Research Square

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# Paraspinal Muscle Fatty Infiltration Is Associated With MRI-Defined Lumbar Fasciitis in Patients With Degenerative Lumbar Spinal Stenosis: A Retrospective Cross-Sectional Study

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## Abstract

# Purpose

To investigate the association between paraspinal muscle fatty infiltration and MRI-defined thoracolumbar fascial signal abnormalities in patients with degenerative lumbar spinal stenosis (DLSS).

# Methods

This retrospective cross-sectional study included 303 patients with DLSS who underwent lumbar MRI between January 2024 and January 2026. MRI-defined thoracolumbar fascial signal abnormalities were identified on sagittal T1-weighted, T2-weighted, and fat-suppressed T2-weighted images. Paraspinal muscle fatty infiltration was assessed using a four-grade MRI-based classification and analyzed both dichotomously (Grades 1–2 vs. Grades 3–4) and as an ordinal variable. Relative cross-sectional areas of the erector spinae, multifidus, and psoas muscles were also measured. Factors associated with thoracolumbar fascial signal abnormalities were evaluated using multivariable logistic regression. Receiver operating characteristic (ROC) analysis was used to assess discriminative performance.

# Results

MRI-defined thoracolumbar fascial signal abnormalities were present in 149 of 303 patients (49.2%). High-grade paraspinal muscle fatty infiltration was more frequent in patients with fascial signal abnormalities than in those without ($P < 0.001$). After adjustment for sex, diabetes mellitus, and relative psoas muscle cross-sectional area, high-grade fatty infiltration remained associated with higher odds of thoracolumbar fascial signal abnormalities (OR, 5.578; 95% CI, 3.325–9.357; $P < 0.001$). High-grade fatty infiltration alone yielded an AUC of 0.711 (95% CI, 0.660–0.761), whereas the multivariable model yielded an AUC of 0.741 (95% CI, 0.684–0.797). When fatty infiltration grade was modeled as an ordinal variable, each one-grade increase was associated with higher odds of fascial signal abnormalities (OR, 3.515; 95% CI, 2.383–5.185; $P < 0.001$), although the proportions across individual grades were not monotonically distributed.

# Conclusions

In patients with degenerative lumbar spinal stenosis, high-grade paraspinal muscle fatty infiltration was associated with the presence of MRI-defined thoracolumbar fascial signal abnormalities. These findings suggest that paraspinal muscle composition and thoracolumbar fascial signal abnormalities may represent related imaging features of the posterior lumbar soft-tissue environment.

## Introduction

Degenerative lumbar spinal stenosis (DLSS) is a prevalent degenerative condition of the lumbar spine and a major cause of low back pain, radicular symptoms, and functional impairment in older adults[1]. Although DLSS has traditionally been considered a consequence of degeneration involving the intervertebral discs, facet joints, and ligamentous structures, increasing attention has been directed toward the contribution of posterior lumbar soft tissues to the degenerative process[2, 3]. Alterations in posterior lumbar soft tissues may affect spinal stability and functional performance, potentially contributing to clinical manifestations of degenerative lumbar disorders[1, 4, 5].

Among posterior lumbar soft tissues, paraspinal muscles contribute to spinal stability and functional capacity[6, 7]. Their degeneration is commonly characterized by muscle atrophy and increased fatty infiltration, reflecting deterioration in muscle quality and altered biomechanical function[8, 9]. MRI-based assessment of paraspinal muscle fatty infiltration is therefore widely used to characterize muscle degeneration[10]. Several grading approaches have been proposed for semi-quantitative assessment of fatty infiltration. Wen et al. recently described a four-grade classification system for lumbar paraspinal muscle fat infiltration, which was used in the present study[11].

The thoracolumbar fascia is an important connective tissue structure within the posterior lumbar compartment and contributes to force transmission between the paraspinal muscles and adjacent spinal structures[12, 13]. Signal abnormalities involving the thoracolumbar fascial region can be observed on lumbar MRI, typically appearing as relatively low signal intensity on T1-weighted images and high signal intensity on T2-weighted and fat-suppressed T2-weighted images[14]. These findings may reflect increased fluid content or other edema-like tissue alterations, although their pathological basis remains uncertain. Factors associated with these MRI-defined thoracolumbar fascial signal abnormalities in patients with degenerative lumbar spinal stenosis have not been well characterized.

Therefore, this study aimed to investigate clinical and imaging factors associated with MRI-defined thoracolumbar fascial signal abnormalities in patients with degenerative lumbar spinal stenosis. We specifically examined whether paraspinal muscle fatty infiltration, as an imaging feature of muscle degeneration, was associated with the presence of thoracolumbar fascial signal abnormalities.

