INSIGHTS-JOURNAL OF
HEALTH AND REHABILITATION

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

COMPARATIVE ANALYSIS OF LEE AND SCHIZAS GRADING SYSTEMS IN THE MRI-BASED DIAGNOSIS OF LUMBAR CANAL STENOSIS

Original Research

Hamad Ahsan[1]*, Tasra Bibi[2], Muhammad Nauman Saleem[3]
[1]Master of Science in AHS, Department of Allied Health Sciences, Superior University Lahore, Pakistan.
[2]PhD Pathology, Assistant Professor, MLT, Department of Allied Health Sciences, Superior University Lahore, Pakistan.
[3]Master of Sciences in Diagnostic Ultrasound, University Institute of Radiological Sciences and Medical Imaging Technologies (UIRSMIT) Faculty of Allied Health Sciences (FAHS), The University of Lahore, Lahore, Pakistan.
Corresponding Author: Muhammad Nauman Saleem, Master of Sciences in Diagnostic Ultrasound, University Institute of Radiological Sciences and Medical Imaging Technologies (UIRSMIT) Faculty of Allied Health Sciences (FAHS), The University of Lahore, Lahore, Pakistan. naumansaleem72@gmail.com
Acknowledgement: The authors acknowledge the contributions of the radiology and research teams at Farooq Hospital Lahore for their support in data collection and analysis.

Conflict of Interest: None

Grant Support & Financial Support: None

ABSTRACT

Background: Lumbar canal stenosis (LCS) is a degenerative spinal condition leading to compression of neural structures, often resulting in pain and functional impairment. MRI serves as the gold standard for diagnosing LCS, with grading systems playing a crucial role in assessing stenosis severity. The LEE and SCHIZAS grading systems are widely utilized, yet their comparative reliability, clinical applicability, and diagnostic accuracy require further evaluation to optimize patient management and improve standardization in radiological assessments.

Objective: This study aimed to compare the LEE and SCHIZAS grading systems for MRI-based diagnosis of lumbar canal stenosis by assessing their inter-observer agreement, test-retest reliability, and correlation with clinical outcomes.

Methods: A cross-sectional study was conducted over four months at Farooq Hospital Lahore, including 222 patients diagnosed with LCS. MRI scans were obtained using a Toshiba 1.5T scanner, with both axial and sagittal lumbar spine images assessed. Two independent radiologists graded stenosis severity using the LEE and SCHIZAS systems. Inter-observer agreement was evaluated using Cohen's kappa, and inter-system correlation was analyzed using Spearman's coefficient. Symptom severity and functional impairment were assessed using the Oswestry Disability Index (ODI).

Results: The LEE grading system demonstrated excellent inter-observer agreement ($\kappa = 0.85$), while the SCHIZAS system showed good agreement ($\kappa = 0.78$). A strong correlation ($r = 0.82$, $p < 0.001$) was observed between the two systems. The LEE system exhibited higher sensitivity (89%) and specificity (85%) compared to the SCHIZAS system (86% sensitivity, 82% specificity). Symptom severity scores ranged from 4.2 ± 1.3 to 8.9 ± 1.7 in the LEE system and 4.3 ± 1.2 to 8.8 ± 1.6 in the SCHIZAS system. ODI scores progressively increased with stenosis severity, reaching $62.3\% \pm 12.5\%$ in LEE Grade 4 and $63.5\% \pm 11.8\%$ in SCHIZAS Grade D.

Conclusion: Both grading systems demonstrated strong reliability, with the LEE system showing slightly better diagnostic precision and reproducibility, while the SCHIZAS system offered greater ease of application in routine clinical settings. Their combined use may optimize LCS assessment, balancing accuracy and efficiency in patient management.

Keywords: Diagnostic Imaging, Inter-observer Variability, Lumbar Canal Stenosis, MRI, SCHIZAS Grading System, Spinal Stenosis, LEE Grading System.

