



# LUMBAR SPINAL CANAL MORPHOMETRY

## LOMBER SPİNAL KANAL MORFOMETRİSİ

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### SUMMARY:

**Objective:** The aim of the study is to collect data of the mean morphometric values for spinal canal, dural sac and ligamentum flavum.

**Materials and Method:** We inspected 63 MRI scans of lumbar spine that obtained in adult patients who were admitted to our clinic for lumbar axial pain retrospectively.

**Results:** 63 patients (33 females, 52.4%, and 30 males, 47.6%) were included in the study. Accordingly, mean age was  $37.7 \pm 12.2$  years. Mean values of measurements of spinal canal area, dural sac area, ligamentum flavum area, ligamentum flavum thickness were measured. When the measurements were compared between females and males, only L5 spinal canal was found to be different between females and males ( $p=0.041$ ), and males had greater values.

**Conclusions:** Morphometry of the spinal canal and ligamentum flavum is important to be inspected by the researchers and spinal surgeons because LSS operations must be planned with these data; otherwise failed back surgery is the inevitable result.

**Key Words:** Spinal canal area, Dural sac area, Ligamentum flavum morphology.

**Level of Evidence:** Morphometric study, Level III

### ÖZET:

**Amaç:** Çalışmamızın amacı spinal kanal, dural kese ve ligamentum flavumun ortalama morfometrik değerleri hakkında veri toplamaktır.

**Materyal ve Metod:** Kliniğimize aksiyel bel ağrısı nedeniyle başvuran 63 hastanın MRI görüntüleri retrospektif olarak incelendi.

**Sonuçlar:** Çalışmaya 63 hasta dahil edildi (33 kadın, %52.4, ve 30 erkek, %47.6). Ortalama hasta yaşı  $37.7 \pm 12.2$  olarak bulundu. Lomber her seviye için spinal kanal alanı, dural kese alanı, ligamentum flavum alanı ve ligamentum flavum kalınlığı ortalama değerleri hesaplandı. Sonuçlar kadın ve erkekler arasında karşılaştırıldığında, sadece L5 spinal kanalında farklılık saptandı ( $p=0.041$ ), ve erkeklerde daha büyük olarak bulundu.

**Çıkarım:** Spinal kanal, dural kese ve ligamentum flavum morfometresinin araştırmacılar ve spinal cerrahlar tarafından bilinmesi önemlidir çünkü lomber dar kanal cerrahisinin planlanması bu verilere göre yapılmalıdır aksi takdirde başarısız bel cerrahisi kaçınılmaz sonudur.

**Anahtar kelimeler:** Spinal kanal alanı, Dural kese alanı, Ligamentum flavum morfolojisi.

**Kanıt Düzeyi:** Morfometrik analiz, Düzey III

## INTRODUCTION:

Spinal stenosis can be defined as a which causes neurogenic intermittent, radicular pain, claudication and sensory and motor disturbances in the lower extremities diagnosed with narrowing of the spinal canal caused by mechanical compression of the spinal nerve roots<sup>11</sup>. The most common spinal disease have been diagnosed in elderly patients is lumbar spinal stenosis (LSS).

Magnetic resonance imaging (MRI) is considered to be an appropriate measurement tool for studying LSS with some limitations. MRI examination is imagined in supine position, but LSS symptoms are often provoked by standing postures so the results of MRI are not always compatible with the clinical symptoms<sup>10</sup>.