## Methods

# Study design and patient population

Consecutive patients with degenerative lumbar spinal stenosis (DLSS) who underwent lumbar MRI between January 2024 and January 2026 were retrospectively screened. Patients were eligible if they met the following criteria: (1) a diagnosis of DLSS based on clinical and imaging findings; (2) availability of lumbar MRI examinations including T1-weighted, T2-weighted, and fat-suppressed T2-weighted sequences of sufficient image quality; and (3) availability of complete clinical data required for the analysis. Patients were excluded for the following reasons: (1) spinal infection, tumor, or fracture; (2) previous lumbar surgery; (3) high-grade spondylolisthesis or segmental instability; (4) spinal deformity;

(5) incomplete clinical data; (6) inadequate MRI quality or missing essential sequences; (7) neuromuscular disorders; or (8) autoimmune or systemic inflammatory diseases. Demographic characteristics and relevant comorbidities were extracted from electronic medical records. MRI assessments were performed as described below.

## MRI assessment of thoracolumbar fascial signal abnormalities

All lumbar MRI examinations were performed using a 3.0-T MRI system and included sagittal T1-weighted, T2-weighted, and fat-suppressed T2-weighted sequences. Thoracolumbar fascial signal abnormalities were defined as relatively low signal intensity in the thoracolumbar fascial region on T1-weighted images with corresponding high signal intensity on T2-weighted and fat-suppressed T2-weighted images[14]. Patients showing these predefined imaging features were classified as having MRI-defined thoracolumbar fascial signal abnormalities.

Two observers experienced in spinal imaging independently reviewed all MRI examinations while blinded to the patients' clinical information. Disagreements were resolved by consensus. Interobserver agreement was assessed using Cohen's kappa coefficient for categorical variables and intraclass correlation coefficients (ICCs) for continuous measurements.

## Assessment of paraspinal muscle fatty infiltration

Paraspinal muscle fatty infiltration was assessed using a semiquantitative four-grade MRI classification adapted from Wen et al. [11]. The multifidus and erector spinae muscles were evaluated bilaterally on axial lumbar MR images. Fatty infiltration was visually graded according to the estimated proportion of intramuscular fat as Grade 1 (< 10%), Grade 2 (10–30%), Grade 3 (30–50%), or Grade 4 (> 50%) [11]. The highest grade observed among the evaluated muscles on either side was used as the patient-level fatty infiltration grade. For the primary analysis, Grades 1–2 were categorized as low-grade fatty infiltration and Grades 3–4 as high-grade fatty infiltration. The original four-grade classification was additionally analyzed as an ordinal variable.

## Measurement of MRI-derived parameters

Paraspinal muscle cross-sectional areas were additionally assessed as MRI-derived measures of muscle morphology. Measurements were performed on axial T2-weighted images at the L4–5 disc level. The cross-sectional areas (CSAs) of the erector spinae, multifidus, and psoas muscles were manually delineated bilaterally according to previously reported MRI-based measurement methods [15]. For each muscle, the mean CSA of the left and right sides was used for analysis. To account for differences in body size, the mean bilateral CSA of each muscle was normalized to the corresponding vertebral body area. The resulting relative CSAs were recorded as rES-CSA, rMF-CSA, and rPM-CSA, respectively.

# Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA) and R version 4.5.2 (R Foundation for Statistical Computing, Vienna, Austria). Continuous variables were assessed for normality using the Shapiro–Wilk test. Normally distributed variables were expressed as mean ± standard deviation and compared using independent-samples t tests, whereas non-normally distributed variables were expressed as median (interquartile range) and compared using Mann–Whitney U tests. Categorical variables were expressed as counts and percentages and compared using the chi-square test or Fisher's exact test, as appropriate.

Variables with $P < 0.05$ in the between-group comparisons were entered into the multivariable logistic regression model to identify factors independently associated with MRI-defined thoracolumbar fascial signal abnormalities. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported.The discriminative performance of high-grade paraspinal muscle fatty infiltration and the multivariable logistic regression model was assessed using receiver operating characteristic (ROC) curve analysis. Areas under the curve (AUCs) with 95% CIs were reported. In a secondary analysis, the original four-grade fatty infiltration classification was entered as an ordinal variable in logistic regression to estimate the change in odds of thoracolumbar fascial signal abnormalities per one-grade increase. All statistical tests were two-sided, and $P < 0.05$ was considered statistically significant.

## Results

# Study population and baseline characteristics

After application of the predefined eligibility criteria, 52 patients were excluded because of spinal infection, tumor, fracture, previous lumbar surgery, high-grade spondylolisthesis, segmental instability, or spinal deformity. Of the remaining 343 patients, 22 were excluded because of incomplete clinical information or inadequate MRI image quality, and 18 because of neuromuscular disorders or autoimmune or systemic inflammatory diseases. Finally, 303 patients were included in the analysis (Fig. 1).

Among the 303 included patients, MRI-defined thoracolumbar fascial signal abnormalities were present in 149 patients (49.2%) and absent in 154 patients. Baseline characteristics according to the presence or absence of fascial signal abnormalities are presented in Table 1.

