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Original research article

"Thickened" ligamentum flavum caused by laminectomy

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ABSTRACT

Objective: The purpose of this study was to evaluate the effect of a laminectomy on the adjacent ligamentum flavum (LF) by measuring LF thickness using magnetic resonance imaging (MRI).
Materials and methods: A total of 78 patients (31 man, 47 woman) with laminectomy were included in our study. After determination of laminectomy level, measurements were done from the thickest parts of the bilateral LF at the upper level of the laminectomy where bilateral facet joints were evident at the slice.
Results: Ipsilateral ligamentum flavum with laminectomy was significantly thicker than the contralateral ligamentum flavum with laminectomy.
Conclusion: Laminectomy cause thickening of ligamentum flavum. Therefore we assume that it should kept in mind that LFH may develop at the adjacent level to the laminectomy and careful clinical and radiological assessments' should be done to exclude LFH in cases who complain about the recurrence of complaints during the post-operative period after laminectomy.
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1. Introduction

The ligamentum flavum (LF) covers most of the posterolateral part of the lumbar spinal canal. LF hypertrophy has been considered as a cause of lumbar spinal stenosis (LSS). Ligamentum flavum hypertrophy (LFH) is mostly caused by mechanical stress and increased physical activity. Degenerative disc diseases and inflammatory changes can also reduce the diameter of the spinal canal which can eventually lead to

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the development of spinal stenosis symptoms by compressing the dural sac and nerve roots [1–6].

Lumbar spinal stenosis (LSS) is one of the most common indications for spinal surgery in the elderly. A decompressive laminectomy without fusion is the most commonly used surgical method [5,7]. Local tissue trauma and postoperative spinal instability are among the most common complications. Studies have shown that a total laminectomy increases segmental instability unless a fusion is performed. Segmental instability can also lead to increased mechanical stress [7–12].

There were a few studies that investigate the correlation between LFH and LSS. Park et al. who investigated LF thickening by measuring the thickness of LF in patients with LSS on magnetic resonance imaging (MRI). They found that the mean thickness was 4.44 mm, which was significantly thicker than the LF in the control group without LSS (2.44 mm) [2]. Sakamaki et al. investigate the pathogenesis of LFH in patients with low back or leg pain. They found that LF thickness increased with age [12].

We could not find an article written in English literature that reported on the impact of a laminectomy on LF. Our hypothesis is that a laminectomy may cause LFH due to the mechanical stress produced by post-operative spinal instability. The purpose of this study was to evaluate the effect of a laminectomy on the adjacent LF by measuring LF thickness using MRI.

2. Materials and methods

This study was approved by ethics committee that raise the requirement to get informed consent. Using the picture archiving and communication system (PACS) (Extreme PACS, Ankara), we identified 2845 consecutive lumbar MRI scans of 2693 patients from March 2009 to December 2009 by using the word "laminectomy" in the search engine on the PACS system. A total of 234 patients who had laminectomy surgery were found using the PACS system. These patients were retrospectively examined by consensus of two radiologist ((FBH) with 2 years of experience in neuroradiology, (KBE) with 10 years of neuroradiology experience). The exclusion criteria were the presence of post-operative granulation tissue, severe scoliosis and degenerative changes, absence of posterior elements (spinous process or pedicle), presence of fixation materials and the absence of upper level slices in patients with a laminectomy. After exclusion of 156 patients, a total of 78 patients between the ages of 23–80 years [31 men, 47 women; mean age 48.7 ± 13.1 years; postoperative period ranging from 1 to 16 years] with laminectomy were included in the study.

MRI examinations were performed using a 1.5 Tesla MR system (Philips, Achieva, and Intera Nova, Netherlands). Phased array spine coils were used for all examinations. T1 weighted (W) images (TR/TE interval 400–847/8–9 ms) and T2W images (TR/TE interval 2889–3612/100–120 ms) in the sagittal plane and balanced fast field echo (BFFE) (TR/TE interval 5.5–9/2–4 ms, Flip Angle 45°) sequences in the axial plane were obtained with a 4 mm slice thickness, 0.4 mm interslice gap, 26–28 cm of field of view (FOV), 280–288 × 208–209 matrix, 2–3 NEX value for sagittal images, 2 mm slice thickness, 0.4 mm interslice gap, 15–16 cm FOV, 224 × 199 matrix and 2–3 NEX value for axial images.

