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ORIGINAL RESEARCH

Prevalence and Demographic Associations of Ligamentum Flavum Hypertrophy in Lumbar Spinal Stenosis

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Background: The ligamentum flavum (LF) is a posterolateral ligament of the spinal canal. Ligamentum flavum hypertrophy (LFH) is a principal degenerative determinant of lumbar spinal stenosis (LSS), causing reduction of canal and foraminal space and thereby promoting nerve roots compression. LFH prevalence and severity increase with advancing age, rendering it a key factor in the clinical presentation and surgical approaches.

Objective: This study aims to determine the prevalence of LFH in patients undergoing surgical decompression for LSS.

Methods: This cross-sectional study was conducted in the Department of Neurosurgery at Aliabad University Hospital and included all patients diagnosed with LSS (per surgical protocols and/or MRI reports) from January to December 2025. The association between age, gender, and LFH was also tested using a chi-square test in SPSS 26.0.

Results: Of 239 patients with LSS, 128 (53.6%) were males and 111 (46.4%) were females. LFH was present in 102 (42.7%) patients, including 64 (50.0%) males and 38 (34.2%) females; with a significant association between LFH and male sex ($p = 0.014$). LFH prevalence increases markedly with age (21–30 years: 18.5%; 61–70 years: 93.9%; p=0.001). Anatomically, LFH was most frequent at L4–L5 (40.2%) and L3–L4 (18.6%).

Conclusion: LFH represents a major pathological component of LSS, with prevalence increasing progressively with age. LFH was more frequent in male patients and was most commonly localized to L3 to L5. Accordingly, standardized preoperative cautions for LFH should be considered to support the selection of the surgical approach.

Keywords: ligamentum flavum hypertrophy, low back pain, lumbar disc herniation, lumbar spine stenosis

Introduction

Lumbar spinal stenosis (LSS) is one of the most common spinal disorders in the elderly population and represents one of the leading indications for spinal surgery. Ligamentum Flavum Hypertrophy (LFH) is a major contributor to acquired LSS. The Ligamentum Flavum (LF) is an important anatomical structure that covers the posterolateral portion of the spinal canal. It tends to increase with age.[1,2] Its thickness is from 3.5 to 6 mm.[3] LFH, which plays a significant role in LSS and nerve roots compression, has considerable clinical importance. A thickness of 4 mm or greater is generally considered hypertrophic, and surgical intervention is often required.[4,5] The pathology of LSS involves degenerative changes in the facet joints and hypertrophy of the LF. These changes are usually irreversible and frequently necessitate surgical intervention.[6] Patients with LSS typically present with low back pain, lower limb weakness, and neurogenic claudication. Both LFH and Lumbar Disc Herniation (LDH) contribute to the reduction of spinal canal space and compression of the thecal sac and nerve roots. Even in the absence of disc herniation or osteophyte formation, LFH alone may lead to canal stenosis and clinical symptoms.[7]

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The first report of LFH was published in 1881 by the German neurologist Dr. Hermann Oppenheim, who described it as a cause of myeloradiculopathy.[8] Recent advances in spinal instrumentation and full-endoscopic surgical techniques have led to favorable clinical outcomes in the treatment of spinal pathologies.[9] Patients who do not respond to conservative treatment require surgical intervention. Traditional surgical techniques focus on complete decompression and may be associated with complications.[10]

The prevalence of LFH increases over time and with advancing age; patients aged 60 years and older had higher rates of LFH. The degenerative alteration occurs as a result of aging or mechanical instability, and LFH is a key factor in acquired LSS.[4,11,12] Studies in Egypt show that LFH was responsible for LSS in 24.5% of patients, and was more prevalent with increasing age, observed in 32.9% of participants. No significant differences in LFH were noted between males and females.[7,13] In Japan, among patients aged over 65 years with LSS, approximately 51% had LFH.[6] The Israeli data indicate that LFH is independent of gender and increases with age at all levels.[1] Serbian and Egyptian data indicate that the prevalence of LSS is more frequent at the vertebral level of L4/L5, with a secondary peak at L3/L4.[13,14]

Accurate identification of the primary pathological driver of LSS is essential to select a targeted decompressive surgery strategy. In many surgical settings in Afghanistan, procedures are frequently performed without systematic etiologic assessment. This nonselective practice is associated with persistent symptoms, higher rates of reoperation, and more frequent postoperative complications. This study aims to determine the prevalence of LFH in patients undergoing surgical decompression for LSS, with particular attention to patients' age, gender, and the specific lumbar vertebral level.