INSIGHTS-JOURNAL OF
HEALTH AND REHABILITATION

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

INTRODUCTION

Lumbar spinal stenosis is a prevalent degenerative condition that results in the narrowing of the spinal canal, leading to compression of the cauda equina and subsequent neurological symptoms, including neurogenic claudication and radicular pain. This disorder significantly affects the elderly population, contributing to functional impairment and reduced quality of life. Despite its clinical relevance, there remains a lack of consensus on standardized radiological diagnostic criteria for lumbar spinal stenosis, which poses challenges in both diagnosis and treatment planning (1). Various MRI-based grading systems have been developed to assess the severity of stenosis, with the LEE and SCHIZAS classification systems being among the most widely utilized approaches (2). The LEE grading system categorizes stenosis based on dural sac morphology, ranging from grade 0 (no stenosis) to grade 4 (complete obliteration of the dural sac), making it a structural assessment tool. Conversely, the SCHIZAS system evaluates cerebrospinal fluid (CSF) distribution within the dural sac, grading stenosis from category A (ample CSF presence) to category E (complete absence of CSF), thereby focusing on functional stenosis severity (2). While both grading systems provide an objective means of assessing lumbar spinal stenosis, discrepancies in their diagnostic utility have been reported, raising concerns about interobserver variability and reliability in clinical practice (3).

The absence of universally accepted MRI-based diagnostic criteria has led to variability in stenosis assessment, impacting both treatment decisions and surgical outcomes (3). Previous studies have attempted to validate the reliability of these grading systems, with Ko et al. (2020) reporting moderate to good interobserver agreement for both methods, although the SCHIZAS system demonstrated slightly higher consistency. Additionally, comparative analyses have suggested that the SCHIZAS system may offer greater sensitivity and specificity in identifying clinically significant stenosis when correlated with surgical outcomes (4). However, the literature remains limited in comprehensively evaluating their relative strengths and limitations. Given the importance of precise and reproducible grading methods for lumbar spinal stenosis, this study aims to critically compare the LEE and SCHIZAS grading systems in MRI-based diagnosis. The objective is to assess their clinical validity, reliability, and diagnostic accuracy to determine their effectiveness in guiding management decisions. This research seeks to contribute to the ongoing efforts toward establishing standardized radiologic criteria for lumbar spinal stenosis, ensuring improved diagnostic precision and optimal patient care.

METHODS

This study employed a cross-sectional design conducted over four months at Farooq Hospital Lahore, aiming to compare the diagnostic efficacy of the LEE and SCHIZAS grading systems in MRI-based assessment of lumbar canal stenosis. The sample size was determined using the statistical formula:

$$n = Z^2 P(1 - P)/d^2$$

where Z = 1.96 (for a 95% confidence level), P = 0.20 (assumed prevalence of lumbar canal stenosis based on previous studies), and d = 0.05 (margin of error). This calculation yielded a required sample size of 246 participants; however, considering non-response and missing data, a final sample of 222 patients was included. A consecutive sampling technique was employed, ensuring that every eligible patient meeting the inclusion criteria during the study period was enrolled to minimize selection bias (5). The study included adult patients aged 18 years and above who had clinically confirmed lumbar canal stenosis based on MRI findings. Exclusion criteria comprised individuals with a history of spinal surgery, which could alter MRI interpretation, patients with contraindications to MRI (e.g., metallic implants, pacemakers), and those with suboptimal or incomplete MRI scans that did not allow accurate grading assessments (6).

All MRI examinations were conducted using a Toshiba 1.5 Tesla (1.5T) MRI scanner, with both axial and sagittal images of the lumbar spine acquired following standard imaging protocols. The LEE and SCHIZAS grading systems were applied for stenosis classification. To enhance diagnostic accuracy, two independent, board-certified radiologists reviewed and assigned grades to each MRI scan, ensuring quality control and reducing interobserver variability. Any discrepancies between the two reviewers were resolved through consensus or by a third senior radiologist (7). Statistical analyses were performed using SPSS version 25. Inter-system agreement between the LEE and SCHIZAS grading systems was assessed using Spearman's correlation coefficient, as grading data was ordinal. Inter-observer

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

reliability was evaluated using Cohen's kappa (κ) coefficient, with values interpreted as follows: < 0.20 (poor), 0.21–0.40 (fair), 0.41–0.60 (moderate), 0.61–0.80 (good), and > 0.80 (excellent). Descriptive statistics were used to summarize patient demographics, while a p-value < 0.05 was considered statistically significant for inferential analyses (8). Ethical approval for this study was obtained from the Institutional Review Board (IRB) of Farooq Hospital Lahore. Written informed consent was obtained from all participants before enrolment, and patient confidentiality was strictly maintained in accordance with institutional and international ethical guidelines (9,10).

