Ligamentum Flavum Hypertrophy in Asymptomatic and Chronic Low Back Pain Patients

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Introduction

Spinal stenosis of the lumbar spine represents a significant cause of back pain in the aging adult. Nerve impingement results from both bony canal narrowing and soft tissue enlargement, with up to 40% of stenosis attributable to hypertrophy of the soft tissues including the ligamentum flavum (LF). Theories propose that thickness increases with spinal instability and mechanical stress to the spine, causing scar formation that leads to fibrosis and hypertrophy [1]. The coexistence of LF thickening and disc degeneration in many stenotic patients has suggested that LF hypertrophy may be due to “buckling” of the LF into the spinal canal, in addition to purely degenerative hypertrophy from scar formation. The current study sought to obtain a more thorough understanding of LF thickening by age and by level, and it also sought to assess whether LF thickening is correlated with low back pain (LBP) symptoms and degenerative disc and facet changes (loss of disk height, facet joint width narrowing).

Methods

A total of 83 volunteers were enrolled in this IRB-approved study. Each subject was screened by the authors for pre-existing lumbar spine pathology and pain episodes to categorize each subject in either the asymptomatic group or the symptomatic group with low back pain symptoms. Magnetic resonance imaging (MRI) was used to provide a cross-sectional view of the lumbar spinal canal. A 1.5-T MR unit was used to obtain 3.0 mm-thick axial proton-density images using standard clinical techniques. Images slices at the level of the inferior aspect of the disk space (from L1/2 to L5/S1) were chosen for analysis so as to maximize visualization of the LF. After selection, the MRI images were analyzed by custom software written in Visual C++ (MFC). LF images were captured and enlarged 800% using a bilinear interpolation size conversion algorithm that allowed for enhanced image quality and provided a basis for more accurate measurement. LF thickness was assessed using medial, lateral, and mean thickness measurements. To determine medial and lateral measurement points, a line was automatically drawn from the lateral extent of the LF to midline: the medial measurement occurred 1/3 of the distance from midline, and the lateral measure occurred at 2/3 from midline. Measurement lines were perpendicular to LF length. Mean thickness was found by measuring the LF length and total area via our custom program, allowing a mean thickness to be calculated. LF thickness was compared between sides (right vs. left) to ensure that neither was greater, and the data was pooled to form average thickness values. Average thickness by all 3 measurement methods were compared to differentiate thickness differences between levels (L1-L5), age groups (20’s, 30’s, 40’s, 50’s), gender, and asymptomatic-symptomatic low back pain patients. Disc height and facet joint space width at each disc level were measured by the least distance measurement method in 3D models created by CT images taken for the same subject [2]. LF thickness data were then compared to disc height, facet joint width, and disc grade (Pfirrmann classification) to assess for a correlation. For analysis, statistical significance was set at the level of p<0.05. Paired t-tests were used to compare thickness on left and right sides. Unpaired t-tests were used to compare measurements between genders and asymptomatic-symptomatic subjects. Differences based on age and spinal level were assessed using medial, lateral, and mean thickness measurements. To determine statistical significance, we used a one-way ANOVA with a Fischer’s post-hoc test. Results are presented as mean and standard error of the mean (SEM).

Results

In comparison of right vs. left-sided LF thickness, results were not significant by all 3 measurement methods (medial, lateral, mean). When examined by lumbar level, LF thickness increased by level caudally from L1/2 to L4/5, then decreased at L5/S1 in all 3 measures. Except at L5/S1, medial LF=medial LF>mean LF. Statistical significance varied by method, with medial LF being significant at all levels except between L1/2, L5/S1 (p=0.13). LF thickness (medial and lateral) did not show differences between genders. The mean LF thickness was greater in males (2.33+/−0.18) than in females (2.15+/−0.16) (p<0.001). LF thickness increased by age (20<30<40<50) in all 3 methods. The lateral thickness was significant between all age groups except 30’s/40’s (p=0.74). All 3 measures showed statistical significance between patients 20-29 y.o. and all other groups. LF thickness was greater in LBP patients compared to asymptomatic subjects overall. Using lateral measure, LF thickness in symptomatic (3.17+/−1.03) > asymptomatic (2.91+/−0.70) (p<0.009). By level, thickness differences (lateral) were significant at the L1/2 (p=0.042) and L3/4 (p=0.009) levels. LF thickness did not show a significant correlation with disc height or facet joint width. LF thickness did, however, increase with disc grade.

Discussion

LF thickness increased with age and with level, peaking at the L4/5 level, using all 3 methods. A previous study had suggested such trends only in symptomatic subjects. The statistically significant difference in LF thickness between asymptomatic and symptomatic subjects could suggest a pattern of lateral-medial thickening, though further study is warranted. Our investigation is the first to demonstrate the lack of correlation between LF thickening and disc height or facet joint width changes, which were thought to accompany LF buckling, suggesting this is not a primary source of LF hypertrophy. Disc degeneration (by grade) was, however, confirmed to correlate positively with LF thickening, suggesting mechanical changes to the spine can contribute greatly to soft tissue hypertrophy. Future study will be required to investigate the correlation between LF hypertrophy and both segmental instability and altered facet kinematics due to degenerative changes.

References:


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