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CORRELATION OF RADIOGRAPHIC PARAMETERS WITH DURAL CROSS-SECTIONAL AREA IN LUMBAR SPINE STENOSIS

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ABSTRACT

Background: Lumbar spinal stenosis (LSS) is a degenerative condition characterized by narrowing of the spinal canal and neural compression, causing low back pain, neurogenic claudication, and neurological deficits. This study aimed to determine the correlation between radiographic parameters and MRI-derived measures of stenosis severity in patients with LSS.

Methodology: This cross sectional study was carried out in Department of Neurosurgery in Services Hospital Lahore, from 10 October 2025 to 10 January 2026. A total of 60 patients aged 25-75 years with clinically and radiologically diagnosed lumbar spinal stenosis were included in the study. Lumbar lordosis angle, lumbosacral angle and lumbosacral joint angle were measured using plain radiographs, while the percentage stenosis and dural cross-sectional area (DCSA) were assessed using MRI. SPSS (Version 27.0) was used to analyze the data. Associations between radiographic and MRI parameters were evaluated using the Spearman's rank correlation coefficient.

Results: weak and statistically significant negative correlation was found between lumbosacral angle and DCSA ($\rho = -0.255$ with $p = 0.049$). No statistically significant correlations were found between lumbar lordosis angle and DCSA ($\rho = -0.195$, $p = 0.134$), or between lumbosacral joint angle and DCSA ($\rho = -0.194$, $p = 0.137$). No statistically significant correlations were observed between percentage stenosis and any of the radiographic parameters ($p > 0.05$).

Conclusion: This study suggested a weak yet statistically significant negative correlation between the lumbosacral angle measured on radiograph and dural cross-sectional area on MRI. However, lumbar lordosis angle or lumbosacral joint angle did not show any correlation with the dural cross-sectional area. Percentage stenosis assessed on MRI did not have any statistically significant correlation with any of the radiographic parameters.

KEYWORDS: degenerative spine disease, dural sac cross sectional area, lumbar lordosis angle, lumbar spinal stenosis (lss), spine measurements

INTRODUCTION

Lumbar spinal stenosis (LSS) is a common degenerative condition and a significant public health concern among the elderly population, often compromising physical function and quality of life. Its clinical spectrum varies from isolated low back pain, pseudoclaudication to sensory or rarely motor deficits [1]. Although advancements have been made in clinical assessment, diagnosis gets challenging sometimes as the symptoms are not always in keeping with the radiological appearance with no clear relationship between clinical complaints and the degree of stenosis as determined by MRI scans, making a thorough radiological assessment of the neural element compromise as well as the bio-dynamics of the spine crucial [2,3].

Magnetic resonance imaging (MRI) is considered to be the most reliable imaging modality for the assessment of lumbar spinal stenosis, effective in directly imaging the dural sac and the neural elements [4]. Among MRI-derived measurements, the dural cross-sectional area (DCSA) has been used as one objective measurement to quantify the central canal stenosis. A decrease in DCSA, suggesting increased anatomical canal narrowing, may relate to the severity of symptoms and functional limitation in certain patient groups [5]. In addition, studies have investigated the association between radiographic spinal alignment parameters and the level of spinal canal narrowing evident on MRI. Alterations in sagittal alignment may increase biomechanical forces along the vertebral axis, leading to degenerative changes in osseous and soft-tissue structures, including facet joint and ligamentum flavum hypertrophy, disc bulging, and pedicular kinking, all of which contribute to canal narrowing. As these alterations in spinal alignment can be assessed on conventional radiographs using regional and global sagittal parameters, they may provide valuable insight into the mechanisms underlying lumbar spinal stenosis [5-7].

