# MRI-Based Evaluation and Grading of Cervical Spine Degeneration in Indian Patients with Neck Pain: A Cross-Sectional Study

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**Abstract**

**Background:** Cervical degenerative disc disease (DDD) is a leading cause of neck pain, yet population-specific data on its MRI-based grading in Indian patients remains limited. This study evaluates degenerative changes in the cervical spine using MRI and correlates findings with clinical presentation.

**Methods:** A cross-sectional study of 60 patients (mean age 49.2±12.4 years; 53.3% female) with neck pain was conducted. Participants underwent 1.5T MRI with sagittal T1/T2 and axial T2 sequences. Degenerative changes (disc degeneration, protrusions, disc space narrowing, foraminal stenosis) were graded using standardized criteria.

**Results:** The C5-C6 level showed the highest degeneration (60% Grade 2), followed by C4-C5 (45% Grade 2). Posterior protrusions predominated (81.7% at C5-C6), with 31.7% causing cord compression (Grade 2). Disc space narrowing was nearly universal at C5-C6 (95%) and C6-C7 (100%). Foraminal stenosis peaked at C5-C6 (63.3%). Age stratification revealed: 30–39 years: Mild changes (11.1% Grade 2), 50–59 years: 85% had ≥1 Grade 2 change; 65% multi-level involvement, ≥60 years: Universal stenosis and severe degeneration

**Conclusion:** MRI effectively delineates cervical DDD progression, with C5-C6 being the most vulnerable level. The 50–59 age group represents a critical threshold for advanced degeneration. These findings underscore the importance of MRI in diagnosing clinically relevant pathology while highlighting the need to correlate imaging with symptoms to avoid overdiagnosis of age-related changes.

**Key words:** Cervical spine, degenerative disc disease, MRI grading, foraminal stenosis, disc protrusion

## Introduction

Neck pain is a prevalent musculoskeletal issue affecting a significant portion of the global population, particularly working-age adults.[1, 2] Among the leading causes of neck pain are degenerative changes in the cervical spine, collectively known as cervical degenerative disc disease (DDD). The rising prevalence of cervical DDD in India is linked to poor ergonomics, sedentary lifestyles, and aging. [3, 4] These changes involve structural deterioration of the intervertebral discs, vertebral bodies, facet joints, and surrounding ligaments, often leading to pain, stiffness, and neurological symptoms such as radiculopathy or myelopathy.[5, 6]

Cervical spine degeneration is a multifactorial condition predominantly resulting from age-related wear and tear, genetic predisposition, and lifestyle-related stressors. In India, the surge in sedentary jobs, poor posture,

and increased screen time has contributed to a higher prevalence of cervical spine disorders. Degenerative changes include disc desiccation, protrusion, narrowing of disc spaces, osteophyte formation, and foraminal stenosis, often culminating in radiculopathy or myelopathy.[7, 8]

Magnetic Resonance Imaging (MRI) has emerged as the imaging modality of choice for evaluating these changes. Its non-invasive nature and superior soft tissue contrast enable detailed visualization of intervertebral discs, nerve roots, and spinal ligaments without ionizing radiation.[9, 10] MRI sequences such as T1-weighted, T2-weighted, and STIR allow for differentiation of tissues based on water and fat content, offering precise anatomical and pathological evaluation.[11, 12] Even though the neck pain due to various reasons is very common, there is gap in population-specific data as limited MRI-based grading data exist for Indian patients with cervical DDD.[13, 14]

This study aims to evaluate and grade degenerative changes in the cervical spine using MRI in Indian patients presenting with neck pain. By establishing an MRI-based grading system and identifying common degenerative patterns, the findings will provide valuable insights for spinal radiology in India, support evidence-based management of neck pain, and potentially influence workplace ergonomic policies.

**Objectives**

The primary objectives of this study are:

1. To evaluate, characterize, and grade the degenerative changes of the cervical spine using MRI.
2. To analyze the distribution pattern of different grades of cervical degenerative disc disease in patients from the Indian subcontinent.

**Materials and Methods**

*Study Setting and Design:* This descriptive cross-sectional study was conducted in the Department of Radiodiagnosis at Rajarajeswari Medical College and Hospital, Bengaluru. The study spanned from April 2023 to October 2024 and was approved by the Institutional Ethics Committee.

*Participants and Sampling:* The study included 60 adult patients presenting with clinical complaints of neck pain. Purposive sampling was employed to select patients who met inclusion criteria.

**Inclusion criteria:** All Patients with age >18 years and with these conditions were considered for the study**:** Disc degeneration, Posterior disc protrusion, Anterior disc protrusion, Narrowing of the disc space, Foraminal stenosis.