After determining the level of operation, thickness of LF was measured in the axial BFFE sequence that was perpendicular to the spinal canal axis and parallel to the laminae from the thickest parts of the bilateral LF at the upper level of the laminectomy where the bilateral facet joints and the entire length of the LF were seen on the slice (Fig. 1a and b). Measurements of the LF thicknesses in this study were grouped as follows: group 1 consisted of patients with a thickness of the LF ipsilateral to the side of the laminectomy, group 2 consisted of patients with thickness of the LF contralateral to the side of the laminectomy. The age and

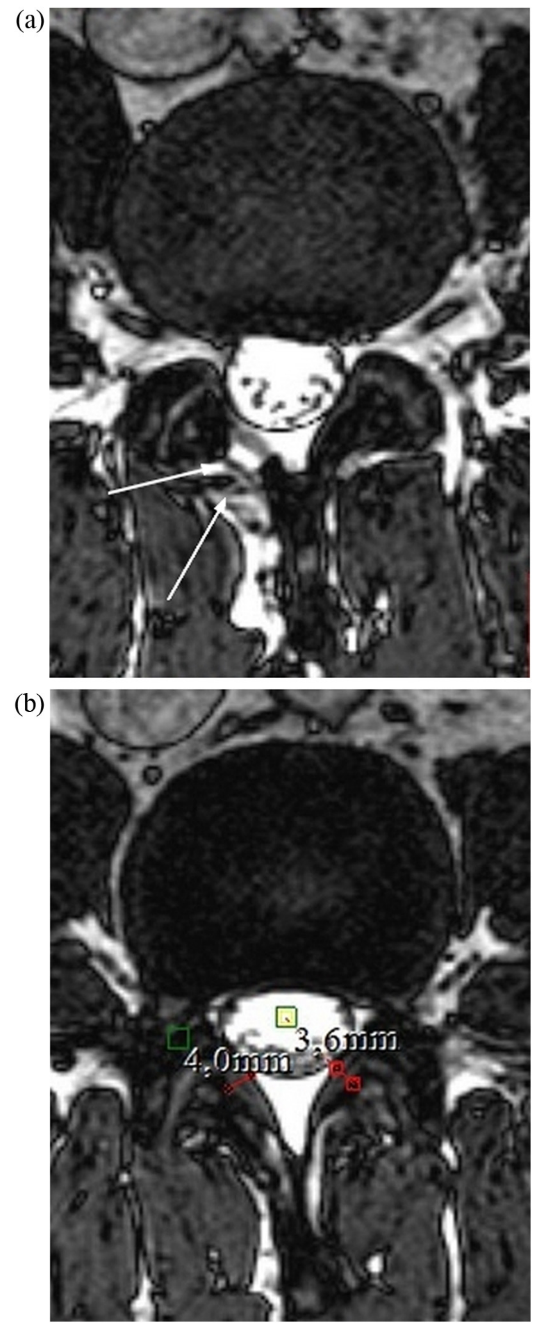

Fig. 1 – MRI images in axial planes show (a) laminectomy defect (arrows) and (b) measurements on the MRI of a 45-year-old male patient one year post-surgery in the L3-4 disc space.

Table 1 – Number of the patients and level of their operations.

Variables	$n = 78$
Operation level	
L2-L3 right laminectomy	1 (%1.3)
L3-L4 right laminectomy	6 (%7.8)
L3-L4 Left laminectomy	4 (%5.2)
L4-L5 right laminectomy	13 (%16.9)
L4-L5 left laminectomy	31 (%39.7)
L5-S1 right laminectomy	10 (%13)
L5-S1 left laminectomy	13 (%16.9)
Number of the operation levels	
Single level	63 (%81.8)
Two level-ipsilateral with each other	13 (%16.9)
Two level-contralateral with each other	1 (1.3%)
Three level-ipsilateral with each other	1 (%1.3)

gender of the patients, time period between the laminectomy surgery and MR examination, laminectomy levels and number of the laminectomies were also recorded.