Table 1
Baseline characteristics according to the presence of MRI-defined thoracolumbar fascial signal abnormalities

| Variable | Absent | Present | Test Statistic | p-Value |
|---|---|---|---|---|
| Number of cases (n) | 154 | 149 | / | / |
| Age(years) | 64 (53–70) | 63 (54–73) | $Z$ =−0.781 | 0.435 |
| Sex (female/male) | 71/83 | 88/61 | $\chi^2$=5.098 | 0.024* |
| BMI (kg/m²) | 24.26 (22.03–26.57) | 24.72 (22.77–26.63) | $Z$ =−1.167 | 0.243 |
| Disease duration(days) | 90 (30–300) | 120 (30–360) | $Z$ =−1.185 | 0.236 |
| Hospital stay(days) | 8 (7–12) | 9 (6–14) | $Z$ =−0.200 | 0.841 |
| Hypertension(yes/no) | 64/90 | 53/96 | $\chi^2$=1.146 | 0.284 |
| Diabetes (yes/no) | 43/111 | 64/85 | $\chi^2$=7.490 | 0.006* |
| Coronary heart disease(yes/no) | 11/143 | 6/143 | $\chi^2$=1.388 | 0.239 |
| rES-CSA | 0.734 (0.626–0.841) | 0.714 (0.577–0.861) | $Z$ =−1.027 | 0.304 |
| rMF-CSA | 0.405 (0.341–0.493) | 0.418 (0.347–0.497) | $Z$ =−0.927 | 0.354 |
| rPM-CSA | 0.590 (0.433–0.690) | 0.470 (0.409–0.630) | $Z$ =−2.840 | 0.005* |
| High-grade paraspinal muscle fatty infiltration (yes/no) | 54/100 | 115/34 | $\chi^2$=54.458 | < 0.001* |

rES-CSA, relative cross-sectional area of erector spinae; rMF-CSA, relative cross-sectional area of multifidus; rPM-CSA, relative cross-sectional area of psoas muscle;* p < 0.05 was considered statistically significant.

Variables with P < 0.05 in the between-group comparisons, including sex, diabetes mellitus, high-grade paraspinal muscle fatty infiltration, and rPM-CSA, were entered into the multivariable logistic regression model (Table 2). After adjustment for these variables, high-grade paraspinal muscle fatty infiltration remained independently associated with the presence of MRI-defined thoracolumbar fascial signal abnormalities (OR, 5.578; 95% CI, 3.325–9.357; P < 0.001). Sex, diabetes mellitus, and rPM-CSA were not significantly associated with fascial signal abnormalities in the multivariable model (all P > 0.05).

Table 2. Multivariable logistic regression analysis of factors associated with MRI-defined thoracolumbar fascial signal abnormalities

| Variables | OR (95% CI) | p-Value |
|---|---|---|
| Sex (male vs female) | **1.306 (0.747–2.282)** | 0.349 |
| Diabetes (yes vs no) | 0.696 (0.410–1.182) | 0.180 |
| High-grade paraspinal muscle fatty infiltration (yes vs no) | 5.578 (3.325–9.357) | <0.001* |
| rPM-CSA | 0.518 (0.104–2.580) | 0.422 |

CI, confidence interval; OR, odds ratio.rPM-CSA, relative cross-sectional area of psoas muscle;

* p < 0.05 was considered statistically significant.

## Assessment of thoracolumbar fascial signal abnormalities and interobserver agreement

Representative MRI examples of thoracolumbar fascial signal abnormalities are shown in Fig. 2.Interobserver agreement for the assessment of thoracolumbar fascial signal abnormalities was excellent, with a Cohen's κ coefficient of 0.85 (P < 0.001).Quantitative MRI-derived measurements, including rES-CSA, rMF-CSA, and rPM-CSA, also demonstrated excellent reproducibility, with ICCs exceeding 0.90.

# Factors associated with MRI-defined thoracolumbar fascial signal abnormalities

In the multivariable model including sex, diabetes mellitus, paraspinal muscle fatty infiltration, and rPM-CSA, high-grade fatty infiltration remained associated with the presence of MRI-defined thoracolumbar fascial signal abnormalities. Compared with low-grade fatty infiltration, high-grade fatty infiltration was associated with higher odds of fascial signal abnormalities (OR, 5.578; 95% CI, 3.325–9.357; P <

0.001).Sex, diabetes mellitus, and rPM-CSA were not significantly associated with fascial signal abnormalities after multivariable adjustment (all P > 0.05).

# Discriminative performance of high-grade paraspinal muscle fatty infiltration and the multivariable model

ROC analysis was used to assess the discriminative performance of high-grade paraspinal muscle fatty infiltration and the multivariable logistic regression model for the presence of MRI-defined thoracolumbar fascial signal abnormalities (Table 3 and Fig. 3).