Furthermore, dynamic and positional MRI studies have shown that the dimensions of the dural sac change with posture and axial loading conditions, which is also indicative of the complex biomechanical behaviour between changes in

spinal alignment and narrowings of the spinal canal. Based on these findings, easy-to-acquire radiographic parameters could be used indirectly to gauge the severity of stenosis and perhaps be studied as screening parameters for lumbar spinal stenosis [8,9]. Current literature highlights the relationship between spinopelvic parameters such as pelvic tilt, lordosis angle and sacral slopes with spinal deformities and have been described to influence the severity of clinical symptoms [10,11]. However, data suggesting significant correlation or predictability for DCSA and other MRI parameters of stenosis severity is scarce and needs further exploration.

The aim of this study was to evaluate the correlation between radiographic and MRI parameters in lumbar spinal stenosis (LSS). Given that radiographs are inexpensive and widely available, establishing meaningful correlations between radiographic and MRI parameters may support their use as a preliminary screening tool to identify patients who would benefit from further MRI evaluation.

MATERIALS AND METHODS

Study design and population

A cross-sectional study was conducted from 10 October 2025 to 10 January 2026 in the Department of Neurosurgery, Services Hospital, Lahore, Pakistan for a duration of three months. Ethical approval was obtained from the IRB (institutional review board) of Services Institute of Medical Sciences (IRB/2025/1760/SIMS) dated 10 October 2025. Patients with clinical characteristics suggestive of lumbar spinal stenosis (LSS) were included in the study population. Before enrolment, the purpose and nature of the study were explained, and written informed consent was obtained. A non-probability consecutive sampling approach was used to recruit 60 patients. This sample size was calculated using an anticipated correlation coefficient of 0.660 between dural cross-sectional area measured on magnetic resonance imaging (MRI) and sagittal radiographic parameters, a 10% beta error, and 5% significance level [12].

Patients aged 25-75 years with clinical symptoms suggestive of lumbar spinal stenosis, MRI evidence of multilevel lumbar spinal stenosis, and available lumbosacral spine radiographs (Anteroposterior and lateral views taken in neutral, flexion, and extension) were included. Exclusion criteria included isolated lumbar disc herniation, single level stenosis, lumbar spinal stenosis secondary to traumatic, infectious, or neoplastic causes, concomitant cervical or thoracic spinal stenosis, and a history of spinal surgery at any level.

Radiological analysis

Radiological measurements were obtained using the institutional Picture Archiving and Communication System(PACS). To minimise interobserver variability and measurement bias, a single investigator analysed all images using a standard measurement protocol. Lumbar spinal stenosis was defined as narrowing of the lumbar spinal canal associated with relevant clinical symptoms and an average dural cross-sectional area (DCSA) of less than 120 mm² on MRI. The axial T2-weighted MR images were used to measure the dural cross sectional area, lumbar dural sac and spinal canal diameters at four segmental levels and mean value for all measured levels were calculated. Percentage stenosis was calculated by the formula:

$$percentagestenosis = \frac{\text{dural sac diameter}}{\text{spinal canal diameter}} x100$$

Intervertebral disc height was measured at the level corresponding to the smallest dural cross-sectional area (DCSA). The anterior disc height (H1) and posterior disc height (H2) were measured, and the mean disc height was calculated as

$$averagedischeight = \frac{H1 + H2}{2}$$

Standing lumbosacral radiographs were used to evaluate three spinopelvic parameters: lumbar lordosis angle, lumbosacral angle, and lumbosacral joint angle. Lumbar lordosis angle was measured using Cobb's method by drawing tangent lines along the superior endplate of L1 and the inferior endplate of S1 and calculating the angle between their perpendiculars [13]. The lumbosacral angle was defined as the angle between the superior endplate of S1 and a horizontal reference line. The lumbosacral joint angle was measured as the angle between the inferior endplate of L5 and the superior endplate of S1.

