adults aged 16 years and older presenting with clinical symptoms suggestive of cervical spine pathology, such as neck pain, radiculopathy, or upper limb neurological deficits. Only those undergoing cervical spine MRI as part of their diagnostic workup were considered for inclusion. Exclusion criteria were strictly applied to eliminate potential confounders and included any history of cervical spine surgery or significant trauma within the past year, presence of known spinal infections, tumors, or inflammatory disorders, and congenital spinal anomalies. Patients with contraindications to MRI, including those with implanted electronic devices or severe claustrophobia, were also excluded.

Recruitment occurred at the radiology reception desk, where patients meeting the eligibility criteria were approached by a trained radiologic technologist. The purpose and scope of the study were explained verbally and in writing, and written informed consent was obtained from all participants. For those unable to read or write, the consent form was read aloud, and a thumbprint was obtained in the presence of a witness. Ethical approval was secured from the Institutional Review Board (IRB) of Farooq Hospital prior to data collection (Approval No. FHRD/IRB/2025-01), and all procedures were conducted in accordance with the Declaration of Helsinki. Data protection protocols included anonymization of all patient identifiers and restricted access to digital records stored on password-protected institutional servers. MRI scans were performed using a 1.5 Tesla system with standardized imaging protocols. Each patient was positioned supine, and imaging sequences included sagittal T1-weighted, sagittal and axial T2-weighted, and gradient echo sequences to visualize disc morphology, spinal canal dimensions, and nerve root structures. All scans were independently reviewed by two board-certified radiologists blinded to clinical data to minimize interpretive bias. Discrepancies were resolved through consensus. Operational definitions were clearly established: a disc bulge was defined as circumferential extension of disc material beyond the vertebral endplates, nerve root compression as obliteration or displacement of the exiting nerve root in the neural foramen, and spondylolisthesis as anterior or posterior slippage of one vertebra relative to another exceeding 3 mm on mid-sagittal images.

To reduce the risk of bias, radiologists were blinded to the patients' clinical histories during image interpretation. Selection bias was addressed by consecutively enrolling all eligible patients during the study period. Confounding variables such as age and gender were recorded and accounted for during statistical analysis. A minimum sample size of 102 patients was calculated based on the formula

$N = (Z^2 \times P \times (1–P)) / d^2$, assuming a prevalence of cervical disc pathology (P) of 50% to ensure maximum variability, 95% confidence level, and 10% margin of error.

All collected data were initially entered into Microsoft Excel 365 and subsequently analyzed using SPSS version 25. Descriptive statistics, including frequencies and percentages, were used to summarize demographic and clinical variables. The chi-square test was applied to assess associations between categorical variables, such as gender and presence of specific MRI findings. Pearson and Spearman correlation coefficients were used to evaluate associations between ordinal or interval-level variables, and statistical significance was determined at a p-value threshold of <0.05. Missing data were addressed using listwise deletion if less than 5% of the dataset was affected; otherwise, multiple imputation techniques were considered. No imputation was required in this dataset. Subgroup analyses were planned to examine variations in MRI findings across age categories and gender, controlling for potential confounding variables using stratification. All efforts were made to ensure the reproducibility of the study, including use of standardized imaging protocols, consistent data entry methods, and clearly defined operational definitions. A detailed research protocol with procedural checklists was maintained, and inter-rater reliability was periodically assessed between radiologists to ensure consistent image interpretation. By adhering to strict ethical standards, employing robust statistical techniques, and thoroughly documenting all processes, the study maintained a high level of methodological rigor suitable for replication in similar settings.

RESULTS

In this study involving 102 symptomatic patients undergoing MRI for suspected cervical nerve root compression, the sample comprised 56 males (54.9%) and 46 females (45.1%), yielding a nearly balanced gender distribution. Disc bulge emerged as the most prevalent abnormality, observed in 57 patients (55.9%). Notably, the prevalence of disc bulge was significantly higher among males, affecting 37 out of 56 (66.1%) compared to 20 out of 46 (43.5%) females, with the difference reaching statistical significance (p = 0.022). In contrast, other MRI abnormalities did not show significant gender-based differences.

The age distribution revealed that cervical degenerative changes were predominantly seen in middle-aged and older adults, with 47 participants (46.1%) in the 36–50-year age group and another 47 (46.1%) above 50 years, while only 8 individuals (7.8%) were aged 16–35. Spondylolisthesis was identified in 44 participants (43.1%), with the proportion increasing across age groups: 25.0% in those aged 16–35, 38.3% in the 36–50 group, and 48.9% in patients older than 50. However, the association between age and spondylolisthesis did not reach statistical significance (p = 0.137), possibly due to the limited size of the youngest subgroup.