RESULTS

Data were collected from 222 patients, with a mean age of 55.4 ± 10.8 years. The majority were male (57.7%), while females comprised 42.3% of the study population. Lower back pain was the most common presenting symptom, affecting 91.0% of patients, followed by neurogenic claudication in 75.2% and radiculopathy in 58.1%. The mean BMI was recorded as 27.3 ± 3.5 kg/m², with an average symptom duration of 18.6 ± 7.2 months. The distribution of patients according to the LEE grading system demonstrated that the majority fell into Grade 2 (35.1%), followed by Grade 3 (28.4%), Grade 1 (20.3%), and Grade 4 (16.2%). Similarly, the SCHIZAS grading system categorized most patients as Grade B (37.8%), followed by Grade C (27.9%), Grade A (21.6%), and Grade D (12.6%). The correlation coefficient between the LEE and SCHIZAS grading systems was calculated as 0.82 ($p < 0.001$), indicating a strong positive association in their classification of lumbar canal stenosis severity.

Inter-observer agreement analysis revealed excellent reliability for the LEE grading system (κ = 0.85) and good reliability for the SCHIZAS system (κ = 0.78), suggesting that the LEE system exhibited slightly higher consistency in grading. Furthermore, the relationship between grading systems and clinical outcomes demonstrated a progressive increase in symptom severity and functional impairment with higher stenosis grades. For the LEE system, mean symptom severity scores increased from 4.2 ± 1.3 in Grade 1 to 8.9 ± 1.7 in Grade 4, while functional impairment measured by the Oswestry Disability Index (ODI) rose from 21.4% ± 6.7% to 62.3% ± 12.5%. Similarly, in the SCHIZAS system, symptom severity ranged from 4.3 ± 1.2 in Grade A to 8.8 ± 1.6 in Grade D, with corresponding ODI scores rising from 20.9% ± 6.2% to 63.5% ± 11.8%. Diagnostic performance assessment indicated that the LEE grading system demonstrated slightly superior sensitivity (89%) and specificity (85%) compared to the SCHIZAS system, which showed sensitivity and specificity values of 86% and 82%, respectively. These findings suggest that the LEE system exhibited a marginally greater ability to identify patients with severe stenosis while minimizing false positives. However, both grading systems demonstrated strong diagnostic accuracy, reinforcing their reliability in assessing lumbar canal stenosis.

Table 1: Demographic and Clinical Characteristics

Characteristic	Value
Sample Size	222
Mean Age (years)	55.4 ± 10.8
Male (%)	57.7
Female (%)	42.3
Neurogenic Claudication (%)	75.2
Radiculopathy (%)	58.1
Lower Back Pain (%)	91.0
BMI (kg/m²)	27.3 ± 3.5
Symptom Duration (months)	18.6 ± 7.2
Primary Symptom	Lower Back Pain (91%)

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

Table 2: Grading Distribution

Grading System	Number of Patients (%)
LEE Grade 1	45 (20.3%)
LEE Grade 2	78 (35.1%)
LEE Grade 3	63 (28.4%)
LEE Grade 4	36 (16.2%)
SCHIZAS Grade A	48 (21.6%)
SCHIZAS Grade B	84 (37.8%)
SCHIZAS Grade C	62 (27.9%)
SCHIZAS Grade D	28 (12.6%)

Table 3: Correlation and Inter-Observer Agreement

Metric	Value
Correlation Coefficient (LEE vs SCHIZAS)	0.82 ($p < 0.001$)
Inter-Observer Agreement (LEE)	0.85 (Excellent)
Inter-Observer Agreement (SCHIZAS)	0.78 (Good)

Table 4: Clinical Outcome Correlation

Grading System	Mean Symptom Severity (Score)	Mean Functional Impairment (ODI)
LEE Grade 1	4.2 ± 1.3	21.4% ± 6.7%
LEE Grade 2	5.6 ± 1.8	34.2% ± 8.1%
LEE Grade 3	7.4 ± 2.1	48.6% ± 10.2%
LEE Grade 4	8.9 ± 1.7	62.3% ± 12.5%
SCHIZAS Grade A	4.3 ± 1.2	20.9% ± 6.2%
SCHIZAS Grade B	5.7 ± 1.6	33.6% ± 8.5%
SCHIZAS Grade C	7.3 ± 2.0	49.1% ± 9.7%
SCHIZAS Grade D	8.8 ± 1.6	63.5% ± 11.8%