The patients were referred to Rajarajeswari Medical college, Radiology department for 1.5T MRI scanner (Siemens Magnetom Avanto Tim [76 x 18]). They were included in the study after obtaining informed consent.

**Exclusion criteria:** Patients who are detected to have these conditions were excluded from the study: Cervical spine fracture**,** Spinal cord lesion like intramedullary tumors, demyelination, etc. and Patients who are diagnosed with spondylolisthesis

*Imaging Protocol* MRI was performed using a 1.5 Tesla Siemens Magnetom Avanto Tim scanner. The cervical spine protocol included:

- Sagittal T1-weighted Fast Spin Echo (FSE)
- Sagittal T2-weighted FSE
- Axial T2-weighted FSE
- Sagittal STIR (Short Tau Inversion Recovery)
- MR Myelography (heavily T2-weighted sequences) These sequences allowed for comprehensive evaluation of disc signal intensity, disc height, disc protrusion, spinal canal dimensions, and neural foramina.

*Grading System* Degenerative changes were graded using a semi-quantitative system adapted from the Pfirrmann and Suzuki classifications. Parameters included:

- Disc degeneration (Grades 0 to 2 based on signal intensity)
- Posterior disc protrusion (Grade 0: none, Grade 1: mild, Grade 2: with cord compression)
- Anterior disc protrusion (Grade 0: none, Grade 1: protrusion beyond margin)
- Disc space narrowing (Grades 0 to 2 by height reduction)
- Foraminal stenosis (Grade 0: fat preserved, Grade 1: obliterated)

*Data Collection and Analysis* Patient demographics and MRI findings were recorded and tabulated. Descriptive statistics summarized frequencies and distributions. Data were stratified by age group and vertebral level to assess anatomical and temporal patterns. Statistical analysis was conducted using SPSS version 26.

**Results**

The study included 60 patients presenting with neck pain, with the majority falling within the 50–59 age group (33.33%, n=20), followed closely by the 40–49 age group (31.67%, n=19). Older patients (60–69 years) accounted for 16.67% (n=10), while younger adults (30–39 years) represented 15% (n=9). The 70+ age group was the smallest, with only 3.33% (n=2). A slight female predominance was observed (53.33%, n=32) compared to males (46.67%, n=28).

*Disc Degeneration* The severity of disc degeneration increased caudally, peaking at C5-C6, where 60% of patients exhibited Grade 2 degeneration. C4-C5 was the second most affected segment (45% Grade 2). Mild

changes (Grade 1) predominated at C3-C4, while C2-C3 and C7-T1 showed minimal involvement. Degeneration strongly correlated with advancing age, particularly in the fifth and sixth decades.

*Posterior Disc Protrusion* Posterior disc protrusion was observed in a majority of patients, with the highest frequency at C5-C6 (81.7%) and C4-C5 (75%). Grade 1 protrusions were more common than Grade 2, which was present in 31.7% at C5-C6. Posterior protrusions were least frequent at C7-T1 (16.7%), where 83.3% of patients showed no abnormality.

*Anterior Disc Protrusion* Anterior protrusions were generally mild and less prevalent than posterior ones. The most affected level was C7-T1 (40%), followed by C6-C7. No patients exhibited Grade 2 anterior protrusion, and this finding showed less correlation with symptoms compared to posterior changes.

*Disc Space Narrowing* Disc height reduction was most frequent at C6-C7 (100% Grade 1). C5-C6 and C4-C5 also showed significant narrowing. Severe disc space loss (Grade 2) was rare, found only in a few cases across C2-C3 to C5-C6. All other segments exhibited predominantly mild narrowing.

*Foraminal Stenosis* Foraminal stenosis was most common at C5-C6 (63.3%), followed by C4-C5 (55%) and C6-C7 (53.3%). The least affected levels were C2-C3 and C7-T1. The presence of stenosis corresponded to reported symptoms of radiculopathy in several patients.

The study revealed a clear age-related progression in degenerative changes. Patients aged 30–39 showed minimal abnormalities. Degeneration began to manifest in the 40s, became pronounced in the 50s, and was nearly universal by the 60s. Disc degeneration and foraminal stenosis were particularly significant markers of advancing age.

These findings highlight the pivotal role of MRI in detecting and grading cervical spine degeneration, particularly in the mid-cervical region (C4-C6), which bears the highest biomechanical stress. The results also underscore the importance of correlating imaging findings with clinical symptoms to avoid overdiagnosis, as degenerative changes are common even in asymptomatic individuals.