STATISTICAL ANALYSIS

Data were analyzed using IBM SPSS Statistics version 27.0. Quantitative variables including lumbar lordosis angle, lumbosacral angle, lumbosacral joint angle, average intervertebral disc height, dural cross-sectional area (DCSA), dural sac diameter and percentage stenosis were expressed as mean ± standard deviation. Shapiro-Wilk test was used to test the distribution of continuous variables. Variables with a non-normal distribution were analyzed using Spearman's rank correlation coefficient. Correlations between radiographic parameters (lumbar lordosis angle, lumbosacral angle, and lumbosacral joint angle) and MRI-derived parameters (DCSA, dural sac diameter, percentage

stenosis, and average disc height) were assessed. Statistical significance was set at $p < 0.05$. Additional analyses were performed after stratification by age and sex to evaluate whether correlations differed across subgroups.

RESULTS

A total of 60 patients with lumbar spinal stenosis were included in the study, comprising 31 (51.7%) males and 29 (48.3%) females. Participants were equally distributed between the two age groups, with 30 (50.0%) patients aged 25-50 years and 30 (50.0%) aged 51-75 years. The mean age was 50.27 ± 10.46 years. The mean lumbar lordosis angle, lumbosacral angle, and lumbosacral joint angle were 29.23 ± 10.21°, 35.51 ± 9.13°, and 13.42 ± 7.49°, respectively. The mean percentage stenosis was 68.05 ± 11.87%, while the mean dural cross-sectional area (DCSA) was 129.10 ± 35.37 mm². The mean intervertebral disc height was 10.17 ± 2.12 mm (Table 1).

TABLE 1: Descriptive statistics of study participants (n = 60)

Variables	Frequency (%) / Mean ± S.D.
Gender	
Male	31 (51.7%)
Female	29 (48.3%)
Age groups	
25–50 years	30 (50.0%)
51–75 years	30 (50.0%)
Mean age (years)	50.27 ± 10.46
Mean Lumbar Lordosis Angle (°)	29.23 ± 10.21
Mean Lumbosacral Angle (°)	35.51 ± 9.13
Mean Lumbosacral Joint Angle (°)	13.42 ± 7.49
Mean Percentage stenosis (%)	68.05 ± 11.87
Mean dural cross-sectional area (mm²)	129.10 ± 35.37
Mean disc space height (mm)	10.17 ± 2.12

The Shapiro-Wilk test demonstrated normal distributions for age, lumbar lordosis angle, lumbosacral angle, and percentage stenosis, whereas lumbosacral joint angle, DCSA, and intervertebral disc height showed non-normal distributions ($p < 0.05$) (Table 2).

TABLE 2: Normality assessment of quantitative variables using the Shapiro–Wilk test

Variable	Shapiro–Wilk Statistic	p-value	Distribution
Age (years)	0.984	0.616	Normal
Lumbar Lordosis Angle (°)	0.980	0.438	Normal
Lumbosacral Angle (°)	0.974	0.228	Normal
Lumbosacral Joint Angle (°)	0.814	<0.001	Non-normal
Percentage Stenosis (%)	0.973	0.215	Normal
Average Dural Cross-Sectional Area (mm²)	0.934	0.003	Non-normal
Average Disc Space Height (mm)	0.947	0.011	Non-normal

A weak but statistically significant negative correlation was observed between lumbosacral angle and DCSA ($\rho = -0.255$, $p = 0.049$). No significant correlations were found between lumbar lordosis angle and DCSA ($\rho = -0.195$, $p = 0.134$) or between lumbosacral joint angle and DCSA ($\rho = -0.194$, $p = 0.137$). Furthermore, percentage stenosis showed no significant correlation with lumbar lordosis angle ($\rho = -0.047$, $p = 0.719$), lumbosacral angle ($\rho = 0.026$, $p = 0.844$), or lumbosacral joint angle ($\rho = 0.066$, $p = 0.618$) (Table 3).