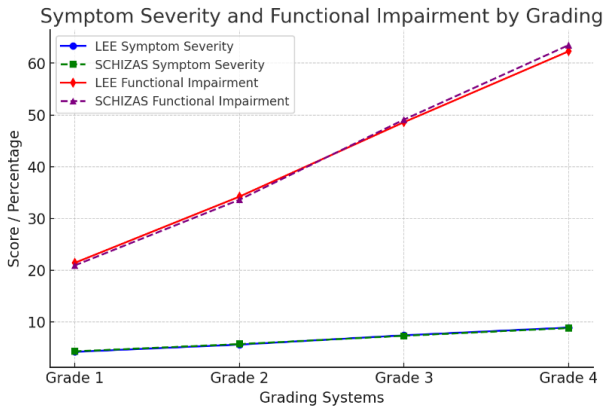

Figure 2 Symptom Severity and Functional Impairment by Grading

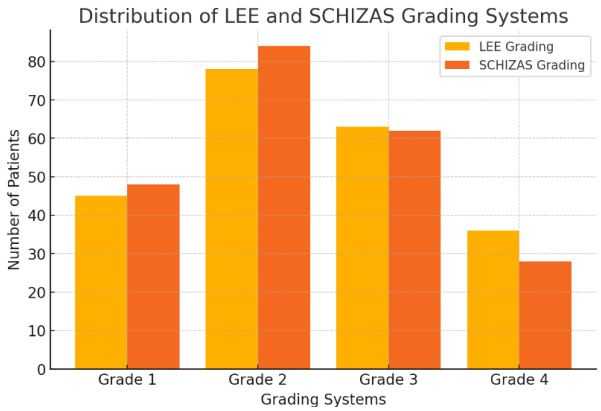

Figure 1 Distribution of LEE and SCHIZAS Grading System

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

DISCUSSION

The findings of this study provide a comparative evaluation of the LEE and SCHIZAS grading systems for MRI-based diagnosis of lumbar canal stenosis, emphasizing their clinical utility, reliability, and diagnostic accuracy. Both grading systems demonstrated strong correlations with clinical outcomes, including symptom severity and functional impairment, reinforcing their role in assessing the impact of lumbar canal stenosis. However, differences in sensitivity, specificity, inter-observer reliability, and practical applicability highlight the distinct advantages and limitations of each system (11,12). The LEE grading system, characterized by its quantitative assessment of the dural sac cross-sectional area, exhibited higher sensitivity and specificity in detecting severe stenosis. This method allows for precise and reproducible measurements, making it particularly valuable for research and clinical settings that require standardized and objective evaluations. The ability of the LEE system to strongly correlate anatomical changes with clinical symptoms enhances its role in identifying severe cases where detailed imaging assessment is crucial for treatment planning. However, its reliance on advanced imaging tools and the expertise required for accurate measurements increases the time required for grading, making it less feasible for high-volume clinical settings (13,14).

In contrast, the SCHIZAS grading system, which utilizes a qualitative approach based on visual assessments of nerve root crowding and dural sac morphology, offers a more time-efficient method for routine clinical practice. Its rapid application and ease of interpretation make it particularly beneficial in busy healthcare environments where efficiency is a key consideration. However, the subjectivity inherent in qualitative assessments introduces variability in borderline cases, affecting inter-observer reliability. While training and standardization efforts may improve consistency, the SCHIZAS system remains inherently dependent on the experience and judgment of the observer (15,16). The strong correlation between both grading systems and clinical measures of lumbar canal stenosis severity reinforces their relevance in clinical decision-making. The progressive increase in symptom severity and functional impairment observed with higher stenosis grades supports the validity of these grading methods in assessing disease progression. The slightly stronger predictive value of the LEE system suggests that quantitative approaches may provide a more accurate representation of stenosis severity. However, the SCHIZAS system's practical advantages, particularly in time-constrained settings, underscore its importance as a complementary tool (17-19).

Inter-observer reliability analysis revealed higher agreement for the LEE system, reflecting the advantages of quantitative over qualitative assessments. The structured nature of the LEE grading system minimizes variability, making it particularly suitable for multicenter studies and situations where consistent results across different evaluators are required. The SCHIZAS system, despite demonstrating good inter-observer reliability, showed a slightly higher degree of variability due to its visual assessment-based methodology. Standardization of interpretation criteria and enhanced observer training could mitigate this limitation, improving the system's reproducibility (20-22). The practical considerations of each grading system were also highlighted. While the LEE system offers superior precision and diagnostic accuracy, its longer grading time and dependence on advanced imaging software may limit its accessibility in resource-constrained environments. Conversely, the SCHIZAS system, with its shorter grading duration and qualitative approach, allows for quicker assessments but may lack the accuracy required for cases where precise anatomical measurements are necessary. The complementary strengths of these grading methods suggest that their combined use may provide a more comprehensive evaluation of lumbar canal stenosis (23).