Table 3
Receiver operating characteristic analysis of high-grade paraspinal muscle fatty infiltration and the multivariable logistic regression model for MRI-defined thoracolumbar fascial signal abnormalities

| Variable | AUC(95% CI) | p-Value |
|---|---|---|
| High-grade paraspinal muscle fatty infiltration | 0.711(0.660–0.761) | < 0.001* |
| Combined logistic regression model | 0.741(0.684–0.797) | < 0.001* |
| AUC, area under the curve; CI, confidence interval;* p < 0.05 was considered statistically significant. | | |

High-grade paraspinal muscle fatty infiltration showed moderate discrimination, with an AUC of 0.711 (95% CI, 0.660–0.761). The multivariable logistic regression model yielded a numerically higher AUC of 0.741 (95% CI, 0.684–0.797).

# Relationship between paraspinal muscle fatty infiltration grade and MRI-defined thoracolumbar fascial signal abnormalities

The prevalence of MRI-defined thoracolumbar fascial signal abnormalities differed across the four grades of paraspinal muscle fatty infiltration (Table 4 and Fig. 4). The observed prevalence was 50.0% (5/10), 23.4% (29/124), 65.0% (89/137), and 81.3% (26/32) for Grades 1–4, respectively. Although the observed proportions were not monotonically distributed across all four grades, ordinal logistic regression showed an overall association between increasing fatty infiltration grade and the presence of MRI-defined thoracolumbar fascial signal abnormalities (OR per one-grade increase, 3.515; 95% CI, 2.383–5.185; P < 0.001).

Table 4
Association between paraspinal muscle fatty infiltration grade and MRI-defined thoracolumbar fascial signal abnormalities

| Paraspinal muscle fatty infiltration grade | Absent,n (%) | Present,n (%) | OR (95% CI) | p-Value |
|---|---|---|---|---|
| Grade 1 | 5 (50.0) | 5 (50.0) | Reference | - |
| Grade 2 | 95 (76.6) | 29 (23.4) | - | - |
| Grade 3 | 48 (35.0) | 89 (65.0) | - | - |
| Grade 4 | 6 (18.8) | 26 (81.3) | - | - |
| Per grade increase | - | - | 3.515(2.383−5.185) | < 0.001* |
| CI,confidence interval;OR,odds ratio;*P < 0.05 was considered statistically significant. | | | | |

# Discussion

In this study, we examined the association between paraspinal muscle fatty infiltration and MRI-defined thoracolumbar fascial signal abnormalities in patients with degenerative lumbar spinal stenosis. MRI-defined thoracolumbar fascial signal abnormalities were present in 49.2% of patients, indicating that these findings were not uncommon in this DLSS cohort. After multivariable adjustment, high-grade paraspinal muscle fatty infiltration remained associated with the presence of thoracolumbar fascial signal abnormalities. When fatty infiltration grade was analyzed as an ordinal variable, each one-grade increase was associated with higher odds of thoracolumbar fascial signal abnormalities, although the proportions across individual grades were not monotonically distributed.

The thoracolumbar fascia is a key connective tissue structure within the posterior lumbar soft-tissue complex and contributes to mechanical force transmission between the paraspinal muscles and adjacent spinal structures[12, 13, 16]. Compared with osseous, discal, and ligamentous degeneration, fascial alterations have received less attention in studies of degenerative lumbar disorders. In the present study, MRI-defined thoracolumbar fascial signal abnormalities were identified by relatively low signal intensity on T1-weighted images and corresponding high signal intensity on T2-weighted and fat-suppressed T2-weighted images[15]. These signal abnormalities should not be regarded as histologically confirmed inflammation; rather, they may reflect increased fluid content, edema-like change, or other alterations within the fascial microenvironment[17, 18]. Taken together, these findings support the interpretation of thoracolumbar fascial signal abnormalities as an imaging feature of posterior lumbar soft-tissue alteration rather than a pathologically confirmed inflammatory diagnosis.

In the multivariable analysis, high-grade paraspinal muscle fatty infiltration remained associated with MRI-defined thoracolumbar fascial signal abnormalities. This association may be considered in the context of the close anatomical and biomechanical relationship between the paraspinal muscles and the

thoracolumbar fascia. The thoracolumbar fascia surrounds and interfaces with the paraspinal musculature and contributes to force transmission and lumbopelvic stability[12, 19]. Paraspinal muscle fatty infiltration is a recognized feature of muscle degeneration and is associated with alterations in muscle structure and function[6]. Such changes in muscle composition could modify the mechanical environment of the adjacent fascia and thereby coexist with MRI-visible fascial signal abnormalities. However, this remains a possible explanation rather than a demonstrated mechanism, and the cross-sectional design of the present study does not establish the direction or causality of this relationship.