## MATERIALS AND METHODS:

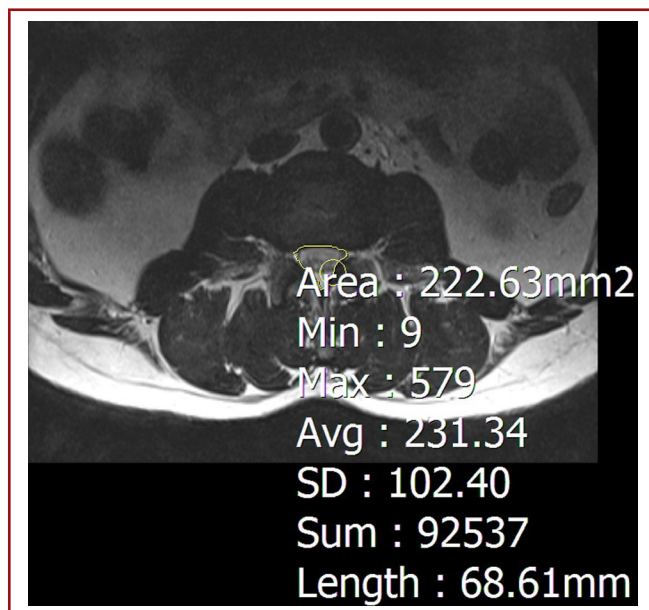
We inspected 63 MRI scans of lumbar spine that obtained in adult patients who were admitted to our clinic for lumbar axial pain retrospectively. Inclusion criterias for patients in the study are, patients had to be older than 17 years ,had no pathological spinal trauma or disease and radiological report of MRI is normal. Patients were excluded if their

radiological examinations were not sufficient for the proposed measurements or if they were known to have pathological conditions of the lumbar spine.

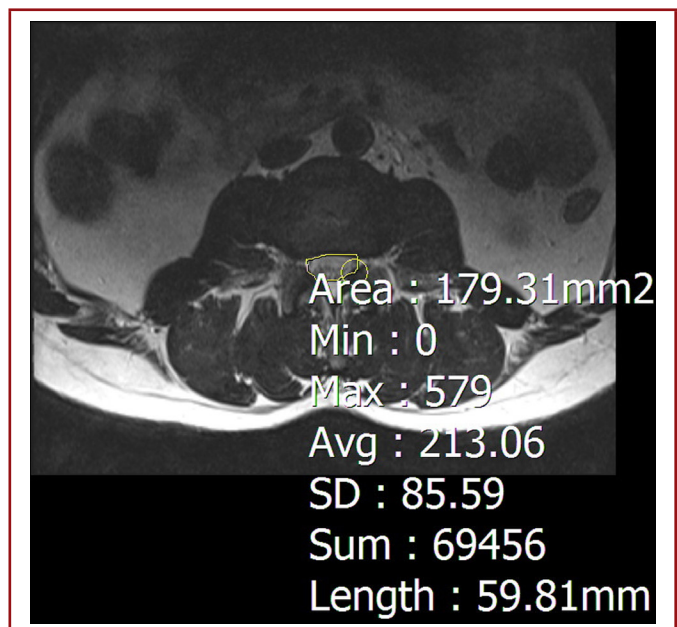
Axial T1-weighted MRI images were inspected at the facet joint level from each patient. We measured the spinal canal cross-sectional area (SCA) (Figure-1) and dural sac cross-sectional area (DSA) (Figure-2) at the facet joint level using a PACS system. The ligamentum flavum cross-sectional area (LFA) (Figure-3) and ligamentum flavum thickness (LFT) (Figure-4) at the same level on the MRI The LFT was measured at the thickest point.

## STATISTICAL ANALYSIS:

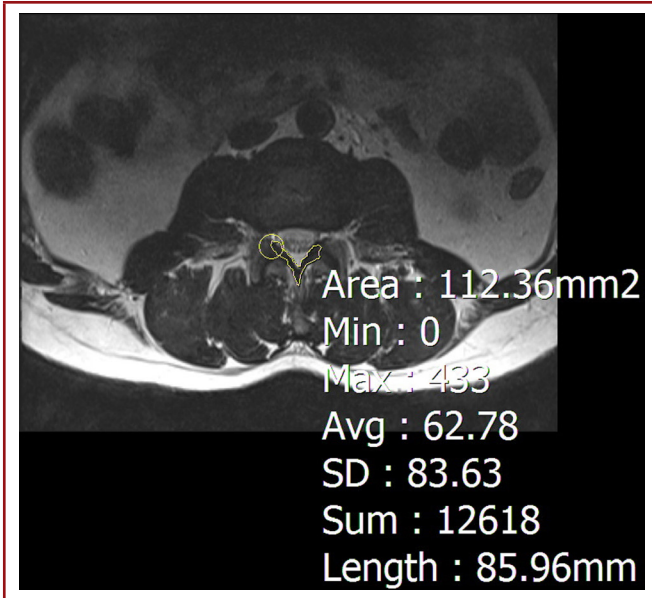
Descriptive data were presented as frequencies and percent for categorical variables, and as mean and standard deviation for numerical variables. Independent group comparisons between both genders were performed with Mann-Whitney U test. P values lower than 0.05 (Type I error level of 5 %) was considered as statistically significant result. All analyses were performed by using IBM SPSS Statistics for Windows, Version 21.0 (Armonk, NY: IBM Corp.).