TABLE 3: Spearman correlation analysis of radiographic and MRI-derived parameters in patients with lumbar spinal stenosis (n = 60)

Radiographic Parameter	Average Dural Cross-Sectional Area (ρ)	p-value	Percentage Stenosis (ρ)	p-value
Lumbar Lordosis Angle (°)	-0.195	0.134	-0.047	0.719
Lumbosacral Angle (°)	-0.255	0.049*	0.026	0.844
Lumbosacral Joint Angle (°)	-0.194	0.137	0.066	0.618

Spearman's rank correlation coefficient (ρ); $p < 0.05$ considered statistically significant.

After stratification by gender (Table 4), no significant correlations were identified between the radiographic parameters and DCSA among male participants. In female participants, lumbosacral joint angle demonstrated a moderate negative correlation with DCSA ($\rho = -0.425$, $p = 0.021$), whereas lumbar lordosis angle and lumbosacral angle were not significantly correlated with DCSA.
[Certain] Do not remove the asterisk from **-0.425*** because that is the only statistically significant correlation shown in this table.

TABLE 4: Gender-stratified correlation between MRI and X-ray parameters

MRI Parameter	Gender	Lumbar Lordosis Angle (ρ)	p-value	Lumbosacral Angle (ρ)	p-value	Lumbosacral Joint Angle (ρ)	p-value
Average Dural Cross-Sectional Area (mm²)	Male	-0.193	0.298	-0.351	0.053	-0.09	0.632
Average Dural Cross-Sectional Area (mm²)	Female	-0.06	0.758	-0.226	0.239	-0.425*	0.021
Percentage Stenosis (%)	Male	-0.121	0.515	-0.122	0.514	-0.006	0.972
Percentage Stenosis (%)	Female	-0.088	0.650	0.076	0.695	-0.015	0.940

Spearman's rank correlation coefficient (ρ); $p < 0.05$ considered statistically significant.

Following age stratification (Table 5), no significant correlations were observed between radiographic parameters and MRI-derived measures in patients aged 25-50 years. In contrast, among patients aged 51-75 years, lumbosacral joint angle demonstrated a moderate negative correlation with DCSA ($\rho = -0.414$, $p = 0.023$). No significant correlations were identified between DCSA and either lumbar lordosis angle or lumbosacral angle in either age group. Percentage stenosis did not show a significant correlation with any radiographic parameter in any age or gender subgroup.

TABLE 5: Age-stratified correlation between MRI and X-ray parameters

MRI Parameter	Age groups	Lumbar Lordosis Angle (ρ)	p-value	Lumbosacral Angle (ρ)	p-value	Lumbosacral Joint Angle (ρ)	p-value
Average Dural Cross-Sectional Area (mm²)	25–50 years	-0.091	0.634	-0.290	0.120	0.043	0.823
Average Dural Cross-Sectional Area (mm²)	51–75 years	-0.187	0.321	-0.133	0.483	-0.414*	0.023
Percentage Stenosis (%)	25–50 years	0.074	0.697	0.047	0.807	0.153	0.420
Percentage Stenosis (%)	51–75 years	-0.230	0.222	-0.110	0.561	-0.049	0.799

Spearman's rank correlation coefficient (ρ); $p < 0.05$ considered statistically significant.

DISCUSSION

This study explored the relationship between radiographic parameters and MRI-derived measures of stenosis severity in patients with lumbar spinal stenosis. The principal finding was a weak but statistically significant inverse association between lumbosacral angle and dural cross-sectional area ($\rho = -0.255$, $p = 0.049$). However, no significant correlations were observed between lumbar lordosis angle or lumbosacral joint angle and DCSA, and none of the radiographic parameters were significantly associated with percentage stenosis. Overall, these findings suggest that conventional static radiographic alignment measures have limited utility in estimating the severity of canal narrowing on MRI.

Lumbar lordosis angle showed no significant association with either DCSA or percentage stenosis. This is consistent with previous studies reporting weak or absent relationships between global lumbar alignment and MRI-based measures of stenosis severity [14,15]. These findings indicate that sagittal alignment alone may not adequately reflect the extent of neural compression in lumbar spinal stenosis, which is likely influenced by multiple structural and biomechanical factors. In contrast, emerging evidence suggests that dynamic radiographic parameters, segmental motion, and loading-related factors may better reflect stenosis severity than static alignment measures [16].