2.1. Statistical analysis

Data analysis was done using the SPSS for Windows 11.5 program (Chicago IL, USA). The distribution of continuous variables was determined using the Shapiro–Wilk test. A Student's *t*-test was used to determine the difference in the LF thickness between the two groups. A one-way analysis of variance (One-Way ANOVA) was used to compare LF thickness in the two groups. The statistical significance level was set to be $p < 0.05$.

3. Results

The number of the patients and the operation levels are summarized in Table 1. The mean thicknesses of the LFs with the ipsilateral and contralateral sides were as follows: 3.58 ± 0.46 mm in group 1 and 3.40 ± 0.40 mm in group 2. The difference between these measurements was statistically significant ($p = 0.00$) (Table 2).

There was no statistically significant difference in the ipsilateral and contralateral LF thicknesses in terms of the number of laminectomies, age, gender, level of the operation, elapsed time since the laminectomy (Tables 3 and 4).

4. Discussion

We found that the mean thickness of the LF in group 1 was significantly greater than that of group 2.

Table 2 – The thickness of ligamentum flavums ipsilateral and contralateral to the sides receiving the laminectomy.

	LF thickness (mm)
Ipsilateral side	3.58 ± 0.46 (2.4–4.6)
Contralateral side	3.40 ± 0.40 (2.2–4.3)
p	0.010

Table 3 – Comparison of the differences in ipsilateral and contralateral ligamentum flavum thickness in terms of gender and level of the operation.

Variables	LF thickness difference (mm)	*p*
Gender		0.447
Female	0.14 ± 0.62 (−1.10–1.40)	
Male	0.24 ± 0.57 (−0.90–1.10)	
Operation level		0.720
L_3-L_4	0.28 ± 0.27 (−0.20–0.80)	
L_4-L_5	0.22 ± 0.67 (−1.10–1.40)	
L_5-S_1	0.12 ± 0.53 (−0.90–1.00)	

The LF covers the large portion of the posterolateral wall of the spinal canal and plays an important role in controlling the intervertebral movements, stabilizing the spine while sitting and standing and providing smoothness in the back wall of the spinal canal and neural foramens. Changes in the size of the LF can cause significant neurological problems [13,14].

Some studies show that thickening of the LF is usually caused by buckling of the LF into the spinal canal due to loss of disc space height rather than to hypertrophy. Some previous studies reported that degenerative changes secondary to the aging process and mechanical stress due to spinal instability lead to thickening of LF [4,13,15–18] however in a study by Safak et al. no such association was found, which was also supported by the results of our study [19].

LF thickening plays an important role in the etiopathology of LSS since it covers the vast majority of the spinal canal [20,1,21]. Towne et al. was the first to report on the need to relieve spinal stenosis caused by thickening of the LF after laminectomy surgery in 1931. He demonstrated that compression of lumbosacral nerve roots was present and was caused by thickening of the LF [3]. Laminectomy and flavectomy is a surgical procedure in which a portion of the lamina is resected. It is generally performed to gain access to the intervertebral disc space during a herniated disc surgery and to relieve stenotic segment in stenosis surgery [5,7]. Previous studies have also shown that total laminectomy increases segmental instability [7–11].

It is known that age, mechanical stress and physical activity play a role in the etiopathology of LFH [2–4,7–10,22]. Sairyo et al. reported that the underlying cause of LFH is development of post-inflammatory scar tissue [18]. The majority of the extracellular matrix of the LF consists of elastic fibers. After injury to the LF, the amount of elastic fibers is reduced and replaced by collagen fibers and then with calcification and ossification, which leads to the development of chondroid metaplasia. When the LF is exposed to stress, the

Table 4 – Comparison of the differences in ipsilateral and contralateral ligamentum flavum thickness in terms of number of laminectomy levels, age, elapsed time since laminectomy.