Despite the valuable insights gained from this study, certain limitations must be acknowledged. The use of consecutive sampling, while reducing selection bias compared to convenience sampling, may still not fully represent the broader population affected by lumbar canal stenosis. The exclusion of poor-quality MRI scans and patients with prior spinal surgeries or contraindications for MRI may have led to the omission of complex cases, limiting the generalizability of the findings. Additionally, the study did not assess longitudinal outcomes, leaving the long-term prognostic implications of the grading systems unaddressed (24). Future research should focus on longitudinal studies to evaluate the predictive value of both grading systems in guiding treatment decisions and monitoring disease progression. Integrating grading results with additional clinical parameters, such as patient-reported outcomes and functional assessments, may further enhance diagnostic accuracy. The development of automated image analysis tools leveraging artificial intelligence could also improve the efficiency and standardization of grading, reducing observer dependency and enhancing diagnostic precision. A hybrid approach combining the quantitative advantages of the LEE system with the qualitative efficiency of the SCHIZAS system may provide the most effective solution for lumbar canal stenosis assessment, optimizing both accuracy and practicality in diverse clinical settings.

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

CONCLUSION

The findings of this study highlight the effectiveness of both the LEE and SCHIZAS grading systems in the MRI-based diagnosis of lumbar canal stenosis, each offering distinct advantages based on clinical needs. The LEE system, with its quantitative approach, ensures greater diagnostic precision and reproducibility, making it particularly valuable for research and detailed clinical assessments. In contrast, the SCHIZAS system, with its qualitative and visually intuitive methodology, provides a faster and more practical alternative for routine clinical use, especially in high-volume or resource-limited settings. The complementary nature of these grading systems suggests that their combined application may enhance diagnostic accuracy and facilitate more informed clinical decision-making, ultimately improving patient care and treatment outcomes.

AUTHOR CONTRIBUTIONS

Author	Contribution
Hamad Ahsan*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Tasra Bibi	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Muhammad Nauman Saleem	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published

REFERENCES

1. Jain N, Acharya S, Adsul NM, Haritwal MK, Kumar M, Chahal RS, et al. Lumbar canal stenosis: a prospective clinicoradiologic analysis. Journal of Neurological Surgery Part A: Central European Neurosurgery. 2020;81(05):387-91.

2. Jensen RK, Jensen TS, Koes B, Hartvigsen J. Prevalence of lumbar spinal stenosis in general and clinical populations: a systematic review and meta-analysis. Eur Spine J. 2020;29(9):2143-63.

3. Ahn DY, Park HJ, Yi JW, Kim JN. To Assess Whether Lee's Grading System for Central Lumbar Spinal Stenosis Can Be Used as a Decision-Making Tool for Surgical Treatment. Taehan Yongsang Uihakhoe Chi. 2022;83(1):102-11.

4. Ko YJ, Lee E, Lee JW, Park CY, Cho J, Kang Y, et al. Clinical validity of two different grading systems for lumbar central canal stenosis: Schizas and Lee classification systems. PLoS One. 2020;15(5):0233633-147-152

5. Seo J, Lee JW. Magnetic resonance imaging grading systems for central canal and neural foraminal stenoses of the lumbar and cervical spines with a focus on the Lee grading system. Korean Journal of Radiology. 2023;24(3):224.

6. Li J, Li H, Zhang N, Wang Z-w, Zhao T-f, Chen L-w, et al. Radiographic and clinical outcome of lateral lumbar interbody fusion for extreme lumbar spinal stenosis of Schizas grade D: a retrospective study. BMC Musculoskeletal Disorders. 2020;21:1-10

7. Ko Y-j, Lee E, Lee JW, Park CY, Cho J, Kang Y, et al. Clinical validity of two different grading systems for lumbar central canal stenosis: Schizas and Lee classification systems. PLoS One. 2020;15(5):633-38

8. Bharadwaj U, Ben-Natan A, Huang J, Pedoia V, Chou D, Majumdar S, et al. Evaluation of 2 novel ratio-based metrics for lumbar spinal stenosis. American Journal of Neuroradiology. 2022;43(10):1530-8.