A weak inverse correlation was observed between lumbosacral angle and DCSA, suggesting that greater lumbosacral inclination may be associated with reduced dural sac dimensions. Although modest, this relationship may reflect altered load transmission at the lumbosacral junction, potentially contributing to progressive degenerative changes in discs, facet joints, and ligamentum flavum. However, given the weak correlation strength, its clinical significance remains uncertain.

Lumbosacral joint angle was not significantly associated with DCSA or percentage stenosis. Similar findings have been reported by Karakoc et al., who observed only limited associations between spinopelvic parameters, muscle degeneration, and clinical outcomes [17]. Collectively, these findings suggest that isolated angular measurements may not adequately capture the complex biomechanical and degenerative processes underlying lumbar spinal stenosis. Recent literature further emphasizes the role of paraspinal muscle quality, segmental instability, and dynamic loading in determining stenosis severity [18,19].

No significant correlations were identified between radiographic parameters and percentage stenosis. This supports previous reports indicating that radiographic alignment and MRI-based measures assess different aspects of spinal degeneration and therefore may not correlate strongly. Sobański et al. similarly highlighted that radiographic severity does not always reflect neural compression on MRI [20], while Beyer et al. noted that plain radiographs are limited in their ability to quantify canal compromise [21].

Although overall associations were limited, lumbosacral joint angle demonstrated a significant negative correlation with DCSA in female participants ($\rho = -0.425$, $p = 0.021$) and in patients aged 51-75 years ($\rho = -0.414$, $p = 0.023$). These findings should be interpreted cautiously given the small subgroup sample sizes but may indicate potential age and sex related differences that warrant further investigation.

Overall, the findings of this study indicate that radiographic alignment parameters demonstrate limited correlation with MRI-derived measures of stenosis severity in lumbar spinal stenosis. Although lumbosacral angle showed a weak inverse association with DCSA, MRI remains the preferred modality for evaluating neural compression and canal narrowing. Conventional radiographs may nevertheless provide complementary information regarding spinal alignment and degenerative biomechanics, particularly in settings where MRI is not readily available.

There are a number of limitations for this study. First, the cross-sectional design precluded assessment of causal relationships between radiographic parameters and stenosis severity. Second, this was a single-centre study with a relatively small sample size, which may limit the generalizability of the findings. Third, potentially relevant factors such as body mass index, pelvic incidence, sacral slope, paraspinal muscle degeneration, and facet joint arthropathy were not evaluated. Finally, imaging findings were not correlated with clinical outcomes or symptom severity, limiting assessment of the functional significance of the observed associations.

CONCLUSION

This study identified a weak but statistically significant correlation between the lumbosacral angle and dural cross-sectional area, suggesting a modest association between sagittal pelvic orientation and canal narrowing in lumbar spinal stenosis. However, lumbar lordosis angle and lumbosacral joint angle showed no significant relationships with dural cross-sectional area or percentage stenosis, and none of the radiographic parameters correlated significantly with stenosis severity overall. These findings indicate that conventional radiographic spinopelvic measurements have limited value in predicting the anatomical severity of lumbar spinal stenosis. MRI remains the gold standard for accurate assessment. Further large-scale prospective studies incorporating comprehensive spinopelvic,clinical and degenerative parameters are warranted to better define the role of radiographic evaluation in this condition.

AUTHOR CONTRIBUTIONS

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Ammara Zafar, Hira Umar, Ajmal Khan, Sana Tariq

Acquisition, analysis, or interpretation of data: Ammara Zafar, Hira Umar, Sana Tariq

Drafting of the manuscript: Ammara Zafar, Hira Umar, Sana Tariq

Critical review of the manuscript for important intellectual content: Ajmal Khan, Sana Tariq

Supervision: Ajmal Khan

DISCLOSURES

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