DOI: 10.7860/JCDR/2026/89546.24010

Original Article

Anatomy Section

Comparative Evaluation of Kang and Lee MRI Grading Systems in Cervical Spinal Canal Stenosis with Clinical and Morphometric Correlation: A Cross-sectional Study

JYOTSNA GANGERA[1], KV RAJASEKHAR[2], S SARAVANA KUMAR[3], BI NAVINKUMAR[4], V YAKAIAH[5]

ABSTRACT

Introduction: Cervical spinal canal stenosis is a common cause of neurological deficit, and Magnetic Resonance Imaging (MRI) plays a key role in assessing its severity. Qualitative grading systems, such as the Kang and Lee classifications, are widely used, while morphometric indices, such as the Torg-Pavlov ratio, provide objective assessment. However, direct comparative evaluation of these systems with clinical correlation remains limited.

Aim: To compare Kang and Lee's MRI grading systems and evaluate the association of Kang grade with clinical symptoms and the Torg-Pavlov ratio.

Materials and Methods: This cross-sectional study included 150 patients who underwent cervical spine MRI at the Malla Reddy Institute of Medical Sciences, Hyderabad, Telangana, India, from April 2023 to October 2024. Stenosis severity was graded using the Kang and Lee grading systems. Clinical symptoms, including neck pain, radiculopathy, and myelopathy, were recorded. Canal and vertebral body diameters were measured to calculate the Torg-Pavlov ratio. Agreement between grading systems was assessed using weighted kappa statistics. Associations with clinical symptoms were analysed using the Chi-square test, and correlations with the Torg-Pavlov ratio were assessed using Spearman's correlation.

Results: The mean age of the study population was 54.53±11.46 years, with equal gender distribution. Neck pain was present in 99 patients (66.0%) radiculopathy in 63 (42.0%), and myelopathy in 42 (28.0%). According to Kang grading, Grade 0, 1, 2, and 3 were observed in 19.3%, 27.3%, 25.3%, and 28.0%, respectively, while Lee grading showed 24.7%, 32.0%, 18.0%, and 25.3%. Clinically significant stenosis (Grade ≥2) was present in 53.3% by Kang and 44.0% by Lee grading. Agreement between grading systems was excellent (κ=0.867). Severe stenosis showed significant association with myelopathy (p-value <0.001). The mean Torg-Pavlov demonstrated strong negative correlation with stenosis severity (Kang rho=-0.95, p-value <0.001; Lee rho=–0.92, p-value <0.001).

Conclusion: Kang and Lee grading systems demonstrate excellent agreement and significant clinical correlation with myelopathy. The Torg-Pavlov ratio provides a reliable quantitative measure that correlates inversely with stenosis severity, supporting the combined use of qualitative and quantitative MRI assessment in evaluating cervical spinal canal stenosis.

Keywords: Cervical canal stenosis, Cervical vertebrae, Magnetic resonance imaging, Myelopathy, Radiculopathy, Spinal cord compression

INTRODUCTION

Cervical spinal canal stenosis results from degenerative changes that reduce canal diameter and may cause neural compression. This condition is a leading cause of cervical myelopathy and contributes significantly to neurological impairment, especially among individuals in middle and older age groups [1,2]. MRI is the modality of choice for evaluating cervical spinal canal stenosis, providing direct visualisation of the spinal cord and prognostic information [3]. To standardise reporting and enhance communication between clinicians and radiologists, multiple MRI-based grading systems have been developed to categorise the severity of cervical canal stenosis. The Kang grading system classifies stenosis based on obliteration of the cerebrospinal fluid space, cord deformity, and signal changes [4]. Validation studies have shown that Kang grading aligns well with clinical presentations and is a reliable method for assessing stenosis severity [5,6]. The Lee grading system offers an alternative morphological approach for evaluating central cervical canal stenosis, incorporating assessments of canal narrowing and spinal cord contour [7]. This system has shown favourable interobserver reliability and clinical utility across multiple investigations [7,8]. However, direct comparisons of the Kang and Lee grading systems within the same patient cohorts remain relatively uncommon in the literature.