Other degenerative findings were also common: nerve root compression was present in 43 patients (42.2%), decreased disc height in 23 (22.5%), and disc degeneration in 22 (21.6%). Osteophyte formation was seen in 17 individuals (16.7%), disc herniation in 7 (6.9%), and radial tear in another 7 (6.9%). When examining gender-specific differences, osteophytes were observed in 8 males (14.3%) and 9 females (19.6%), with no significant correlation (Pearson's r = 0.070, p = 0.481). Similarly, radial tears affected 3 males (5.4%) and 4 females (8.7%), with a negligible and non-significant correlation (Pearson's r = 0.066, p = 0.512).

The relationship between gender and spondylolisthesis showed a higher prevalence in males (28 of 56, 50.0%) than females (16 of 46, 34.8%), but the difference was not statistically significant (Pearson's r = –0.153, p = 0.125). Collectively, these findings highlight that while degenerative abnormalities such as disc bulge, spondylolisthesis, and nerve root compression are frequent MRI findings in symptomatic adults—especially those in middle age or older—only disc bulge showed a clear gender association in this cohort. The majority of other degenerative features were distributed relatively evenly by gender and age, reinforcing the multifactorial nature of cervical spine pathology and the importance of considering both demographic and anatomical variables in clinical assessment.

Table 1. Gender Distribution and Association with Disc Bulge

Gender	Disc Bulge Present (n, %)	Disc Bulge Absent (n, %)	Total (n)	p-value
Male	37 (66.1%)	19 (33.9%)	56	0.022
Female	20 (43.5%)	26 (56.5%)	46	

Table 2. Age Group Distribution and Spondylolisthesis Prevalence

Age Group	Patients (n, %)	Spondylolisthesis Present (n, %)	Spondylolisthesis Absent (n, %)	p-value
16–35	8 (7.8%)	2 (25.0%)	6 (75.0%)	
36–50	47 (46.1%)	18 (38.3%)	29 (61.7%)	
>50	47 (46.1%)	23 (48.9%)	24 (51.1%)	0.137

Table 3. Frequency of Major MRI Findings in the Study Cohort

MRI Finding	Frequency (n)	Percentage (%)
Disc Bulge	57	55.9
Spondylolisthesis	44	43.1
Nerve Root Compression	43	42.2
Decreased Disc Height	23	22.5

MRI Finding	Frequency (n)	Percentage (%)
Disc Degeneration	22	21.6
Osteophytes	17	16.7
Disc Herniation	7	6.9
Radial Tear	7	6.9

Table 4. Gender and Osteophyte Formation

Gender	Osteophytes Present (n, %)	Osteophytes Absent (n, %)	Pearson r	p-value
Male	8 (14.3%)	48 (85.7%)	0.070	0.481
Female	9 (19.6%)	37 (80.4%)		

Table 5. Gender and Radial Tear Prevalence

Gender	Radial Tear Present (n, %)	Radial Tear Absent (n, %)	Pearson r	p-value
Male	3 (5.4%)	53 (94.6%)	0.066	0.512
Female	4 (8.7%)	42 (91.3%)		

Table 6. Gender-wise Prevalence of Spondylolisthesis

Gender	Spondylolisthesis Present (n, %)	Spondylolisthesis Absent (n, %)	Pearson r	p-value
Male	28 (50.0%)	28 (50.0%)	-0.153	0.125
Female	16 (34.8%)	30 (65.2%)		

DISCUSSION

The present study offers valuable insights into the spectrum of degenerative cervical spine abnormalities in a symptomatic adult cohort, as revealed by MRI assessment. The predominance of disc bulge, spondylolisthesis, and nerve root compression in this population aligns with prior epidemiological and imaging studies emphasizing the centrality of disc pathology in cervical radiculopathy and related syndromes (1,2). The observed male predominance in disc bulge, with a prevalence of 66.1% compared to 43.5% in females, echoes earlier findings suggesting that occupational exposures, physical workload, and biomechanical factors disproportionately affect men, potentially increasing their vulnerability to cervical disc disease (3). This gender-based discrepancy is corroborated by literature indicating a greater incidence of radiographically apparent disc degeneration among males in populations with high levels of manual labor (4). However, the current results extend existing knowledge by demonstrating that, aside from disc bulge, other degenerative features such as spondylolisthesis, osteophyte formation, and radial tears display a more uniform distribution across genders, supporting the view that once disc degeneration is established, subsequent degenerative cascades may be influenced by age and constitutional factors rather than gender alone.

