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Role of ligamentum flavum hypertrophy in low back pain

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Abstract
Background: Lumbar canal stenosis is a significant cause of pain and disability. Compression of the neural elements occurs with changes in the local anatomy. The degenerative changes include disc deterioration and facet joint arthrosis and ligamentum flavum hypertrophy. Even though many studies have shown the significance of ligamentum flavum hypertrophy in patients with spinal canal stenosis, very few studies have examined ligamentum flavum thickness and its relation age and lumbar level.
Methods: Study was conducted at Kanyakumari government medical college for a period of 12 months from November 2021 to November 2022. Total of 50 patients were included in the study presenting with complaints of lower back pain, radiculopathy and neurogenic claudication.
Results: Using MR imaging we measured ligamentum flavum of a total 50 patients. Thickness of ligamentum flavum was increased – older patients, lower lumbar level and symptomatic. Lateral recess stenosis, which is a frequent finding with patients with lumbar radiculopathy – close proximity of ligamentum flavum with facet joint where motion and degenerative changes are more appreciated.
Conclusions: Our study confirmed increase in ligamentum flavum thickness as age increased and lumbar level in symptomatic patients. This finding may represent the degenerative process in the ligamentum flavum that occurs with age and also supports the reactive nature of the ligamentum flavum to increased mechanical forces at lower lumbar level.

Keywords: Imaging we, measured, ligamentum flavum

Introduction
Lumbar spinal stenosis represents a significant cause of pain and disability in the aging population. Compression of the neural elements occurs with changes in the local anatomy. Many studies suggest that the ligamentum flavum is a key factor in the pathogenesis of lumbar spinal stenosis [1–6]. The degenerative cascade which includes disc deterioration and facet joint arthrosis, also leads to ligamentum flavum in-folding, hypertrophy, and fibrosis [2, 4, 7, 8]. These changes have been associated with inflammatory changes as well as increased mechanical stresses [2, 3, 5, 6, 9–12]. Even though many studies have shown the significance of ligamentum flavum hypertrophy in patients with spinal stenosis or at the advanced stage of spondylosis, few studies have systematically examined ligamentum flavum thickness and its relation to age and lumbar level at early stages of the degenerative cascade [1, 5, 13–16]. Previous studies measuring ligamentum flavum thickness have differed in their method of measurement, using either computed tomography (CT) or magnetic resonance (MR) imaging [2, 5, 13–16]. Most of these studies lack a direct comparison between patients with lumbar spinal stenosis and a control group. Furthermore, attempts to quantify the thickness of the ligamentum flavum have used single measurements, ignoring possible differences in laterality and location of stenosis, i.e. central versus lateral. More importantly, few studies exist that examine the possible correlation between ligamentum flavum thickness and other factors such as disc height and grade of disc degeneration. Using enhanced MR images as well as bilateral medial and lateral measurements of ligamentum flavum thickness, the current study examined ligamentum flavum thickness across different age groups from 20–60 years of age, gender, and lumbar level in individuals with and without low back pain symptoms. In addition, the effects of disc height and grade of disc degeneration on ligamentum flavum thickness were also analyzed.

Materials and Methods
Study was conducted at Kanyakumari government medical college for a period of 12 months

from November 2021 to November 2022. Total of 50 patients were included in the study presenting with complaints of lower back pain, radiculopathy and neurogenic claudication. Exclusion criteria: patients with previous history of lumbar surgery, radiotherapy, congenital anomalies, cardiac pacemakers. Magnetic resonance imaging performed in all included patients. Sagittal and axial plane used in the study for measurement of Ligamentum Flavum at lumbar spine level. T_2 weighted sagittal images were used to locate the spinal level of intervertebral spaces. After confirmation measurements of the ligamentum flavum thickness measured on T_2 weighted axial images. Ligamentum flavum thickness was compared against the age groups, other pathologies like disc bulge causing compression, causing canal stenosis and facet joint hypertrophy.

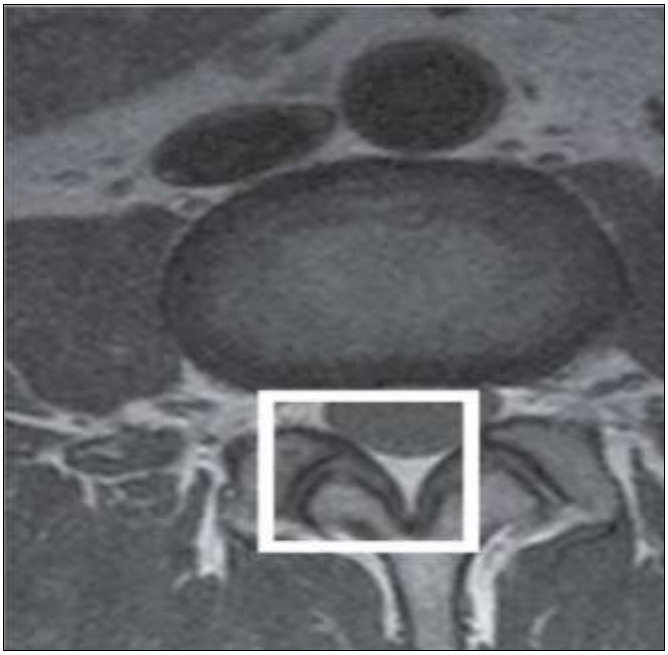

Fig 1: Magnetic resonance imaging performed in all included patients

Results

Table 1: Age distribution

20 – 40 years	**12**	**3.96 mm**
40 -60 years	20	4.73 mm
>60 years	18	4.94 mm

Sex

- Males – 37
- Females - 13
- Average thickness in males – 4.78 mm
- In females – 4.62 mm

Lumbar level

- No significant difference between left and right side noted.
- L 1 and L5 – smallest.
- Increased from L2 to L4 level.