Alongside qualitative grading, quantitative metrics such as the Torg-Pavlov ratio are routinely used to objectively assess the degree of canal narrowing. The Torg-Pavlov ratio, defined as the canal-to-vertebral body diameter ratio, provides an objective measure of stenosis severity, with lower values indicating greater narrowing [9,10]. Integrating both morphological grading and quantitative indices can yield a more holistic assessment of stenosis severity. Direct comparative evaluation of the Kang and Lee grading systems, with clinical and morphometric correlation, remains limited. Clarifying the concordance and clinical significance of these grading frameworks may enhance diagnostic precision and inform therapeutic strategies. Accordingly, this cross-sectional study aims to compare the Kang and Lee MRI grading systems among patients with cervical canal stenosis and to assess their relationships with clinical symptom profiles and quantitative canal measurements, specifically the Torg-Pavlov ratio. The primary objective of the study was to assess the agreement between Kang and Lee MRI grading systems in evaluating cervical spinal canal stenosis. Secondary objectives included evaluating the distribution of stenosis severity, assessing the association between stenosis grades (Kang Grade) and clinical symptoms, and analysing correlations between stenosis severity and morphometric parameters, particularly the Torg-Pavlov ratio.

MATERIALS AND METHODS

This cross-sectional study was conducted at the Malla Reddy Institute of Medical Sciences, Hyderabad, Telangana, India a tertiary care teaching hospital, over 18 months (April 2023 to October 2024). The study was approved by the Institutional Ethics Committee (IEC No. MRIMS/DHR-IEC-88/2022), and written informed consent was obtained from all participants prior to inclusion.

Inclusion criteria: Adults aged 18 years and above presenting with neck pain, radiculopathy, or clinical features suggestive of cervical myelopathy and demonstrating degenerative changes on MRI were included in the study.

Exclusion criteria: Patients with a history of cervical spine trauma, spinal tumours, infection, prior cervical spine surgery, congenital anomalies, inflammatory spine disorders, or poor image quality precluding adequate evaluation were excluded from the study.

Sample size: Sample size was calculated based on the primary outcome of agreement between Kang and Lee grading systems using Cohen's kappa methodology. The calculation assumed a minimum acceptable agreement (κ_0=0.60), representing substantial agreement, and an expected agreement (κ_1=0.80), representing excellent agreement [11,12]. A significance level of 0.05 and 80% power was considered for analysis. Considering potential imbalance in marginal distributions, a 10% inflation factor was applied, resulting in a final sample size of 150 participants.

Study Procedure

A detailed clinical profile was recorded at baseline, including demographic variables (age and sex) and clinical features such as neck pain, radiculopathy, and myelopathy. Symptom duration was recorded in months based on patient history. Clinical variables were categorised as binary (present/absent) for statistical analysis.

All participants underwent cervical spine MRI using a standard imaging protocol, including sagittal T1-weighted, sagittal T2-weighted, axial T2-weighted, and Short Tau Inversion Recovery (STIR) sequences for comprehensive evaluation of spinal canal morphology, intervertebral discs, ligaments, and spinal cord signal. All MRI examinations were interpreted by a senior radiologist with over 20 years of experience who was blinded to detailed clinical findings. The cervical level demonstrating maximal stenosis was identified for grading and quantitative measurement.

Stenosis severity was classified using the Kang and Lee grading systems based on established MRI criteria. Kang grading classified the severity of cervical spinal canal stenosis based on cerebrospinal fluid space obliteration, spinal cord deformity, and intramedullary signal changes [4], while Lee grading primarily assessed stenosis according to the degree of subarachnoid cerebrospinal fluid space obliteration and spinal cord deformity [7]. Kang grading was used for clinical and morphometric correlation analysis due to its incorporation of cord signal changes, which are directly relevant to neurological symptoms [4].

Quantitative measurements were performed at the level of maximal stenosis. The sagittal canal diameter was measured as the shortest distance between the posterior vertebral body margin and the spino-laminar line, while the sagittal vertebral body diameter was measured at the mid-vertebral level. The Torg-Pavlov ratio was calculated as the ratio of sagittal canal diameter to sagittal vertebral body diameter [9,10]. All data were recorded in a standardised format and verified for accuracy prior to analysis.

STATISTICAL ANALYSIS

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean±standard deviation, and categorical variables as frequencies and percentages. Agreement between grading systems was assessed using weighted Cohen's kappa coefficient. Associations between stenosis grades and clinical symptoms were analysed using the Chi-square test or Fisher's exact test where appropriate. Correlation between Torg-Pavlov ratio and stenosis severity was assessed using Spearman's rank correlation coefficient. A p-value <0.05 was considered statistically significant.