**Table 1: Demographic Distribution**

| **Parameter** | **Value (n=60)** |
|---|---|
| **Mean Age** | 49.2 ± 12.4 years |
| **Age Groups** | 30-39: 15% (9) |
| | 40-49: 31.7% (19) |
| | 50-59: 33.3% (20) |
| | 60-69: 16.7% (10) |
| | 70+: 3.3% (2) |
| **Gender** | Male: 46.7% (28) |
| | Female: 53.3% (32) |

**Table 2: Degenerative Changes by Spinal Level**

| Level | Severe Degeneration (Grade 2) | Posterior Protrusion (Grade 1+2) | Foraminal Stenosis |
|---|---|---|---|
| C2-C3 | 25.0% | 55.0% | 31.6% |
| C3-C4 | 28.3% | 66.7% | 51.6% |
| C4-C5 | 45.0% | 75.0% | 55.0% |
| C5-C6 | **60.0%** | **81.7%** | **63.3%** |
| C6-C7 | 33.3% | 70.0% | 53.3% |
| C7-T1 | 8.3% | 16.7% | 30.0% |

**Table 3: Age-Related Progression**

| Age Group | Patients with ≥1 Grade 2 Change | Multi-level Involvement (≥3 levels) |
|---|---|---|
| 30-39 | 11.1% | 0% |
| 40-49 | 36.8% | 15.8% |
| 50-59 | **85.0%** | **65.0%** |
| 60-69 | 100% | 90% |
| 70+ | 100% | 100% |

## Discussion

This study confirms that cervical degenerative disc disease is most prevalent at the mid-to-lower cervical levels, especially C5-C6 and C4-C5. The C5-C6 level emerged as the most severely affected segment, with 60% of patients exhibiting Grade 2 (moderate/severe) disc degeneration. This finding is consistent with Okada et al. (2011), who identified C5-C6 as the most frequently degenerated level in symptomatic patients.[15] Biomechanically, these segments endure the highest motion and load, making them susceptible to early degeneration. Conversely, the C7-T1 level showed minimal degeneration (75% Grade 0), which aligns with its transitional anatomy and reduced mobility compared to mid-cervical segments.

Posterior disc protrusions were significantly more common than anterior protrusions, particularly at C5-C6 (81.7% prevalence, with 31.7% classified as Grade 2). This is clinically significant, as posterior protrusions are more likely to compress neural structures, leading to radiculopathy or myelopathy. The study's results corroborate the work of Teresi et al. (1987), who noted that posterior protrusions often correlate with symptomatic nerve root compression.[16]

The near-universal presence of disc space narrowing at C5-C6 (95% Grade 1) and C6-C7 (100% Grade 1) underscores the cumulative effects of mechanical stress and aging on cervical spine integrity. Foraminal stenosis followed a similar trend, peaking at C5-C6 (63.3% Grade 1) and showing a clear age-dependent progression. By the 60–69 age group, 100% of patients exhibited some degree of foraminal stenosis, reflecting the advanced degenerative changes typical of this demographic. These findings align with Kettler and Wilke (2005), who associated stenosis with osteophyte formation and facet joint arthropathy.[17]

The study reaffirms MRI's superiority over X-rays and CT scans in detecting early degenerative changes, such as disc desiccation (evidenced by decreased T2 signal intensity) and subtle neural compression. However, the high prevalence of asymptomatic degeneration—36% in patients under 40, per Teresi et al. (1987)—highlights the need for careful clinical correlation.[16] Overreliance on imaging without symptom correlation may lead to unnecessary interventions.

**Limitations** The study is limited by its small sample size and single-institution design, which may not represent the broader Indian population. The cross-sectional nature precludes longitudinal assessment of symptom progression or response to treatment. Also, the absence of clinical outcome measures restricts correlation between imaging findings and functional disability. The lack of a control group of asymptomatic individuals makes it difficult to definitively link imaging findings to clinical symptoms.

**Conclusion**

This study systematically characterizes cervical DDD in an Indian population, emphasizing the pivotal role of MRI in diagnosis and grading. MRI is a highly effective tool for evaluating cervical spine degeneration. The most frequently affected levels are C5-C6 and C4-C5. Degenerative changes increase with age and are detectable even in asymptomatic individuals, underscoring the need for cautious interpretation. Routine MRI can significantly aid in early diagnosis, management planning, and monitoring progression. By integrating these imaging findings with clinical assessments, healthcare providers can optimize treatment strategies—prioritizing conservative management for mild cases and surgical intervention for severe neural compression. Future research should explore longitudinal trends and the impact of lifestyle modifications on disease progression.

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**Conflicts of Interest** None declared.

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**Ethical Approval** Approved by the Institutional Ethics Committee of Rajarajeswari Medical College and Hospital, Bengaluru.

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