International Surgery Journal
Hart I et al. Int Surg J. 2025 Dec;12(12):2112-2119
http://www.ijsurgery.com
pISSN 2349-3305 | eISSN 2349-2902

DOI: https://dx.doi.org/10.18203/2349-2902.isj20253835

Original Research Article

Correlation between severity of symptoms and degree of radiologic stenosis in adults with degenerative lumbar spine stenosis

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Received: 13 October 2025
Revised: 13 November 2025
Accepted: 19 November 2025

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ABSTRACT

Background: Degenerative lumbar spine stenosis (LSS) is an increasing cause of morbidity in an ever-ageing population. Correlation of the severity of symptoms with the degree of radiologic stenosis has yielded mixed results. This study aims to correlate the severity of symptoms and degree of radiologic stenosis in adults with degenerative LSS.
Methods: This was a prospective cross-sectional study. Patients recruited were those who had degenerative LSS who gave consent to partake in this study. Patients with lumbar spine stenosis from trauma, infection, tumours, and patients with previous lumbar spine surgery, cerebrovascular accident, motor neuron or demyelinating disease were excluded. Clinical LSS was assessed using the NCOS questionnaire and radiologic LSS severity was categorized using the stenosis ratio (quantitative) and the Shcizas grades (qualitative) obtained from 1.5T magnetic resonance imaging (MRI) scans. Ethical approval was obtained for this study.
Results: Fifty patients participated in this study, 22 males and 28 females. Mean age was 58.4±10.8 years. Sixty-six percent of patients had multilevel stenoses, and L4/5 was the most affected level with critical stenosis (62%). LSS clinical features, as demonstrated by the NCOS, did not correlate significantly with the stenosis ratio (r=0.094, p=0.523). Furthermore, the correlation between the NCOS and the Schizas grade was not statistically significant, rs=-0.187, p=0.202.
Conclusion: Severity of symptoms in degenerative LSS poorly correlates with the degree of radiologic stenosis. Hence clinical and radiologic assessments should guide patient's care.

Keywords: Lumbar spine stenosis, Schizas grade, Stenosis ratio, NCOS

INTRODUCTION

Lumbar spinal stenosis (LSS), the anatomical narrowing of the lumbar canal, is one of the most common degenerative disorders affecting the adult population that may lead to loss of function and inability to execute basic activities of daily living.[1,2] Choosing an optimal management strategy is usually guided by a set of clinical, radiological and measurement indices. However, to date there is uncertainty and discrepancy regarding the

methodology used in assessment. Several assessment tools have evolved over the years to assess the severity and functionality of lumbar canal stenosis (LSS). These include the neurogenic claudication outcome score (NCOS), Oswestry disability index (ODI), Swiss claudication score, oxford claudication score and short form health survey. These assessment tools have their limitations.

The neurogenic claudication outcome score (NCOS) was developed by Weiner and Fraser to measure neurogenic claudication, which is the most common and specific symptom of LSS.[3,4,5] It is also used as an outcome measure of functionality in patients with LSS.[5,6] It comprises questions that specifically assess the extent of neurogenic claudication, pain severity and quality of life. Review of literature showed that NCOS and ODI have a strong correlation in measuring disability of patients with lumbar spinal stenosis.[7,8]

The radiologic assessment of LSS is largely based on magnetic resonance imaging (MRI). It is an excellent tool for assessing lumbar canal diameter and associated stenosis. It is non-invasive and is able to reveal the presence, cause and extent of neural compression in the lumbar spine.[8,9] Schizas grading of LSS on lumbar axial MRI is qualitative and based on the morphological appearance of the dural sac as seen in the axial T2 image of the lumbar spine, taking into account the cerebrospinal fluid (CSF) content and nerve roots distribution.[10] Another method of defining LSS is the stenosis ratio (SR), which is quantitative and MRI-based as well. It is the ratio of the dural sac cross-sectional area (DCSA) of the most stenotic region to that of an adjacent unstenosed part. With the SR, variations in patient size are better controlled for, which allows better comparison of values between patients with LSS.[11]

The objective of this study is to determine whether there is any correlation between clinical features of degenerative lumbar spine stenosis as measured with the NCOS, and radiologic lumbar spine stenosis measured qualitatively by Schizas grading system and quantitatively by stenosis ratio in adult patients with radiologic lumbar spine stenosis.