Materials and Methods

Study Setting

This cross-sectional study was conducted in the Department of Neurosurgery, Aliabad University Hospital, Kabul, Afghanistan, from January to December 2025.

Target Population

The target population of this study includes all patients who undergo a surgical operation for LSS at the Neurosurgery Service of Aliabad University Hospital.

Sampling

Using a census sampling method, all patients diagnosed with LSS (surgical protocols and/or MRI reports), who were admitted to the Department of Neurosurgery during the study period, and aged >20 years, were included in the study. On the other hand, patients with spinal infection, spine trauma, spinal cord tumor, or congenital deformity, as well as those with previous LSS surgery, were excluded from the study.

Data Collection

Data of LSS and LFH obtained from patients' files (surgical protocols and/ or MRI reports). Cases were included in the study if LSS or LFH were documented on the MRI report "Accordance with the radiologist's written report, which was based on measurements obtained from axial images" or identified during the lumbar spine surgery "Intraoperatively, midline and bilateral ligamentum flavum hypertrophy was measured using calibrated instruments". LF thickness of 4 mm or greater was considered as LFH.[3]

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 26.0. Descriptive statistics summarized demographic characteristics of the study participants. Continuous variables were categorized by grouping. Categorical variables were presented as frequencies and percentages. A chi-square test was used to assess the association between age and gender, with LFH.

Ethical Considerations

This study complies with the declaration of Helsinki. The study protocol was reviewed and approved by the Institutional Review Board of Kabul University of Medical Sciences (Protocol ID and ethical approval number: 27, Date of review: 25.12.2024). In addition, the study supervisor has approved the proposal before submission. Informed consent was obtained from study participants before their inclusion in the study. Privacy and confidentiality of participants and their data were strictly maintained throughout the study.

Results

Of the 239 patients diagnosed with LSS based on surgical findings and/or MRI reports, 102 patients (42.7%) were found to have LFH, while 137 (57.3%) did not exhibit LFH.

Among the patients with LSS, 128 (53.6%) were male and 111 (46.4%) were female. LFH was present in 64 males (50.0%) and 38 females (34.2%). A statistically significant association between LFH and male gender was observed ($p = 0.014$) (Table 1).

An important finding of this study was that the proportions of both LSS and LFH increased with advancing age. In the 21–30 and 31–40-year age groups, 5 of 27 (18.5%) and 15 of 60 (25.0%) patients with LSS had LFH, respectively. By contrast, in the 51–60 and 61–70-year age groups, 33 of 48 (68.8%) and 31 of 33 (93.9%) patients with LSS exhibited LFH, respectively. A statistically significant association between LFH and increased age was observed ($p = 0.001$) (Table 2).

The highest incidence of LSS occurred at the L4–L5 level (87 patients; 36.4%), followed by L3–L4 (45 patients; 18.8%) and L5–S1 (37 patients; 15.5%). LFH at these same levels was observed in 41 patients (40.2%), 19 patients (18.6%), and 11 patients (10.8%), respectively (Table 3).

Table 1 Ligamentum Flavum Hypertrophy in Patients with Lumbar Spine Stenosis; Participants' Gender

Gender	Ligamentum Flavum Hypertrophy		
	Yes N (%)	No N (%)	Total (LSS) N (%)
Male	64 (50.0)	64 (50.0)	128 (100)
Female	38 (34.2)	73 (65.8)	111 (100)
Total	102 (42.7)	137 (57.3)	239 (100)

Table 2 Frequency and Percentage of Patients' Age, and Its Association with LFH and LSS

Age of the Patients	Ligamentum Flavum Hypertrophy		
	Yes N (%)	No N (%)	Total (LSS) N (%)
21–30 Years	5 (18.5)	22 (81.5)	27 (100)
31–40 Years	15 (25.0)	45 (75.0)	60 (100)
41–50 Years	18 (25.4)	53 (74.6)	71 (100)
51–60 Years	33 (68.8)	15 (31.2)	48 (100)
61–70 Years	31 (93.9)	2 (6.1)	33 (100)
Total	102 (42.7)	137 (57.3)	239 (100)