Table 2: Lumbar level

L1	3.82 mm
L2	4.1 mm
L3	4.38 mm
L4	4.30 mm
L5	3.96 mm

Lower back pain symptoms

- Neurogenic claudication – Most common.
- Radicular pain
- Back pain.

Thickness of ligamentum flavum was increased – older patients, lower lumbar level and symptomatic.

Discussion

Using MR imaging and custom-developed, spine specific measurement techniques, we examined the thickness of the ligamentum flavum in asymptomatic and chronic low back pain individuals. In our series of 63 subjects, we found ligamentum flavum thickness differs between symptomatic and asymptomatic subjects and increases with higher disc degeneration grade, older age and lower lumbar level. Ligamentum flavum thickness was measured at two different locations in the present study. Previous studies have not agreed upon a uniform method of measuring ligamentum flavum thickness. While certain studies have utilized an area averaging technique, others have assessed ligamentum flavum thickness using a single measurement located at the approximate "middle" of the ligamentum flavum [2, 5, 13, 15, 16]. We believe the medial and lateral measurements provide a better understanding of how ligamentum flavum thickness varies and may affect symptomatology. Lateral ligamentum flavum thickness was significantly greater in low back pain subjects compared to asymptomatic subjects. Medial ligamentum flavum thickness was also greater in low back pain subjects, but the difference was not statistically significant. The finding that an increase in lateral ligamentum flavum thickness was more significant than medial ligamentum flavum thickness is also notable. This is reasonable, given the close proximity of the lateral measurement to the facet joint, where motion and instability are most appreciable. Lateral recess stenosis, which is a frequent finding in older patients with lumbar radiculopathy, may have an earlier basis with lateral thickening of the ligamentum flavum and low back pain. Additionally, both measurements were moderately correlated, which was an expected result. These findings of our study, together with the current literature, support the idea that early changes in the ligamentum flavum may play a key role in chronic low back pain symptoms. While traditionally the focus of discussion has been on the bulging of the disc leading to compression of the cauda equina, there is growing evidence that identifies ligamentum flavum buckling and hypertrophy as the key pathologic feature of spinal stenosis. Hansson *et al*. examined 24 individuals using MRI before and after an external axial load. The authors found the ligamentum flavum to be the primary cause of canal encroachment, with bulging of the ligament leading to 50 to 85% of the reduction in canal area [22]. Since axial loading causes disc height loss [23], this study probed any possible correlations between disc height and the ligamentum flavum thickness. However, no correlation was found between the disc height and the ligamentum flavum thickness in our series. Given that disc height loss associated with disc degeneration is a slow process, bulging of the ligamentum flavum may not occur under a gradual loss of disc height due to the elastic nature of the ligamentum flavum. In contrast, the present study found a low, positive but significant correlation between ligamentum flavum thickness and disc grade (Using the Pfirrmann classification system). The fact that moderate correlation coefficients were obtained between thickness measurements and disc height also shows that loss of disc height might be one of the contributing factors to instability

associated with disc degeneration [18, 19] and stenosis. Contribution of mechanical stresses to ligamentum flavum thickening has been reported in the literature. Sairyo *et al*. [5] used a multidisciplinary approach to study the pathomechanism of ligamentum hypertrophy and found transforming growth factor-beta to be related to the stimulation of fibrosis and summarized the process of ligamentum flavum hypertrophy as beginning with mechanical stress inducing tissue damage, leading to inflammation and scarring, and finally fibrosis. Histologic studies have identified inflammatory markers including tissue inhibitors of matrix metalloproteinases [11, 24], microRNA molecules such as miR-155 [25] and increases in connective tissue growth factor [26] to be related to ligamentum flavum hypertrophy and fibrosis. Although pathogenesis of inflammation in the ligamentum flavum appears to be multifactorial, abnormal movements of the motion segment could cause mechanical stress and, in tern, inflammatory reaction. The limitations of our study may stem from the relatively small sample size and availability of MRI image data. A post hoc analysis was completed to reveal a power of (1-ß) = 0.87. However, it is still possible that this report may be underpowered to reveal differences that truly exist. The selection criteria for the low back pain group excluded subjects with severe disc collapse and stenosis. Although this serves to increase the specificity of our findings, the sensitivity of the study may have been compromised. Given that the parent study for this research was not designed to obtain normative data, our results might be limited due to relatively small subject population. However, one of the intended contributions to the field via this report, is communicating the development and use of this new method to quantify the thickness of the ligamentum flavum using clinically-available image sets. Future studies including individuals older than 60 years of age will shed light on the degenerative cascade of the spondylosis including ligamentum flavum hypertrophy. With respect to the choice for the mid-image slice, alas, 3.0 mm is still thicker than ideal, but that comes also with the fact that it is practically the only slice available that captures the ligamentum flavum at mid disc. It is also, difficult to standardize and adjacent slices might not be consistent in terms of displaying the appropriate views, especially in the posterior processes. The scout view helped in choosing this image to account for orientation and location.

Conclusions

Direct relationships between increasing age, ligamentum flavum thickness and have been insinuated by others working in the field of spine biomechanics. Our study confirmed an increase in ligamentum flavum thickness both medially and laterally as age increased and as lumbar level increased (caudally), through the L4/5 level. The thickness at the L5/S1 level varied by method but was comparatively thicker using the lateral measurement. This finding may represent the degenerative process in the ligamentum flavum that occurs with age and also supports the reactive nature of the ligamentum flavum to increased mechanical forces at the lower lumbar levels.

Conflict of Interest

Not available

Financial Support

Not available

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