METHODS

This was a prospective, cross-sectional study, carried out in Memfys Hospital, Enugu, which is a major neurosurgery referral centre located in the South-East region of Nigeria. The study period was between September 2022 and January 2023.

The study population consisted of consenting Nigerian adults aged 40 years and above who had various degrees of radiologic degenerative LSS, as determined by the participating radiologist. Patients with lumbar spine stenosis from trauma, infection, or tumours were excluded. Also, patients with previous lumbar spine surgery, cerebrovascular accident, motor neuron disease, and demyelinating disease were excluded. Patients with Paget's disease of bone (spine), achondroplasia, congenital scoliosis or kyphosis, demineralizing bone diseases and Von Recklinghausen disease of bone were excluded.

Recruited patients had MRI investigations performed by a radiographer using a 16-channel 1.5T MRI scanner (GE SIGNA Explorer, USA), software version SV25. The subjects were positioned supine on the MRI table and underwent the lumbar spine scan. A T2-weighted whole spine screening was also done to exclude other pathologies in the cervical and thoracic spine, which could confound degenerative LSS. Axial T2-weighted images were obtained using a fast spin echo sequence (TE:20, TR:3000, FOV:240×240, slice thickness 3mm, Nex; 2 slices per slab; 0.6×0.8-pixel size; 195.3kHz bandwidth, image time 3 mins and 7 secs). The axial slices targeted the disc levels with maximum compression, and the T2 sequence was preferred because it revealed the CSF contained in the dural sac clearly. Axial T1 images were also obtained to exclude epidural fat, which resembled CSF on axial T2 images. They were viewed by the researcher with the RadiAnt DICOM viewer (64-bit) laptop application. The Schizas grade of stenosis was assigned, depending on the extent of nerve root distribution within the CSF at the region of maximal stenosis and confirmed by the Radiologist. The dural sac cross-sectional area (DSCA) at the point of maximal stenosis (D1) and that just above without stenosis (D2) were measured using the RadiAnt DICOM viewer (64-bit) laptop application. The stenosis ratio was calculated by dividing the D1 by D2 expressed in percentage (quantitative LSS measurement) as seen in Figure 1.

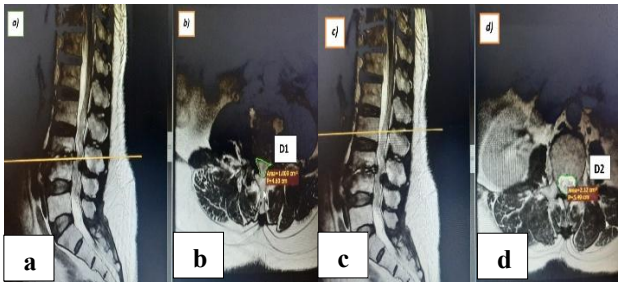

Figure 1: (a) Sagittal and axial, (b) T2WI showing L3/L4 degenerative disc disease with lumbar canal stenosis (D1), (c) sagittal, and (d) axial T2WI of the same patient at the level without canal stenosis (D2).

Qualitative LSS grading was done in accordance with Schizas description of radiologic stenosis classified as: grade A: nerve rootlets partially filled the dural sac with clearly visible CSF (no stenosis), grade B: nerve rootlets fill up the dural sac with some CSF visible (moderate stenosis), grade C: nerve rootlets and CSF not visible, but epidural fat seen posteriorly (severe stenosis) and grade D: no nerve rootlets, CSF or epidural fat visible (extreme stenosis).[8,10]

Patients were interviewed by the researcher using a structured questionnaire to obtain demographics and rule out possible confounding diagnoses or exclusion criteria. Also, they were required to tick the appropriate answers in the NCOS questionnaire to ascertain the severity of clinical symptoms and total scores were obtained. The researcher assisted the patients who were not educated enough to understand the questionnaire.

To standardize the measurements, two radiologists repeated each of the first ten DCSA measurements taken by the researcher to assess for inter-examiner variability using Cronbach's alpha.[12] All the measurements were taken by the researcher twice, and the average was calculated to reduce intra-examiner variability.