In the present study, paraspinal muscle fatty infiltration was associated with thoracolumbar fascial signal abnormalities, whereas BMI and relative muscle cross-sectional areas were not significantly associated after multivariable adjustment. BMI is a global anthropometric measure and does not directly characterize paraspinal muscle composition. Previous MRI studies have likewise reported that BMI may not correlate with fatty infiltration of the multifidus, erector spinae, or psoas muscles[20].Muscle cross-sectional area and fatty infiltration also represent different aspects of paraspinal muscle degeneration. Sun et al. reported greater paraspinal muscle fatty infiltration in patients with degenerative lumbar disease despite no significant difference in overall muscle cross-sectional area[21].Fatty infiltration is therefore better considered a compositional feature of paraspinal muscle degeneration and has been associated with altered muscle structure and function[6]. These findings suggest that muscle composition and muscle size should be considered as related but distinct imaging features when evaluating paraspinal muscle degeneration.

Analysis of the original four-grade classification provided additional information on the association between paraspinal muscle fatty infiltration and MRI-defined thoracolumbar fascial signal abnormalities. Although the primary analysis used a dichotomized classification, analysis of the original grades allowed the association to be examined without collapsing the four categories into two groups. The proportion of patients with fascial signal abnormalities was not monotonically distributed across the four grades; however, when fatty infiltration grade was modeled as an ordinal variable, each one-grade increase was associated with higher odds of thoracolumbar fascial signal abnormalities (OR, 3.515; 95% CI, 2.383–5.185). Given the non-monotonic distribution across individual grades, this finding should be interpreted as evidence of an overall ordinal association rather than a strictly dose-dependent relationship.

ROC analysis yielded an AUC of 0.711 for high-grade paraspinal muscle fatty infiltration and 0.741 for the multivariable model. The numerically higher AUC of the multivariable model should be interpreted cautiously because no formal comparison between the two ROC curves was performed. More importantly, the present analysis was intended to characterize the association and discriminative ability of the imaging features rather than to develop or validate a diagnostic model. This cautious interpretation is consistent with recent systematic-review evidence indicating that, despite growing interest in paraspinal muscle imaging in LSS, its clinical utility remains uncertain because of heterogeneity in imaging methods and reported associations[3].

Several limitations should be acknowledged. First, this was a retrospective single-center study, which may have introduced selection bias and limited the generalizability of the findings. Second, the cross-sectional design precludes determination of the temporal or causal relationship between paraspinal muscle fatty infiltration and thoracolumbar fascial signal abnormalities. Third, thoracolumbar fascial signal abnormalities were defined according to MRI characteristics without histopathological confirmation; therefore, their underlying pathological substrate remains uncertain. Fourth, paraspinal muscle fatty infiltration was assessed using a semiquantitative visual grading approach, which may be influenced by observer-dependent assessment despite the use of predefined grading criteria. Finally, the present study focused primarily on imaging associations and did not evaluate the relationship between fascial signal abnormalities and patient-reported symptoms or longitudinal clinical outcomes. Further longitudinal studies incorporating quantitative muscle composition measurements and clinical outcomes are warranted.

# Conclusions

In patients with degenerative lumbar spinal stenosis, high-grade paraspinal muscle fatty infiltration was associated with the presence of MRI-defined thoracolumbar fascial signal abnormalities. These findings suggest that paraspinal muscle composition and thoracolumbar fascial signal abnormalities may represent related imaging features of the posterior lumbar soft-tissue environment.

# Declarations

### Ethics approval and consent to participate

This retrospective study was approved by the Ethics Committee of Fujian Medical University (Approval No. 2026KY771) and was conducted in accordance with the Declaration of Helsinki. The requirement for informed consent was waived by the Ethics Committee because of the retrospective nature of the study.

### Consent for publication

Not applicable.

### Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

### Competing interests

The authors declare that they have no competing interests.

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**Authors' contributions**

Ruixiong Du：Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources and Writing – original draft. Xin Lin: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation and Visualization. Xiaoqing Ye: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation and Visualization. Ruixiong Du：Xin Lin and Xiaoqing Ye contributed equally to this work. Dingwei Wu and Guozhen Wei : Methodology, Validation and Visualization. Jinrong Zhang, Taotao Lin and Xianfeng Lin: Methodology and Visualization. Feiyue Lin and Long Chen: Conceptualization, Project administration, Supervision and Writing – review & editing.