RESULTS

The study included 150 patients with a mean age of 54.53±11.46 years, including 76 males (50.7%) and 74 females (49.3%). Neck pain was the most common presenting symptom, observed in 99 patients (66.0%), followed by radiculopathy in 63 (42.0%) and myelopathy in 42 patients (28.0%) [Table/Fig-1].

Variable	Value
Age (years)	
Mean±SD	54.53±11.46
Median (Range)	55.0 (32-75)
Sex, n (%)	
Male	76 (50.7)
Female	74 (49.3)
Clinical Presentation, n (%)	
Neck pain	99 (66.0)
Radiculopathy	63 (42.0)
Myelopathy	42 (28.0)
Symptom duration (months)	
Mean±SD	25.93±11.50
Median (Range)	24.0 (6-48)

[Table/Fig-1]: Demographic and clinical characteristics of the study population (N=150).

Grade wise distribution of Kang and Lee is shown in [Table/Fig-2]. Clinically significant stenosis (Grade ≥2) was present in 80 patients (53.3%) by Kang grading and 65 patients (43.3%) by Lee grading.

Grade	Kang Grade, n (%)	Lee Grade, n (%)
Grade 0	29 (19.3)	37 (24.7)
Grade 1	41 (27.3)	48 (32.0)
Grade 2	38 (25.3)	27 (18.0)
Grade 3	42 (28.0)	38 (25.3)
Clinically significant (Grade ≥2)	80 (53.3)	65 (43.3)

[Table/Fig-2]: Distribution of stenosis severity according to Kang and Lee Grading systems.

Cross-tabulation demonstrated near-perfect agreement at extreme grades. All patients classified as Kang Grade 0 corresponded to Lee Grade 0, while the majority of Kang Grade 3 cases aligned with Lee Grade 3. Some variability was observed in the intermediate grades, with partial overlap between adjacent categories. Overall, the weighted kappa indicated excellent agreement between the two grading systems (κ=0.867, 95% CI: 0.821-0.913), as illustrated in [Table/Fig-3].

A statistically significant association was observed between stenosis severity and clinical symptoms. Neck pain was present across most grades except in normal cases, without a strictly linear trend. Radiculopathy showed a distinct pattern, being more frequent in

	Lee Grade 0	Lee Grade 1	Lee Grade 2	Lee Grade 3	Total
Kang Grade 0	29 (100.0)	0 (0.0)	0 (0.0)	0	29
Kang Grade 1	8 (19.5)	29 (70.7)	4 (9.8)	0	41
Kang Grade 2	0	19 (50.0)	19 (50.0)	0	38
Kang Grade 3	0	0	4 (9.5)	38 (90.5)	42
Total	37	48	27	38	150

[Table/Fig-3]: Cross-tabulation and agreement between Kang and Lee Grading systems.

moderate stenosis and less common in severe disease. This pattern likely reflects a transition from predominant nerve root compression in moderate stenosis to spinal cord compression in advanced disease, where myelopathic features predominate. In contrast, myelopathy was exclusively associated with severe stenosis, indicating its correlation with advanced spinal cord compression [Table/Fig-4]. Clinical associations are presented using the Kang grading system, given its closer alignment with anatomical severity and its incorporation of spinal cord signal changes.

Kang Grade	Neck pain, n (%)	No neck pain, n (%)	Total
Grade 0	0	29 (100.0)	29
Grade 1	34 (82.9)	7 (17.1)	41
Grade 2	23 (60.5)	15 (39.5)	38
Grade 3	42 (100.0)	0	42
Total	99	51	150
Chi-square Test	**χ^2=88.5, df=3, p-value <0.001**		
Kang Grade	**Radiculopathy, n (%)**	**No Radiculopathy, n (%)**	**Total**
Grade 0	0	29 (100.0)	29
Grade 1	11 (26.8)	30 (73.2)	41
Grade 2	38 (100.0)	0	38
Grade 3	14 (33.3)	28 (66.7)	42
Total	63	87	150
Chi-square test	**χ^2=88.6, df=3, p-value <0.001**		
Kang Grade	**Myelopathy, n (%)**	**No Myelopathy, n (%)**	**Total**
Grade 0	0	29 (100.0)	29
Grade 1	0	41 (100.0)	41
Grade 2	0	38 (100.0)	38
Grade 3	42 (100.0)	0	42
Total	42	108	150
Chi-square Test	**χ^2=150.0, df=3, p-value <0.001**		

[Table/Fig-4]: Association between Kang Grade and clinical symptoms.
Data were presented as frequency (percentage). Association between Kang grade (0-3) and clinical symptoms (neck pain, radiculopathy, myelopathy) was analysed using Pearson's Chi-square test; Fisher's-exact test was applied where expected cell counts were <5. A p-value <0.05 was considered statistically significant

Morphometric analysis demonstrated a progressive reduction in canal diameter with increasing stenosis severity. The vertebral body diameter also showed a decreasing trend, though less pronounced. The Torg-Pavlov ratio exhibited a consistent stepwise decline across grades, supporting its role as an objective indicator of canal narrowing. These findings confirm a strong relationship between qualitative grading and quantitative anatomical measurements [Table/Fig-5].

