CMMB

ORIGINAL PAPERS

https://doi.org/10.31689/rmm.2025.32.4.369

Neurosurgical MRI Insights: Morphology and Dimensions of Lumbar Vertebral Canal in Midsagittal and Axial Sections

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Abstract

Background: Knowing the dimensions of lumbar spinal canal is crucial to diagnose lumbar stenosis with the Magnetic resonance imaging is the most accepted and accurate modality for diagnosis. This study aimed to estimate the lumbar canal diameters in anteroposterior and cross-sectional areas by MR studies performed for middle aged population.

Methods: This is a cross-sectional study with Magnetic resonance images for the lumbosacral spine collected from young (18-26 years), Antero-posterior and transverse diameters for the Dural sac, the ligamentous interfacet diameter, and the cross-sectional area for the Dural sac were measured for all lumbar vertebrae. Chi-square and t-test were used to calculate various variables.

Results: 54 patients enrolled in the study, mean age was 22.6 years old, with a 1:1 male-to-female ratio. No significant P-Values were found between both genders at the 0.05 level of significancy, all

Conclusion: The lumbar cross-sectional area dural sac, ligamentous interfacet distant, AP sagittal spinal canal, transverse axial, AP axial dural sac, and AP axial spinal canal showed a non-significant difference in young age group females than males' measurements in a sample of patients attending MRI units.

Keywords: spinal canal; dural sac, lumbar stenosis; T2 weighted MRI.

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INTRODUCTION

The vertebral canal, the spinal cavity, is formed by the vertebral column that holds the spinal cord and the bilaterally branched roots, making the central nervous system.[1] The vertebral canal's primary purpose is to provide a safe passageway for the spinal cord along the spinal column, enabling innervation throughout the body.[2] The foramina of the vertebrae encircle this canal. The posterior longitudinal ligament anteriorly and the ligamentum flavum posteriorly guard the canal in the intervertebral spaces.[1]

The Lumbar spinal canal constitutes the part of the spinal canal passing through the lumbar vertebrae. The spinal canal diameter shows diversity through different vertebral regions; in contrast to the cervical and thoracic regions, the lumbar vertebral has a wide spinal canal space, with the fifth lumbar diameter being the widest at about 17.5 mm. Lumbar stenosis could be defined as progressive canal narrowing due to multifactorial degenerative factors in spinal joints, intervertebral discs, and ligamentum flavum[3,4]. With the advanced narrowing of the area surrounding the neurovascular elements, varying degrees of clinical symptoms appeared, including intermittent neurogenic claudication, radiculopathy in the lower limbs with pain and paresthesia feeling, chronic low back pain, urination–defecation impairment, altered sensation and weakness of the lower limbs. Lumbar spinal stenosis (LSS) resulting from the reduction of the lumbar spinal diameters could have different etiologies, congenital, acquired, or even from a combination of many etiologies with superadded degenerative issues[5].

While these anatomical descriptions and measurements are necessary for diagnosing LSS, assessment of the severity of the condition leading a patient to ask for a consultation could not be achieved through them. Occasionally, severe anatomical stenosis could be found incidentally in asymptomatic patients[6]. Symptoms may not be clear unless the spinal cord or the nerves are compressed. Many imaging modalities are being used to diagnose these conditions. Magnetic resonance imaging is increasingly used as the most accepted and accurate modality for diagnosis. However, several research reported that MRI is equal to computed tomography. In contrast, others reported that CT is better than MRI[1,7]. However, in current clinical practice, MRI is the favorable imaging modality for Lumbar stenosis diagnosis and evaluation.[7]

For the diagnosis of LSS, there are currently not generally recognized diagnostic or categorization standards. As a result, research employs wildly disparate eligibility standards, which restricts how broadly the results may be applied.[8,9] Among the elderly, LSS could be a highly disabling disease and a common cause of spinal surgery. Many modalities of treatment, ranging from lifestyle modification and different medications to decompressive surgeries with more need future research to achieve accepted modalities for diagnosis[9,10,11,12].

This study aims to estimate the lumbar canal diameters in anteroposterior and cross-sectional areas by MR imaging in patients attending neurosurgical and orthopedic clinics with no profound lumbar canal stenosis.