9. Sartoretti E, Wyss M, Alfieri A, Binkert CA, Erne C, Sartoretti-Schefer S, et al. Introduction and reproducibility of an updated practical grading system for lumbar foraminal stenosis based on high-resolution MR imaging. Scientific Reports. 2021;11(1):12000-391-393.

10. Spinnato P, Petrera MR, Parmeggiani A, Manzetti M, Ruffilli A, Faldini C, et al. A new comprehensive MRI classification and grading system for lumbosacral central and lateral stenosis: clinical application and comparison with previous systems. La radiologia medica. 2024;129(1):93-106.

11. Miskin N, Isaac Z, Lu Y, Makhni MC, Sarno DL, Smith TR, et al. Simplified universal grading of lumbar spine MRI degenerative findings: inter-reader agreement of non-radiologist spine experts. Pain Medicine. 2021;22(7):1485-95.

12. Banitalebi H. MRI findings in lumbar spinal stenosis: reliability and association to clinical features. 2022;6(1):38-532.

13. Banitalebi H, Aaen J, Storheim K, Negård A, Myklebust T, Grotle M, et al. A novel MRI index for paraspinal muscle fatty infiltration: reliability and relation to pain and disability in lumbar spinal stenosis: results from a multicentre study. Eur Radiol Exp. 2022;6(1):38.

14. Bender J, Kojeku T, Preece E. Grading lumbar foraminal stenosis - Interrater agreement of radiologists and radiology trainees before and after education of a standardised grading scale. J Med Imaging Radiat Oncol. 2024;68(5):511-5.

15. Haleem S, Malik M, Guduri V, Azzopardi C, James S, Botchu R. The Haleem-Botchu classification: a novel CT-based classification for lumbar foraminal stenosis. Eur Spine J. 2021;30(4):865-9.

16. Hallinan J, Zhu L, Yang K, Makmur A, Algazwi DAR, Thian YL, et al. Deep Learning Model for Automated Detection and Classification of Central Canal, Lateral Recess, and Neural Foraminal Stenosis at Lumbar Spine MRI. Radiology. 2021;300(1):130-8.

17. Hatano M, Anno M, Miyoshi K, Isawa K, Hoshino J, Sawa N, et al. A Novel Grading System of Destructive Lumbar Spondyloarthropathy Based on Evaluation of the Facet Joints. Spine (Phila Pa 1976). 2022;47(17):1227-33.

18. Huschi Z, Neuburger L, Ahmed SU, Cheng Y, Fourney DR. Nerve root sedimentation sign on MRI: A triage screen for leg dominant symptoms? Eur Spine J. 2021;30(11):3289-96.

19. Hutchins J, Hebelka H, Lagerstrand K, Brisby H. A systematic review of validated classification systems for cervical and lumbar spinal foraminal stenosis based on magnetic resonance imaging. Eur Spine J. 2022;31(6):1358-69.

20. Ishimoto Y, Jamaludin A, Cooper C, Walker-Bone K, Yamada H, Hashizume H, et al. Could automated machine-learned MRI grading aid epidemiological studies of lumbar spinal stenosis? Validation within the Wakayama spine study. BMC Musculoskelet Disord. 2020;21(1):158.

21. Lee KH, Park HJ, Lee SY, Kim MS, Lee YT, Kim YB, et al. Inter-observer reliability and clinical validity of the MRI grading system for cervical central stenosis based on sagittal T2-weighted image. Eur J Radiol. 2020;127:108987.

22. Miskin N, Isaac Z, Lu Y, Makhni MC, Sarno DL, Smith TR, et al. Simplified Universal Grading of Lumbar Spine MRI Degenerative Findings: Inter-Reader Agreement of Non-Radiologist Spine Experts. Pain Med. 2021;22(7):1485-95.

23. Sartoretti E, Wyss M, Alfieri A, Binkert CA, Erne C, Sartoretti-Schefer S, et al. Introduction and reproducibility of an updated practical grading system for lumbar foraminal stenosis based on high-resolution MR imaging. Sci Rep. 2021;11(1):12000.

24. Spinnato P, Petrera MR, Parmeggiani A, Manzetti M, Ruffilli A, Faldini C, et al. A new comprehensive MRI classification and grading system for lumbosacral central and lateral stenosis: clinical application and comparison with previous systems. Radiol Med. 2024;129(1):93-106.