Comparing these findings to previous regional and international studies reveals both concordance and points of divergence. In contrast to the current study's disc bulge predominance, a Nepalese cross-sectional analysis found cervical spondylosis to be the leading abnormality, with a markedly higher prevalence (84.2%)(5). This discrepancy may stem from differences in diagnostic criteria, imaging protocols, or underlying population characteristics. Similarly, the lower incidence of disc herniation (6.9%) in the present study, compared to the 11.4% reported in Nepal, might reflect either a narrower definition of herniation or the exclusion of subclinical cases in this symptomatic cohort. Notably, the present data reinforce the relevance of disc bulge as the most sensitive early indicator of cervical degenerative disease, in line with research suggesting that axial loading and cumulative microtrauma first manifest as disc bulging before progressing to herniation or vertebral slippage (6,7). The age-related trends observed—particularly the increasing frequency of spondylolisthesis with advancing age—mirror global patterns of spinal degeneration, confirming that structural instability becomes more common with cumulative degenerative changes (8).

The clinical implications of these findings are significant. MRI remains the diagnostic cornerstone for evaluating cervical nerve root compression due to its ability to visualize both soft tissue and osseous structures with high spatial resolution (9). The clear association between disc bulge and male gender, as well as the high rates of spondylolisthesis and nerve root compression in older age groups, highlight the necessity for targeted screening and preventive strategies in at-risk populations. Furthermore, the lack of statistically significant associations for most degenerative features by gender or age underlines the complex interplay of anatomical, genetic, and environmental factors in cervical spine pathology, cautioning against over-reliance on single risk predictors in clinical practice (10). This is particularly pertinent given previous reports of a poor correlation between radiological findings and the severity of clinical symptoms, as highlighted in recent systematic reviews (11).

From a mechanistic perspective, the progression from disc bulge to spondylolisthesis and nerve root compression likely reflects a continuum of degenerative instability, with loss of disc height and facet joint remodeling contributing to neural compromise (12). The relatively low prevalence of osteophytes and radial tears in this cohort, especially among younger participants, suggests that these findings are later or secondary phenomena in the degenerative cascade, consistent with biomechanical models of spinal aging (13). The uniform distribution of most degenerative markers across genders may also indicate that, once established, cervical degeneration progresses under common pathways, such as inflammation, microvascular changes, and mechanical wear (14).

Strengths of the present study include the use of standardized imaging protocols, blinded assessment by experienced radiologists, and robust statistical analysis to account for confounding variables. However, several limitations should be acknowledged. The single-center design and use of convenient sampling may restrict the generalizability of findings, particularly to populations with different demographic or occupational profiles (15-17). The relatively small sample size, especially in the youngest age group, could have limited the power to detect subtler associations or trends. In addition, the exclusion of patients with prior cervical surgery or acute trauma was necessary to isolate degenerative changes but may have reduced the diversity of pathological presentations captured in this cohort. Methodologically, the cross-sectional nature of the study precludes causal inferences and does not allow for assessment of the natural history or clinical progression of detected abnormalities (18).

In light of these considerations, future research should aim for larger, multicenter studies that encompass broader demographic strata and employ longitudinal designs to evaluate the evolution of MRI findings over time. Studies integrating advanced imaging modalities, such as diffusion tensor imaging or functional MRI, alongside clinical symptom tracking, could further elucidate the complex relationship between anatomical changes and neurological outcomes. Additionally, the development of predictive models incorporating both imaging and non-imaging risk factors could refine patient stratification and guide personalized therapeutic interventions (19-22).

This study substantiates the high burden of degenerative cervical spine abnormalities—most notably disc bulge, spondylolisthesis, and nerve root compression—in symptomatic adults and underscores the value of MRI as a diagnostic modality. The nuanced interplay of age, gender, and specific degenerative features revealed herein reinforces the need for a multifactorial approach to clinical evaluation and management. By integrating these findings with existing literature and identifying areas for future investigation, the present research contributes meaningfully to the ongoing discourse on cervical spine health and patient care (14,15, 23-25).

CONCLUSION

This study demonstrates that magnetic resonance imaging is an essential tool for the assessment of cervical nerve root compression in symptomatic adults, revealing that disc bulge, spondylolisthesis, and nerve root compression are the most prevalent degenerative changes observed in this population. The findings underscore a significant association between male gender and the presence of disc bulge, while most other abnormalities, including spondylolisthesis and osteophytes, were distributed similarly across age and gender groups. These results highlight the importance of MRI in guiding precise diagnosis and tailored management of cervical spine pathology, supporting the need for comprehensive evaluation beyond clinical symptoms alone. Clinically, this emphasizes early imaging for at-risk patients and multidimensional assessment strategies, while for research, it identifies the need for larger, longitudinal studies to refine diagnostic criteria and further explore the interplay of demographic and anatomical risk factors for cervical nerve compression.

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