SUBJECTS AND METHODS

This cross-sectional study was carried out at Al-Kindy Teaching Hospital and Al-Kindy College of Medicine from November to December 2024. Magnetic resonance images for the lumbosacral spine were collected from young (18-26 years) patients having a mass index (BMI) < 30 and were attending the MRI unit referred from different neurosurgical and orthopedic clinics for various causes. Patients with spinal deformity, a history of spinal trauma, or spinal surgery at the lumbar region were excluded from the study.

All recruited patients have the procedure requested by the referring clinics through a 1.5 Tesla MRI scanner machine of GE OPTIMA GEM. Standard protocols were performed, including T1 sagittal, T2 Sagittal, T2 axial, and MR myelography sagittal and coronal planes.

During the procedure, first to 5th lumbar vertebrae were measured through T2 axial sections for all lumbar vertebrae.

- Antero-posterior diameter for the Dural sac was measured between the middle vertebral body and the middle of the spinous process at the posterior border of the Dural sac.
- The anteroposterior diameter for the spinal canal was measured between the middle vertebral body and the middle of the spinous process.
- The transverse diameter of the Dural sac is measured between the lateral borders of the Dural sac at the level of the lateral recess.
- The ligamentous interfacet diameter was measured at the facet joint level between the inner parts of the ligamentum flavum.
- The cross-sectional area for the Dural sac was measured at the intervertebral level from the middle border of the ligament flavum posteriorly to the disc on each side.

On T2 sagittal images for lumbar vertebrae, the lumbar spinal canal sagittal diameter measured between the middle of the posterior aspect of the vertebral body to the spinolaminar line.

Each participant's informed consent and agreement were crucial to enrolling in the study. They were provided with detailed and clear information regarding the purpose of the study; additional information was provided related to the MRI procedure regarding the length, noise levels, and the requirement to remain still. Privacy and anonymity were adhered to throughout the whole study. Recorded data was stored securely, and only the research personnel could access it.

The study protocol was approved by the scientific council at Al-Kindy College of Medicine and properly registered at the University of Baghdad's scientific research plan.

The IBM SPSS 22 software (Chicago, IL, USA) was used to analyze the data statistically. The chi-square and t-test were used to calculate the various variables, and a p-value of less than 0.05 was considered significant.

RESULTS

Among 63 patients referred to the MRI unit at Al-Kindy Teaching Hospital, 54 of them enrolled in the study due to the research inclusion/ exclusion criteria. The mean age was 22.6 years old, with a 1:1 male-to-female ratio.

Different measurements were performed for each Lumbar vertebra and expressed in millimeters, as shown in Table 1. Measures for the axial T2 weighted MRI study are pointed out in Figure 1, while the Antero-posterior diameter of the spinal canal shown in the sagittal T2 weighted MRI study is pointed out in Figure 2. (Figure 1, Figure 2)

Table 1. Mean and standard deviations of different measurements for each Lumbar vertebra

	cross sectional area dural sac	ligamentous interfacet distant	AP sagittal spinal canal	transverse axial	AP axial dural sac	AP axial spinal canal
L1	164.38 ± 37.82	13.07 ± 1.32	16.90 ±1.78	19.51 ± 2.65	13.24 ± 1.54	19.71 ± 2.00
L2	160.42 ± 33.84	12.86 ± 1.27	16.36 ± 1.58	19.43 ± 2.30	13.17 ± 1.46	19.83 ± 2.16
L3	154.21 ± 35.30	12.65 ± 1.34	15.69 ± 1.70	19.26 ± 2.59	12.49 ± 1.83	19.51 ± 2.06
L4	143.64 ± 35.97	13.00 ± 1.52	15.86 ± 1.84	19.05 ± 2.78	12.40 ± 1.97	18.39 ± 2.09
L5	152.98 ± 35.96	14.84 ± 1.67	15.87 ± 1.54	20.26 ± 2.75	13.23 ± 1.72	17.24 ± 2.18