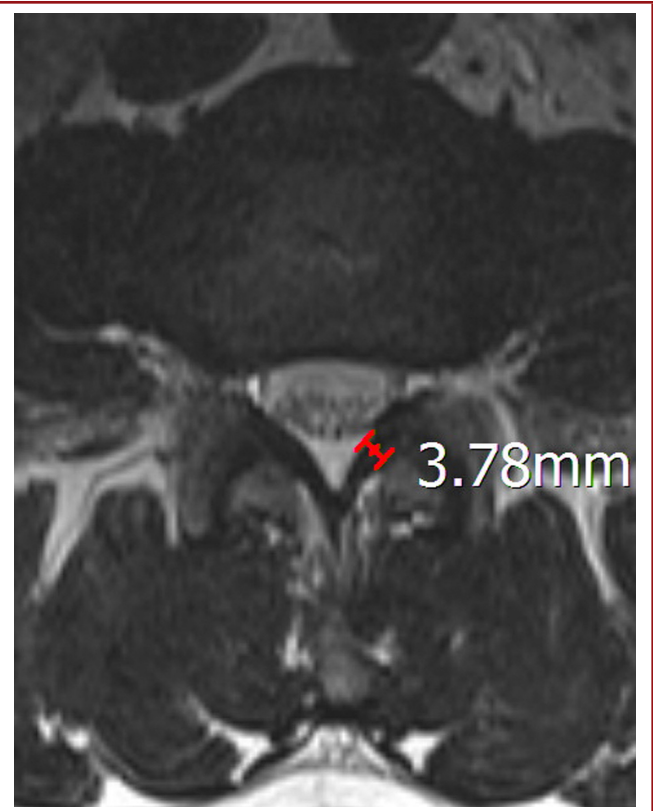
**Figure-1.** Axial T1-weighted MRI images were inspected at the facet joint level from each patient. We measured the spinal canal cross-sectional area (SCA) .



**Figure-2.** Dural sac cross-sectional area (DSA) at the facet joint level using a PACS system.



**Figure-3.** The ligamentum flavum cross-sectional area (LFA).



**Figure-4.** Ligamentum flavum thickness (LFT) at the same level on the MRI

**Table-1.** General characteristics of patients

	n	%
Gender		
Female	33	52.4
Male	30	47.6
	Mean	SD
Age	37.7	12.2

## RESULTS:

63 patients (33 females, 52.4%, and 30 males, 47.6%) were included in the study. General characteristics of patients were presented in Table-1. Accordingly, mean age was 37.7 ± 12.2 years.

When the measurements were compared between females and males, only L5 spinal canal was found to be different between females and males ( $p=0.041$ ), and males had greater values. Mean values of measurements of SCA, DSA, LFA, LFT and comparisons between genders are presented in Table-2.