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# Figures

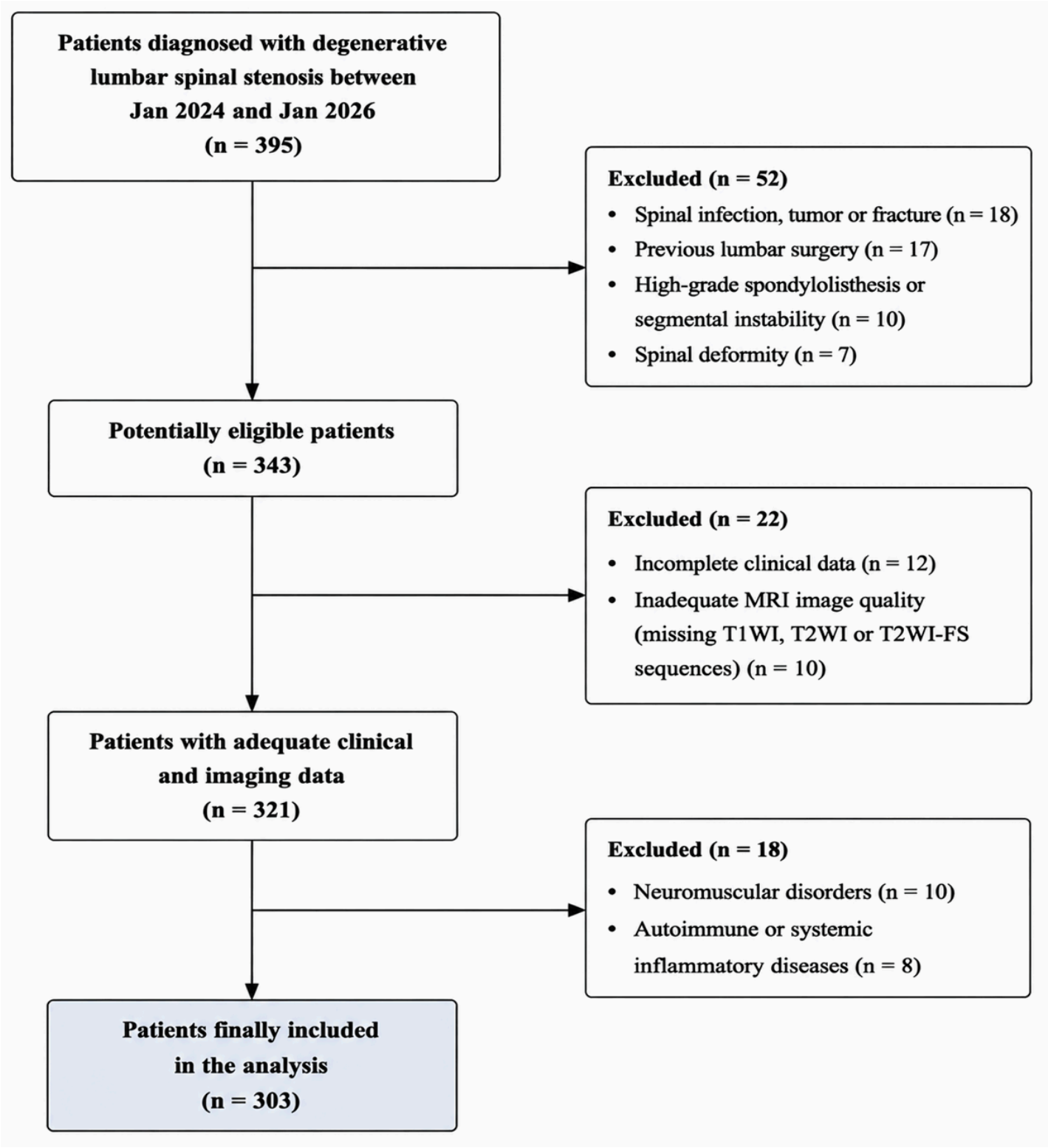



**Figure 1**

Flow diagram showing the inclusion and exclusion process of patients with degenerative lumbar spinal stenosis (DLSS). A total of 395 patients were initially screened, and 303 patients were included in the final analysis after applying the predefined eligibility criteria.