The formula for calculating the required sample size for a cross-sectional study according to Habib et al.[13]

$$N = z^2pq/d^2$$

Where N is the sample size, z is the standard normal deviate (1.96 at 95% confidence level), p is the proportion of cases, q is (1-p), and d is the precision set at 10% for this study. In 2018, 264 patients were diagnosed with radiologic degenerative lumbar spine stenosis out of 297 cases with chronic low back pain. This gave a proportion (p) of 0.889 and a q of 0.111 (1-0.889). Substituting into the equation gave;

$$N = (1.96)^2 \times 0.889 \times 0.111/(0.1)^2 = 38\ subjects$$

The final sample size for this study was 42 subjects after adding an attrition rate of 10%.

Purposive convenient sampling was employed, where consenting adults ≥40 years of age with degenerative lumbar spine stenosis were enrolled till sample size was achieved.

All statistical analyses were done using descriptive and inferential statistics. Descriptive analysis involved the use of tables and cross-tables. Inferential statistics was employed in testing the hypotheses using statistical correlation tests (Pearson and Spearman correlation). The statistical package for social sciences (version 20 SPSS Inc, Chicago, IL) was used for all statistical analyses.

A written informed consent was obtained at the time of enrolment into the study. Ethical approval was obtained for this study.

RESULTS

Fifty subjects were recruited and completed the study, with 22 males (44.0%) and 28 females (56.0%). The mean age of participants was 58.4±10.8 years (Table 1).

Forty-four subjects (88.0%) had concomitant back and leg pain, while six subjects (12.0%) had either backpain or leg pain. The symptom severity affected the jobs of 35 subjects (70.0%). Most subjects had multi-level stenosis affecting the lumbar spine. However, the L4/5 level is the commonest area for critical stenosis.

The mean NCOS of the subjects was 45.56 (SD=14.69) (Table 2).

Table 3 highlights the radiologic characteristics of respondents.

Table 1: Biodata distribution of respondents: shows the subjects' biodata and occupation of respondents.

Characteristics	N	%
Age distribution (years)		
40-49	12	24.0
50-59	14	28.0
60-69	16	32.0
≥70	8	16.0
Total	50	100.0
Mean age	58.4±10.8	
Sex distribution		
Male	22	44.0
Female	28	56.0
Total	50	100.0
Occupation		
Trader/businessman	19	38.0
Public servant	15	30.0
Retiree	9	18.0
Farmer	3	6.0
Unemployed	4	8.0
Total	50	100.0

Table 2: Depicts subjects' responses to the NCOS components.

Characteristics	N	%
Walking distance		
Less than 100 yards	17	34.0
100 yards–½ mile	22	44.0
½ mile–1mile	8	16.0
Longer than 1 mile	3	6.0
Standing duration		
Less than 5 minutes	13	26.0
5–15 minutes	27	54.0

Continued.

Characteristics	N	%
15–45 minutes	7	14.0
As long as I like	3	6.0
Have back pain		
Severe	26	52.0
Moderate	18	36.0
Mild	5	10.0
None	1	2.0
Have leg pain		
Severe	24	48.0
Moderate	15	30.0
Mild	3	6.0
None	8	16.0
Have numbness/tingling		
Severe	12	24.0
Moderate	17	34.0
Mild	12	24.0
None	9	18.0
Have heaviness/weakness		
Severe	3	6.0
Moderate	16	32.0
Mild	10	20.0
None	21	42.0
Affected sporting		
Severe	16	32.0
Moderate	21	42.0
Mild	12	24.0
None	1	2.0
Affected household chores		
Severe	9	18.0
Moderate	25	50.0
Mild	12	24.0
None	4	8.0
Affected walking activity		
Severe	16	33.3
Moderate	22	45.8
Mild	8	16.7
None	2	4.1
Affected standing		
Severe	13	26.0
Moderate	27	54.0
Mild	7	14.0
None	3	6.0
Affected sitting		
Severe	0	0.0
Moderate	13	26.0
Mild	12	24.0
None	25	50.0
Affected sex life		
Severe	6	12.0
Moderate	10	20.0
Mild	1	2.0
None	33	66.0
How long to rest to recover		
Less than 5 minutes	8	16.0

Continued.