Post-hoc analysis revealed that differences between all grades were statistically significant, indicating that each category represents a distinct level of anatomical severity. The magnitude of change was greatest between normal and severe stenosis, while consistent differences between adjacent grades further supported the validity of the grading system as an ordinal measure of disease severity [Table/Fig-6a-c].

Correlation analysis demonstrated strong inverse relationships between stenosis severity and morphometric parameters. Kang grading showed a near-perfect negative correlation with canal diameter and Torg-Pavlov ratio, indicating that increasing stenosis severity is associated with progressive anatomical narrowing. Similar trends were observed for vertebral body measurements, reinforcing the consistency between qualitative grading and quantitative assessment [Table/Fig-7].

Parameter	Kang Grade 0 (n=29)	Kang Grade 1 (n=41)	Kang Grade 2 (n=38)	Kang Grade 3 (n=42)	p-value
Canal diameter (mm)	16.82±0.34	12.88±0.65	10.70±0.55	8.64±0.51	<0.001
Vertebral body diameter (mm)	20.68±0.28	18.70±0.60	17.43±0.40	15.81±0.26	<0.001
Torg-Pavlov ratio	0.814± 0.021	0.689± 0.017	0.615± 0.035	0.546± 0.026	<0.001

[Table/Fig-5]: Comparison of Torg-Pavlov measurements across Kang Grades.
Data expressed as mean±standard deviation. Differences across Kang grades were analysed using One-way Analysis of Variance (ANOVA). A p-value <0.05 was considered statistically significant

a) Canal diameter (mm) - Mean Differences (p-value).				
Comparison	**Grade 0**	**Grade 1**	**Grade 2**	**Grade 3**
Grade 0	—	3.94 (p<0.001)	6.12 (p<0.001)	8.19 (p<0.001)
Grade 1		—	2.18 (p<0.001)	4.24 (p<0.001)
Grade 2			—	2.07 (p<0.001)
Grade 3				—
b) Vertebral body diameter (mm) - Mean Differences (p-value).				
Comparison	**Grade 0**	**Grade 1**	**Grade 2**	**Grade 3**
Grade 0	—	1.98 (p<0.001)	3.25 (p<0.001)	4.87 (p<0.001)
Grade 1		—	1.27 (p<0.001)	2.89 (p<0.001)
Grade 2			—	1.62 (p<0.001)
Grade 3				—
c) Torg-Pavlov ratio - Mean Differences (p-value).				
Comparison	**Grade 0**	**Grade 1**	**Grade 2**	**Grade 3**
Grade 0	—	0.125 (p<0.001)	0.199 (p<0.001)	0.268 (p<0.001)
Grade 1		—	0.074 (p<0.001)	0.143 (p<0.001)
Grade 2			—	0.069 (p<0.001)
Grade 3				—

[Table/Fig-6]: Post-hoc analysis - pairwise comparisons of Torg-Pavlov measurements across Kang Grades.
Post-hoc pairwise comparisons between stenosis grades were conducted using Tukey's Honestly Significant Difference (HSD) test after a significant One-way ANOVA. A p-value <0.05 was considered statistically significant

Variable	Kang Grade	Torg-Pavlov Ratio	Canal diameter	Vertebral body diameter
Kang Grade	1.000	-0.950 (p<0.001)	-0.964 (p<0.001)	-0.954 (p<0.001)
Torg-Pavlov ratio		1.000	0.989 (p<0.001)	0.907 (p<0.001)
Canal diameter			1.000	0.944 (p<0.001)
Vertebral body diameter				1.000

[Table/Fig-7]: Correlation matrix of key study variables.
Correlation between Kang grade and morphometric parameters was analysed using Spearman's rank correlation coefficient (rho). A p-value <0.05 was considered statistically significant. All tests were two-tailed

DISCUSSION

The present study demonstrated excellent agreement between Kang and Lee MRI grading systems, with strong alignment between stenosis severity, clinical presentation, and morphometric parameters. These findings reinforce the complementary roles of qualitative grading and quantitative assessment in evaluating degenerative cervical spine disease [13,14].