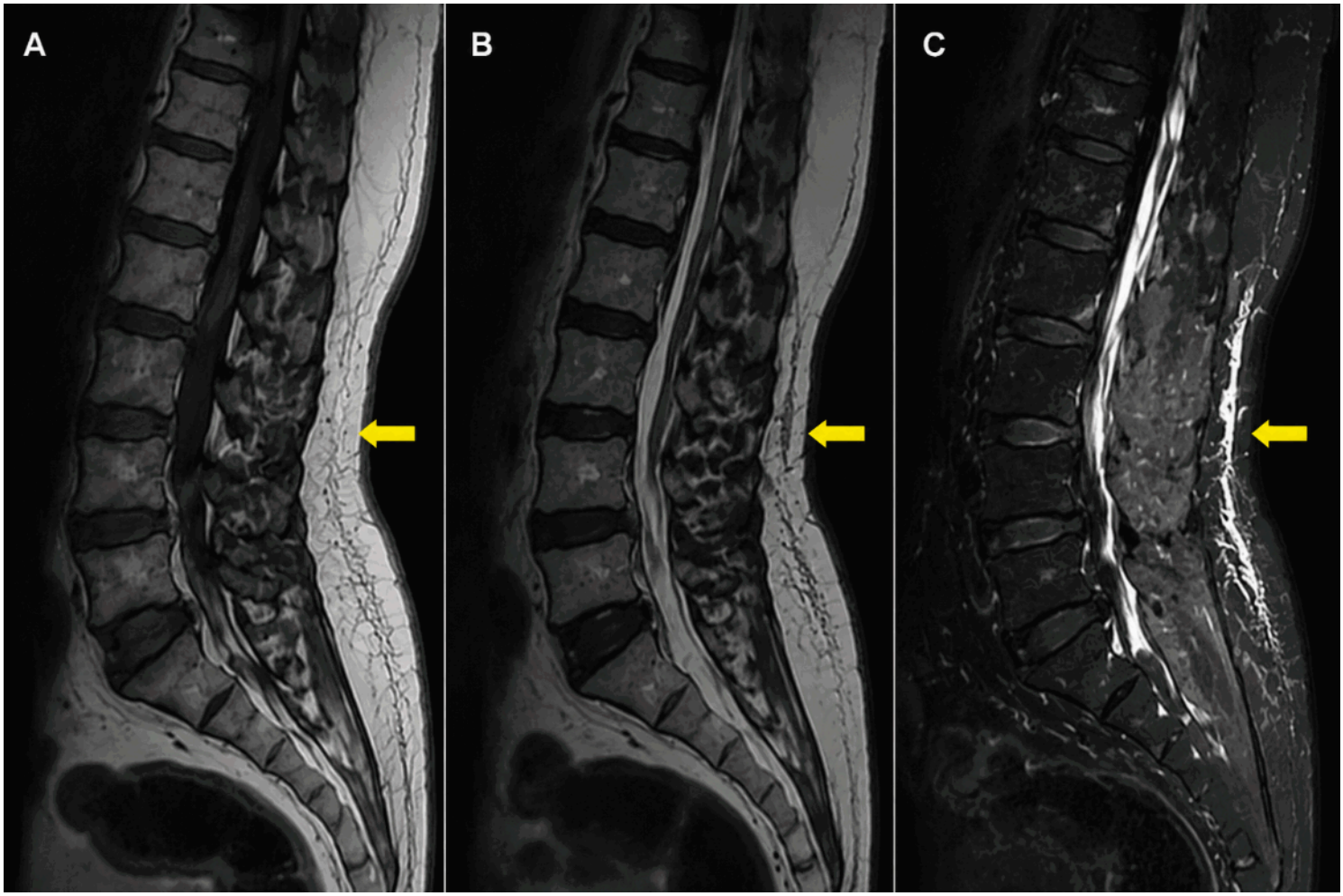



**Figure 2**

Representative sagittal lumbar MRI images demonstrating MRI-defined thoracolumbar fascial signal abnormalities. The thoracolumbar fascial region shows relatively low signal intensity on T1-weighted imaging (A) and corresponding high signal intensity on T2-weighted (B) and fat-suppressed T2-weighted imaging (C), representing the predefined imaging features used to identify thoracolumbar fascial signal abnormalities.