Characteristics	N	%
5–10 minutes	16	32.0
Longer than 10 minutes	26	52.0
Analgesic frequency		
Frequently	6	12.0
Daily	21	42.0
Occasionally	21	42.0
Never	2	4.0
Consultation frequency		
Frequently	1	2.0
Daily	0	0.0
Occasionally	49	98.0
Never	0	0.0
Pain level (10-vas)		
0–2	20	40.0
3–5	27	54.0
6–10	3	6.0
NCOS by categories		
20-39	20	40.0
40-59	23	46.0
60-79	6	12.0
80-89	1	2.0
Total	50	100.0

Most subjects had Schizas grade C stenosis on axial T2-weighted MRI as noted above.

Determination of the stenosis ratio

To ensure reliability of the measurements, an intraclass correlation coefficient of 0.999, p<0.001 was obtained where DCSA measurements were repeated for 10 patients by the researcher about a month after initial measurements were taken.

Two radiologists repeated the DCSA measurements on 10 subjects and an interclass correlation coefficient of 0.984, p<0.001 was obtained between the researcher and the first radiologist, and 0.928, p=0.008 between the researcher and the second radiologist. The average dural sac cross-sectional area at the critical area of stenosis in the subjects was 67.46 mm^2 (SD=41.85), while it was 171.36 mm^2 (SD=45.59) at the normal segment above it. Hence, the mean stenosis ratio (SR) was 39% (SD=19).

Correlation between the NCOS and the stenosis ratio (SR)

The correlation between the NCOS and SR was insignificant, r=0.094, p=0.523. The chart below is a scatterplot showing the relationship between the two indices (Figure 2). The correlation remained insignificant when patients with only L4/L5 disease were assessed, r=0.050, p=0.798. When patients with severe stenosis (<70 mm^2 DCSA) were considered, the correlation between SR and NCOS remained poor with r=0.142, p=0.454. Correlation between low back pain VAS and SR was weak, r=-0.31.

Table 3: Radiologic characteristics of respondents.

Characteristics	N	%
Radiologic stenotic levels		
1-level	3	6.0
2-levels	14	28.0
Multilevel	33	66.0
Total	50	100.0
Critically stenotic level		
L2/3	1	2.0
L3/4	10	20.0
L4/5	31	62.0
L5/S1	8	16.0
Total	50	100.0
Schiza's grade of patients		
A1	2	4.0
A2	6	12.0
A3	4	8.0
A4	1	2.0
B	7	14.0
C	22	44.0
D	8	16.0
Total	50	100.0

Correlation between the NCOS and Schizas grade

The correlation between the NCOS and the Schizas grade was not statistically significant, rs=-0.187, p=0.202, as shown in the chart below. Again, the correlation remained insignificant when patients with only L4/L5 disease were assessed, rs=-0.185, p=0.327, and when those with Schizas

grade C and D were assessed, rs=-0.122, p=0.521 (Figure 3).

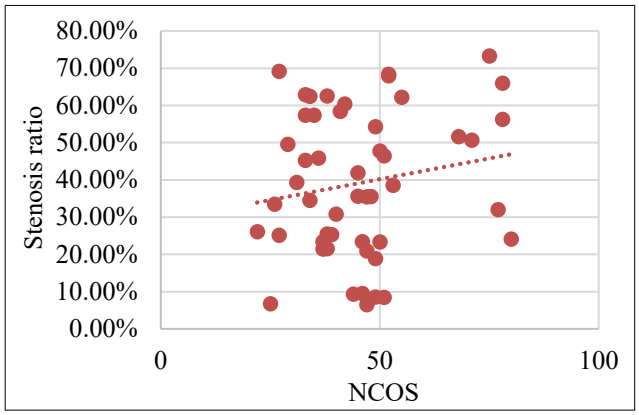

Figure 2: A scatterplot of SR and NCOS showing an insignificant weak relationship.

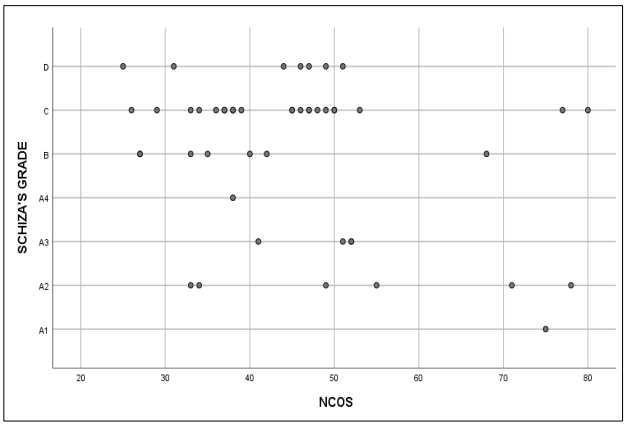

Figure 3: The scatterplot of the NCOS and Schizas grade showing a poorly defined linear relationship.