The demographic profile and symptom distribution observed were consistent with established epidemiology of degenerative cervical myelopathy, where axial pain predominates, and myelopathy reflects advanced disease [1,2,13]. Current clinical frameworks emphasise that imaging must correlate with neurological findings, underscoring the need for grading systems that reflect clinically meaningful severity [14].

Although both grading systems showed comparable distributions, Kang's grading system identified a slightly higher proportion of severe cases, likely because it incorporates CSF obliteration, cord deformity, and signal changes [4]. Variability in intermediate grades

reflects differences in grading thresholds and highlights the inherent subjectivity of qualitative MRI-based classification systems [8].

Excellent agreement between grading systems supports their reliability in clinical practice, consistent with prior validation studies [4,8]. However, discrepancies in intermediate grades remain clinically relevant, as treatment decisions often depend on distinguishing moderate from severe disease.

The observed clinical correlations are pathophysiologically consistent. Radiculopathy peaked in moderate stenosis and declined in severe disease, suggesting a transition from nerve root-predominant compression to cord-dominant involvement. Myelopathy was confined to severe stenosis, aligning with established disease progression and clinical guidelines [1,5,15].

Morphometric analysis showed a progressive reduction in canal diameter and Torg-Pavlov ratio with increasing severity, confirming their role as objective markers of canal narrowing [3,9,10]. However, quantitative parameters should be interpreted alongside qualitative features, as morphometry alone may not fully capture clinical relevance [16].

Strong inverse correlations between grading severity and morphometric parameters further support the anatomical validity of MRI grading, although measurements at the level of maximal stenosis may accentuate these relationships. Intramedullary signal changes remain a key marker of disease severity and prognosis, with prior studies demonstrating their association with clinical outcomes [17,18]. Integration of signal characteristics with grading and clinical parameters may further improve prognostic assessment.

A key strength of this study was the integrated evaluation of grading systems, clinical symptoms, and morphometric parameters within a single cohort, providing a more comprehensive assessment than prior studies evaluating these components independently.

The findings of this study have important clinical implications. The demonstrated agreement between Kang and Lee grading systems supports their interchangeable use in routine reporting. In addition, the strong correlation between grading severity, clinical symptoms, and morphometric parameters highlights the value of combining qualitative and quantitative MRI assessment for more accurate severity stratification. This integrated approach may aid clinicians in identifying patients at higher risk of neurological deterioration and improve decision-making in the management of cervical spinal canal stenosis.

Limitation(s)

However, limitations include the single-centre design, absence of interobserver variability assessment, lack of standardised functional scoring, and cross-sectional design, which precludes evaluation of longitudinal outcomes.

Future studies should incorporate multicentre validation, functional scales, and follow-up data to define prognostic thresholds better.

CONCLUSION(S)

In conclusion, Kang and Lee's MRI grading systems demonstrate excellent agreement in assessing cervical spinal canal stenosis and show significant correlation with clinical symptom severity. A combined qualitative and quantitative MRI approach provides a comprehensive assessment of disease severity and may improve clinical risk stratification.

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PARTICULARS OF CONTRIBUTORS:
1. PhD Scholar, Department of Anatomy, Meenakshi Academy of Higher Education and Research, Chennai, Tamil Nadu, India.
2. Professor, Department of Radiology, Meenakshi Medical College Hospital and Research Institute, Chennai, Tamil Nadu, India.
3. Associate Professor, Department of Anatomy, Meenakshi Medical College Hospital and Research Institute, Chennai, Tamil Nadu, India.
4. Professor, Department of Anatomy, Malla Reddy Institute of Medical Sciences, Suraram, Telangana, India.
5. Professor, Department of Pharmacology, Malla Reddy Medical College for Women, Suraram, Telangana, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Jyotsna Gangera,
PhD Scholar, Department of Anatomy, Meenakshi Academy of Higher Education and Research, Chennai, Tamil Nadu, India.
E-mail: Jyotsnagangera1@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Apr 25, 2026
- Manual Googling: May 23, 2026
- iThenticate Software: May 26, 2026 (1%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Apr 06, 2026**
Date of Peer Review: **Apr 28, 2026**
Date of Acceptance: **May 28, 2026**
Date of Publishing: **Aug 01, 2026**