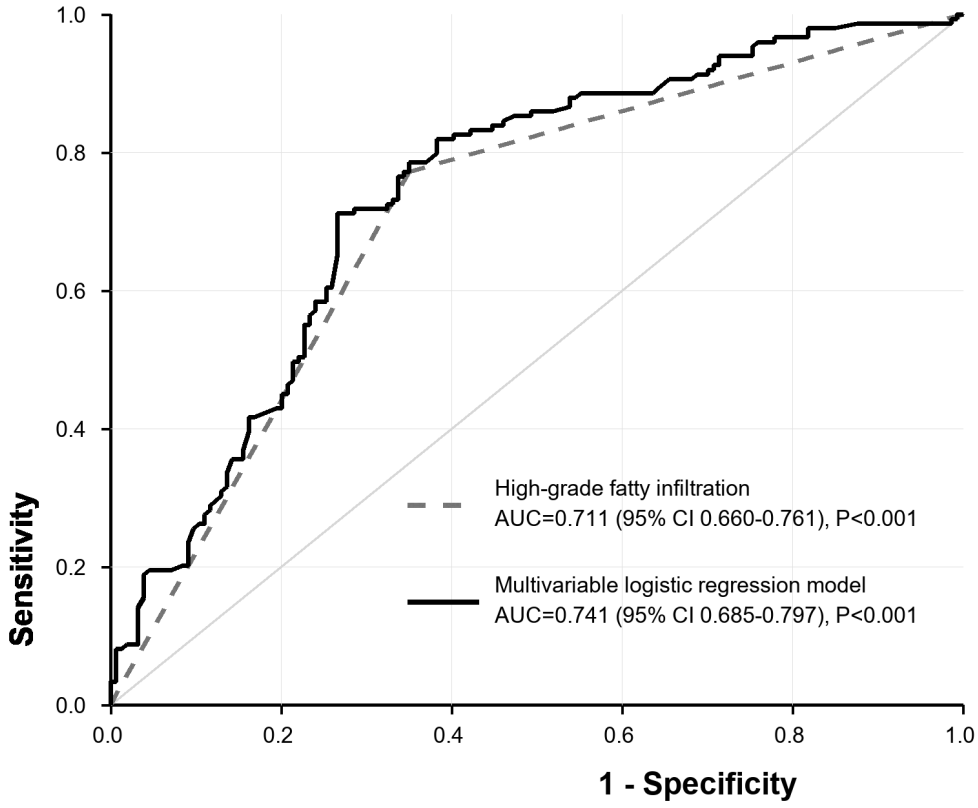



**Figure 3**

Receiver operating characteristic (ROC) curves showing the discriminative performance of high-grade paraspinal muscle fatty infiltration and the multivariable logistic regression model for the presence of MRI-defined thoracolumbar fascial signal abnormalities.

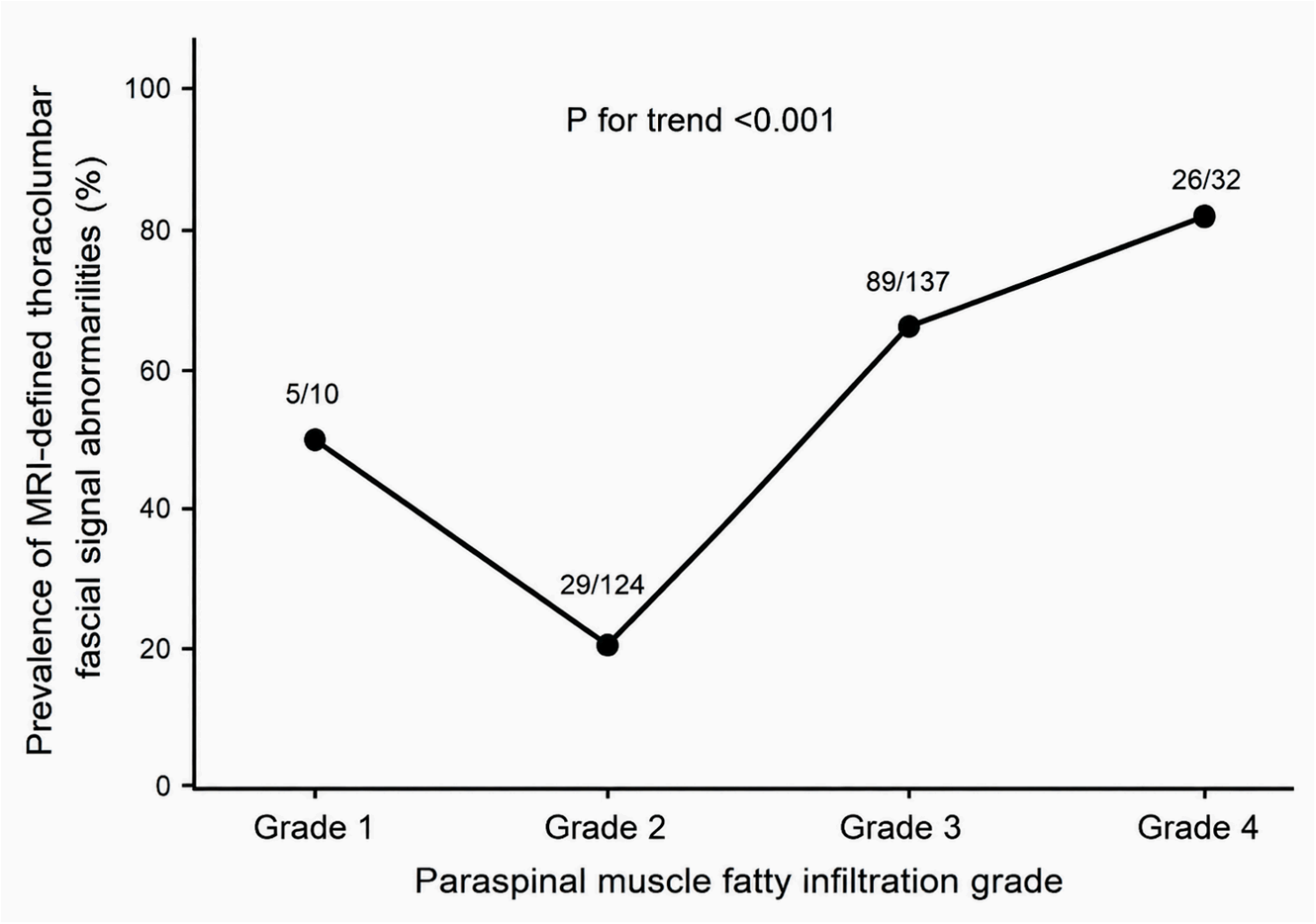



**Figure 4**

Proportion of patients with MRI-defined thoracolumbar fascial signal abnormalities across the four grades of paraspinal muscle fatty infiltration.