DISCUSSION

Degenerative lumbar spine stenosis is a disease which is common in middle age to the elderly. The modal age range for our patients was 60-69 years as seen in Table 1, and the mean age distribution was 58.4±10.8 years, which corresponds to the average ages in Nigerian studies.[2,14] The mean age in a Norwegian study done by Clemens et al was 68.1±9.4 years, and that done by Sigmundsson et al in Sweden revealed LSS was most common in the age range 70-79 years.[15,16] However, Azimi et al in Iran reported an average age of 49.4±9.8 years.[17] The sex distribution in this study was 22 males and 28 females, showing a female preponderance as reported in some studies.[2,8,12,17,18] Other studies revealed a slight male preponderance, but a test of significance was not done.[1,2] In this study, traders/businessmen were the most affected, followed by public servants and retirees. These patients had been involved, at one time or another, in activities that involved stress in the lumbar spine. Fatigba et al also reported degenerative LSS to be more common in traders.[19] Most subjects had multi-level stenosis affecting the lumbar spine (Table 2) using thecal indentation as described by Schizas. However, the L4/5 level was the commonest area for critical stenosis, followed distantly by the L3/4, L5/S1, L2/3 levels, and none involving L1/2 (Table 3). This finding was also supported by Muoghalu et al. Sigmundsson et al also demonstrated the L4/5 level to be the most affected, followed by the L3/4 level. According to Ige et al and Ajiboye et al, L4/5 was most affected, followed closely by L5/S1.[2,18]

The mean NCOS of the subjects was 45.56 (S.D.=14.69). This comprised patients who required and those who did not require surgical intervention. This contrasts with the study done by Azimi et al in Iran, who had an average preoperative NCOS of 25.9 (SD 12.6), and Suyasa et al reported theirs to be 20.1 (SD 8.5).[17,20] Mahadewa et al reported an average preoperative NCOS of 40.7(SD=1.8) in males and 39.7 (SD=2.51) in females.[21] As seen in Table 2, 86% of respondents had NCOS between 20 and 59, and just one patient had NCOS above 80 (no asymptomatic patient). The extent of symptoms and neurogenic claudication most probably influenced their need for further investigation.

In this study, LSS clinical features, as demonstrated by the NCOS, did not correlate significantly with the stenosis ratio (r=0.094, p=0.523). This was shown in the scatterplot in Figure 2. Furthermore, the correlation between the NCOS and the Schizas grade was not statistically significant, rs=-0.187, p=0.202 as shown in Figure 3. A subgroup analysis of Schizas grade C and D was done and revealed a poor correlation with NCOS (rs=-0.122, p=0.521). In addition, when patients with significant stenosis (DCSA<70 mm^2) were analysed, a poor correlation was identified with NCOS. These findings underscore the point that clinical features of degenerative LSS do not significantly correlate with the degree of radiologic stenosis. Clemens et al, Sigmundsson et al, Jin et al and Vialle et al all corroborated this.[15,16,22,23] Ishimoto et al demonstrated an association of radiographic LSS with clinical symptoms in a cohort of the general population with severe central stenosis.[24] He utilized a combination of thorough clinical assessment and Zurich claudication questionnaire (excluding the postoperative questions) for the clinical assessment of LSS and qualitatively assessed the central canal stenosis with the MRI. Goni et al showed that for all his patients, radiologic LSS did not significantly correlate with the extent of disability as measured by the ODI; however, when patients with significant stenosis (DCSA<70 mm^2) were analysed, there was a significant correlation.[25] This finding among patients with DCSA<70 mm^2 was not reproducible in this study. His study population was selected based on the homogeneity of symptoms, not all patients who presented with symptoms of LSS. His sample population also included more patients with congenital LSS, and he had just eleven patients (22%) with significant stenosis. Prasetya et al demonstrated a significant negative correlation between NCOS and Schizas grade of radiologic stenosis in patients with LSS (r=-0.90, p<0.001) and a significant positive correlation