**Table-2.** Comparisons of measurements between genders

	Female		Male		P
	Mean	SD	Mean	SD	
Age	37.3	14.6	38.0	10.3	0.916
L1 SP CAN	240.1	32.1	249.0	62.0	0.751
L1 DUR SAC	160.1	45.1	173.6	51.5	0.481
L1 FL AR	99.5	39.1	87.1	9.0	0.572
L1 FL TH	2.3	0.4	2.4	0.2	0.619
L2 SP CAN	239.6	51.2	227.2	66.4	0.778
L2 DUR SAC	158.3	42.1	147.0	56.6	0.481
L2 FL AR	102.6	32.4	114.2	17.3	0.090
L2 FL TH	2.2	0.4	2.3	0.3	0.180
L3 SP CAN	246.4	28.0	238.5	35.5	0.647
L3 DUR SAC	154.9	35.4	143.8	26.2	0.438
L3 FL AR	107.0	33.0	111.2	19.5	0.548
L3 FL TH	2.4	0.5	2.2	0.3	0.972
L4 SP CAN	231.3	50.2	247.3	31.8	0.360
L4 DUR SAC	155.0	49.4	152.2	36.4	0.916
L4 FL AR	127.1	30.6	124.8	32.8	0.724
L4 FL TH	2.5	0.5	2.4	0.7	0.360
L5 SP CAN	222.6	76.6	288.0	42.8	0.041
L5 DUR SAC	151.8	62.6	163.5	68.9	0.526
L5 FL AR	124.4	40.6	157.6	38.3	0.057
L5 FL TH	29.7	85.5	2.6	0.5	0.698

SP CAN: Spinal Canal Area, DUR SAC: Dural Sac Area, FL AR: Ligamentum Flavum Area, FL TH: Ligamentum Flavum Thickness

## DISCUSSION:

Spinal stenosis represents a combination of pathogenic factors, including the the facet joints, ligamentum flavum (LF), intervertebral disk and crosssectional area of the cauda equina<sup>4</sup>. Many experimental studies have been performed to evaluate associations between the morphological parameters on MRI and the symptoms and signs in LSS<sup>6</sup>.

The ligamentum flavum is a segmentally organized structure that connects the vertebral laminae<sup>7</sup>. The pathogenesis of LF thickening has been associated with the reductions in the elastin and collagen ratio or age-related fibrosis, and is a major cause of LSS<sup>9</sup>.

Kim et al reviewed 117 patients who underwent MRI of the L-spine, diagnosed as LSS<sup>3</sup>. They measured DSA, SCA, LFA and LFT at the most stenotic intervertebral level on MRI. Clinical outcomes were investigated using the patient-assessed quantitative measurement of visual analog scale and subjective disability was assessed by the Oswestry Disability Index(ODI)<sup>3</sup>. Additionally, subjective walking distance

(SWD) was also collected from electronic medical records. Larger LFA and LFT values are associated with higher ODI values. A larger DSA and SCA are associated with a longer SWD before claudication occurs<sup>3</sup>.

Altinkaya measured 224 patients LF and concluded that thickening of the LF is correlated with disc degeneration, aging, body mass index, LSS, spinal level and disc herniation<sup>1</sup>. They also reported that thickening of the LF is due to buckling of the LF into the spinal canal secondary to disc degeneration more than to LF hypertrophy and sex and the degree of pain were not correlated with the thickness of the LF<sup>1</sup>. Sakamaki et al reported that thickening of LF at L4–5 had already started in patients in the 30–39 age bracket and that thickening of the LF was not the buckling of the LF into the spinal canal with disc degeneration; and the thickness of LF at L2–3 may serve as an indicator of LSCS at multiple levels<sup>8</sup>.

Choi et al reported that axial loaded MRI may contribute to overcoming a limitation of MRI in decumbency, which can overlook dynamic spinal disorders such as dynamic lumbar spinal stenosis<sup>2</sup>.

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Ogikubo et al inspected 82 patient and reported that the mCSA was a strong predictor of the preoperative walking ability, leg and back pain, and was directly related to the quality of life of patients with central spinal stenosis<sup>5</sup>.

Finally, we inspected 63 MRI scans of lumbar spine from axial T1-weighted MRI images at the facet joint level from each patient. Morphometry of the spinal canal and ligamentum flavum is important to be inspected by the researchers and spinal surgeons because LSS operations must be planned with these data; otherwise failed back surgery is the inevitable result.

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