Variables	*R*	*p*
Ages	−0.044	0.700
Elapsed time since laminectomy	−0.179	0.116
Number of laminectomy levels	0.026	0.822

LF is injured and later when healing occurs, fibrotic scar tissue develops [23–25]. In recently published article Kang et al. reported that degenerated and herniated intervertebral disc provide an important pathomechanism in hypertrophy and ossification of the LF through inflammatory cytokines [25]. We hypothesized that the stability of the vertebral column was being disturbed after laminectomy. This impaired stability increases mechanical stress especially on the LF at the ipsilateral side with the laminectomy. Eventually, increased mechanical stress may cause to release of inflammatory cytokines that could result in thickening of the LF.

We were unable to find an article written in English that reported on the impact of a laminectomy on LF. Therefore, this is the first study written in English examining the impact of laminectomy on the LF using MRI images.

There are some limitations in our study. Firstly, we were unable to obtain the preoperative MRI scans of the patients and measure the preoperative thickness of LF, therefore the amount of LF thickening could not be determined. The second limitation of our study is that we only measured and compared the thicknesses of the LF at one upper level laminectomy. Therefore, we did not determine how the laminectomy influences LF thickness at other levels. Future prospective studies which include the preoperative and postoperative measurements of LF in larger patient populations are needed to understand the effect of laminectomy on LF thickness more accurately.

To conclude, we observed that laminectomy affected the thickness of the ipsilateral LF. This suggests that laminectomy may play a role in the development of LSS. Therefore, it is possible that thickening of the LF may develop at the level adjacent to the laminectomy and that careful clinical and radiological evaluation should be done to exclude LF thickening in patients who have recurrent complaints in the postoperative period after laminectomy.

Conflict of interest

The authors declare that they have no conflict of interest.

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We declare that there is no financial disclosure for the manuscript.

Ethics

The work described in this article has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans; Uniform Requirements for manuscripts submitted to Biomedical journals.

REFERENCES

[1] Kurz LT, Dvorak J. Lumbar spinal stenosis: clinical; radiologic and electrodiagnostic diagnosis of degenerative lumbar stenosis. In: Wiesel SW, Weinstein JN, Herkowitz H, Dvorak J, Bell G, editors. The lumbar spine. Philadelphia: WM Saunders Co.; 1996. p. 731–7.

[2] Park JB, Chang H, Lee JK. Quantitative analysis of transforming growth factor-beta 1 in ligamentum flavum of lumbar spinal stenosis and disc herniation. Spine 2001;26: E492–5.

[3] Towne EB, Reichert FL. Compression of the lumbosacral roots of the spinal cord by thickened ligamenta flava. Ann Surg 1931;94:327–36.

[4] Fukuyama S, Nakamura T, Ikeda T, Takagi K. The effect of mechanical stress on hypertrophy of the lumbar ligamentum flavum. J Spinal Disord 1995;8:126–30.

[5] Zausinger S, Mehrkens JH, März U, Rothwinkler M, Uhl E, Tonn JC. Surgical treatment of lumbar spinal canal stenosis in elderly patients. MMW Fortschr Med 2006;148 (43):29–32.

[6] Lachowski M, Podgórski JK, Twarkowski P, Delimat L. Radiological diagnosis of iatrogenic stenosis of the lumbar spine in patients after surgical treatment of intervertebral disk displacement. Neurol Neurochir Pol 1992;26(January–February (1)):66–72.

[7] Ofluoğlu AE, Karasu A, Ekinci B, Toplamaoğlu H. The effect of laminectomy on instability in the management of degenerative lumbar stenosis surgery: a retrospective radiographic assessment. Turk Neurosurg 2007;17(3): 178–82.