between NCOS and ODI (r=0.91, p<0.001). His study population was similar to that for this study, with 35 patients; however, his study was a retrospective study. This study may have to be done among other populations to confirm this correlation. The poor correlation established in this study could stem from other lumbar spine pain generators other than spinal stenosis. Discogenic pain or facet joint disease pain is typically aggravated by three-dimensional movements where there is maximum stress to the synovium or joint cartilage.[26] This finding is similar to patients' pain reports in degenerative lumbar stenosis, where pain is aggravated by prolonged walking or standing. Ishfaq et al demonstrated that clinical features of degenerative lumbar stenosis using NCOS in a Pakistani population did not significantly correlate with the radiologic degree of stenosis. His findings were in tandem with what we found as well.[27] Could there be racial differences in pain perception? Some authors have reported that blacks were less likely to receive opioid medications for low back pain.[28,29] This infers that the black population may perceive less pain requiring analgesics compared to other races. This may have accounted for the difference in outcomes as compared with the study of Prasetya et al.[8] The typical multi-level nature of degenerative lumbar spine stenosis, which was not considered, may have resulted in the poor correlation observed in this study. Only the level with the worst canal stenosis was considered in the radiologic analyses in this study. Nevertheless, the findings in this study show that to make a diagnosis of degenerative LSS, the clinical features and radiologic findings must be considered together, not either.

From Table 2, three patients (6%) did not manifest neurogenic claudication, characterised by limitation in walking. Seventeen (34%) patients could not walk past 100 yards (≈100 m), and 22 (44%) patients walked between 100 yards and half a mile (≈100-800 m). Azimi et al demonstrated an average walking distance of 279.6±143 m. Standing duration was reduced in 94% of patients, 26% less than 5 minutes, 54% between 5 and 15 minutes and 14% between 15 and 45 minutes. These show that walking distance and standing duration are commonly affected in patients with LSS. 26 (52%), 18 (36%), and 1 patient reported severe, moderate and no low back pain, respectively. Mean low back pain VAS was 7.08 (SD 1.54). 24 (48%), 15 (30%), and 8 (16%) patients reported severe, moderate and no leg pain. Muoghalu et al reported a mean preoperative VAS of 8.26 (SD 1.46), which was more than what this study obtained.[14] This further affirms that low back pain (when it occurs in LSS) may be severe, especially in patients going for surgery. This study also demonstrated a poor correlation between the degree of low back pain and the stenosis ratio. These were in keeping with the findings of Sigmundsson et al who showed a poor correlation between the VAS of low back pain and leg pain versus DCSA (which defined radiologic LSS).[16] Numbness/tingling was severe, moderate, and mild in 12 (24%), 17 (34%) and 12 (24%) patients, respectively. 21 (42%) patients did not report heaviness or weakness in their lower limbs. Sporting and household chores were affected in virtually all patients, and 42 (84%) patients required more than 5 minutes of rest to recover from neurogenic claudication. The symptom severity affected the jobs of 35 subjects (70.0%). These reveal the extent of disability patients with degenerative LSS face. Patients with LSS usually have resolution of neurogenic claudication features when their hips are flexed, as when they sit. In this study, 50% of respondents reported no symptoms while sitting. The other respondents may have had concomitant exit foraminal stenosis, which accounted for their radicular symptoms.

Limitations

This study did not consider the multilevel nature of degenerative LSS. The level with maximum compression was used in the analyses. This may be an area to be explored in further studies. Secondly, this single-centre study may need to be done in other locations to validate the results obtained.

CONCLUSION

In conclusion, for adult patients with degenerative lumbar spine stenosis, the correlation between the severity of symptoms and the degree of radiologic stenosis is poor. This implies that proper clinical evaluation and radiologic assessment should both be used to guide the patient's intervention, and not either.

ACKNOWLEDGEMENTS

Authors would like to thank the Management and staff of Memfys Hospital Enugu, Enugu State, Nigeria where this study was conducted. They also thank Dr. Ned Ndafia, Dr. Campbell Francis, and Dr. Ekene Nnamani, who helped with study conceptualisation and collection of data. They appreciate Rivers State University, for its support during this study period.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Hart I, Okwunodulu O, Ajare EC, Ohaegbulam SC. Correlation between severity of symptoms and degree of radiologic stenosis in adults with degenerative lumbar spine stenosis. Int Surg J 2025;12:2112-9.