Table 3 Prevalence of LFH, LSS, and Their Association with the Lumbar Spine Level

Level of Lumbar Spine	Ligamentum Flavum Hypertrophy		
	Yes N (%)	No N (%)	Total (LSS) N (%)
L1–L2 Lumbar Spine Stenosis	0 (0.0)	2 (1.5)	2 (0.8)
L2–L3 Lumbar Spine Stenosis	1 (1.0)	3 (2.2)	4 (1.7)
L3–L4 Lumbar Spine Stenosis	19 (18.6)	26 (19.0)	45 (18.8)
L4–L5 Lumbar Spine Stenosis	41 (40.2)	46 (33.6)	87 (36.4)
L5–S1 Lumbar Spine Stenosis	11 (10.8)	26 (19.0)	37 (15.5)
L4–L5 and L5–S1 Lumbar Spine Stenosis	15 (14.7)	17 (12.4)	32 (13.4)
L3–L4 and L4–L5 Lumbar Spine Stenosis	5 (4.9)	10 (7.3)	15 (6.3)
L2–L3 and L3–L4 Lumbar Spine Stenosis	3 (2.9)	1 (0.7)	4 (1.7)
L1–L2 and L2–L3 Lumbar Spine Stenosis	1 (1.0)	0 (0.0)	1 (0.4)
Multi-Level Lumbar Spine Stenosis	6 (5.9)	6 (4.4)	12 (5)
Total	102 (100)	137 (100)	239 (100)

Discussion

This study aimed to determine the prevalence of LFH among patients with LSS and to assess its associations with age, sex, and lumbar spine level. This is the first investigation of its kind in Afghanistan and provides important and actionable findings for selecting surgical approaches for LSS and preventing anticipated operative complications.

Overall, 42.7% of patients with LSS in our study exhibited LFH, a proportion higher than those reported in two Egyptian studies (24.5% and 32.9%).[7,13] Similarly, the prevalence of LFH among patients with LSS increases with advancing age, reaching 93.9% at age 61–70, which is comparable to the finding of a Japanese study reporting a prevalence of 51.0% at age 65,[6] also this result is consistent with other studies from Israel, Saudi Arabia, Egypt (Two studies), Turkey, and Japan,[1,4,7,13,15,16] and collectively indicate a global trend of increasing LFH prevalence with advancing age. The prevalence may be attributable to the more common physically demanding labor among the Afghan population and delayed presentation for medical care. International studies suggest that prolonged engagement in heavy physical labor may accelerate lumbar degeneration and contribute to LSS and LFH.[17]

Regarding gender distribution, 50.0% of male patients and 34.2% of female patients had LFH, showing a statistically significant association between LFH and male sex ($p = 0.014$); in other words, LFH was observed more frequently in males than in females. This finding differs from the Egyptian and Turkish studies, which reported no substantial gender-related difference in LFH prevalence.[7,15] A plausible explanation for the higher LFH prevalence among males in our sample is the greater exposure to heavy labor and sustained outdoor physical activities.

The highest frequencies of LSS were observed at L4–L5 (36.4%), and L3–L4 (18.8%) Levels; and the highest prevalence of LFH also was observed at the same levels, L4–L5 (40.2%), and L3–L4 (18.6%). These level-specific distributions of LFH are in agreement with studies in Serbia, L4–L5 (50.0%), and L3–L4 (36.7%),[14] and in Egypt, L4–L5 (70.8%).[13] The Spinal level with LFH, in Turkey, was found more common at L3-L4 and L4-L5, in India at L4-L5, and in Nepal at L5-S1 and L4-L5.[18–20] Overall, these findings demonstrate that LFH occurs more frequently at the lower lumbar segments (L3 to L5).

Limitations and Future Directions

This study is limited by its single-center setting and focuses on a single year (2025), which may affect the generalizability of the findings. Future multi-center studies, including correlations with functional outcomes, are recommended to validate and expand these findings.

Conclusion

The findings of this study demonstrate that LFH constitutes a substantial proportion of pathology among patients with LSS and that LFH prevalence increases progressively with advancing age. LFH was more prevalent in male patients, and the highest frequencies were observed at the L3 to L5 levels. Consequently, greater cautions for LFH should be considered to support selection of the surgical approach for LSS.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis, and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

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