[8] Tai CL, Hsieh PH, Chen WP, Chen LH, Chen WJ, Lai PL. Biomechanical comparison of lumbar spine instability between laminectomy and bilateral laminotomy for spinal stenosis syndrome – an experimental study in porcine model. BMC Musculoskelet Disord 2008;11(9):84.

[9] Hopp E, Tsou PM. Postdecompression lumbar instability. Clin Ortop 1988;227:143–51.

[10] Johnsson KE, Willner S, Johnsson K. Postoperative instability after decompression for lumbar spinal stenosis. Spine 1986;11:107–10.

[11] Katz JN, Lipson SJ, Larson MG. The outcome of decompressive laminectomy for degenerative lumbar stenosis. J Bone Joint Surg Am 1991;73:809–16.

[12] Sakamaki T, Sairyo K, Sakai T, Tamura T, Okada Y, Mikami H. Measurements of ligamentum flavum thickening at lumbar spine using MRI. Arch Orthop Trauma Surg 2009;129 (10):1415–9.

[13] Postacchini F, Gumina S, Cinotti G, Perugia D, DeMartino C. Ligamenta flava in lumbar disc herniation and spinal stenosis. Light Electron Microsc Morphol Spine 1994;19 (8):917–22.

[14] Nagashima C, Takahama M, Shibata T, Nakamura H, Okada K, Morita H, et al. Calcium pyrophosphate dihydrate deposits in the cervical ligamenta flava causing myeloradiculopathy. J Neurosurg 1984;60(1): 69–80.

[15] Nachemson AL, Evans JH. Some mechanical properties of the third human lumbar interlaminar ligament (ligamentum flavum). J Biomech 1968;1(3):211–20.

[16] Schräder PK, Grob D, Rahn BA, Cordey J, Dvorak J. Histology of the ligamentum flavum in patients with degenerative lumbar spinal stenosis. Eur Spine J 1999;8 (4):323–8.

[17] Sairyo K, Biyani A, Goel V, Leaman D, Booth Jr R, Thomas J, et al. Pathomechanism of ligamentum flavum hypertrophy: a multidisciplinary investigation based on clinical biomechanical, histologic and biologic assessments. Spine 2005;30(23):2649–56.

[18] Sairyo K, Biyani A, Goel VK, Leaman DW, Booth Jr R, Thomas J, et al. Lumbar ligamentum flavum hypertrophy is due to accumulation of inflammation-related scar tissue. Spine 2007;32(11):E340–7.

[19] Safak AA, Is M, Sevinc O, Barut C, Eryoruk N, Erdogmus B, et al. The thickness of the ligamentum flavum in relation to age and gender. Clin Anat 2010;23(January (1)): 79–83.
[20] Önel D, Sarı H, Dönmez Ç. Lumbar spinal stenosis: clinical/radiologic therapeutic evaluation in 145 patients. Conservative treatment or surgical intervention? Spine 1993;18(2):291–8.
[21] Marcotte PJ, Virella A. Lumbar spinal stenosis: treatment options and result. Semin Neurosurg 2000;11(2):231–41.
[22] Altinkaya N, Yildirim T, Demir S, Alkan O, Sarica FB. Factors associated with the thickness of the ligamentum flavum: is ligamentum flavum thickening due to hypertrophy or buckling? Spine (Phila PA 1976) 2011;36(July (16)):E1093–7. http://dx.doi.org/10.1097/BRS.0b013e318203e2b5
[23] Evans JH, Nachemson AL. Biomechanical study of human ligamentum flavum. J Anat 1969;105:188–9.
[24] Majima T, Lo IK, Randle JA, Marchuk LL, Shrive NG, Frank CB, et al. ACL transection influences mRNA levels for collagen type 1 and TNF-alpha in MCL scar. J Orthop Res 2002;20(3):520–5.
[25] Kang YM, Suk KS, Lee BH, Kim HS, Lee KI, Park SY, et al. Herniated intervertebral disk induces hypertrophy and ossification of ligamentum flavum. J Spinal Disord Tech 2014;27(October (7)):382–9. http://dx.doi.org/10.1097/BSD.0b013e3182a26532