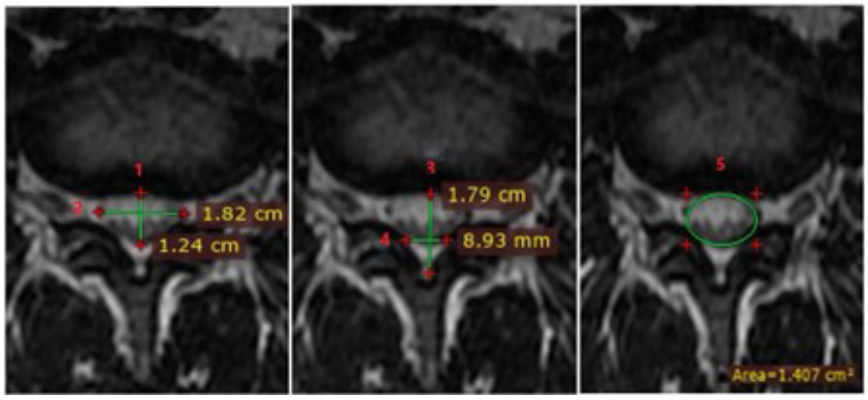

Figure 1. Axial T2 weighted MRI study 1. Antero-posterior diameter of the Dural sac,2. Transverse diameter of the Dural sac, 3. Antero-posterior diameter of the spinal canal,4. Ligamentous interfacet diameter,5. Cross sectional area of the Dural sac.

Figure 2. Sagittal T2 weighted MRI study showing Antero-posterior diameter of the spinal canal

When comparing each mean measurement of the whole lumbar vertebrae between genders, all show non-significant P-Values. **Table 2**.

Table 2. Mean and standard deviation of different measurements for Lumbar vertebra as average in male, female, and combined with P-Values.

		Lumbar Vertebrae	
		Maen ±SD	P- Value
cross sectional area dural sac	Male	153.00 ± 35.96	0.99
	Female	153.00 ± 36.09	
	Combined	153.00 ± 35.96	
ligamentous interfacet distant	Male	13.08 ± 1.54	0.06
	Female	13.49 ± 1.69	
	Combined	13.29 ± 1.63	
AP sagittal spinal canal	Male	16.19 ± 1.91	0.62
	Female	16.08 ± 1.55	
	Combined	16.14 ± 1.74	
transverse axial	Male	19.48 ± 2.93	0.90
	Female	19.52 ± 2.30	
	Combined	19.50 ± 2.63	
AP axial dural sac	Male	12.94 ± 1.78	0.76
	Female	12.88 ± 1.71	
	Combined	12.91 ± 1.74	
AP axial spinal canal	Male	19.00 ± 2.58	0.64
	Female	18.87 ± 2.01	
	Combined	18.93 ± 2.31	

All measurements show non-significant P-Values between both genders at the 0.05 level of significancy.

DISCUSSION

It would be possible to determine the circumstances in which individuals are exposed to back pathologies by describing the variations in spine architecture across groups. Neurosurgery, neurology, and orthopedics benefit greatly from the morphometric information of the vertebrae[13]. Internal fixation of the vertebral column is a favorable option for managing spinal trauma, lumbar canal stenosis, spondylolisthesis, and malignancies. Due to the high risk of postoperative complications, spine surgery, including internal fixation, is one of the most difficult procedures to conduct[14]. Future research involving a bigger population may reference the morphometrical data of the several lumbar vertebral components obtained from this study.

Anatomically, the cross-sectional area of the dural sac seems to decrease as the vertebral level increases (from L1-L4), as the current study results match (table 1 and Figure 1). The conus medullaris is typically found in the first lumbar vertebral foramen because the adult human spinal cord terminates around the lowest point of the central part of the first lumbar vertebral body. Keeping in mind that it may terminate above or below this level[15]. Regarding the cross-sectional area dural sac at the L5 level, there was an increase in the measurement; the oval form of the spinal canal and thecal sac may have changed to a triangular one at L4/5, which coincides with a previous study[16].

In our investigation, we also considered the MRI measurements of lumbar ligamentous interfacet distance at the inward borders of the ligamentum flavum by the lower end plate of the body. Since it is considered one of the factors causing lumbar spinal stenosis and/or Neurological Claudication. Our measurements of ligamentous interfacet distance were higher than the cut-off value of 12 mm, with a slight decrease in L2 and L3 levels. This could be due to the variation in age, gender, and weight of the selected study sample.

Measurements of AP distance of the lumbar spinal canal and transverse axial diameter displayed a gradual decrease in millimeters and decreasing lumbar levels (Figures 1 and 2). The transverse axial diameter is the most common cause of narrowing of the lumbar spinal canal before the reduction in the sagittal diameter caused by short pedicles[17]. The first researcher to quantitatively evaluate stenosis was Verbiest. According to his classification, stenosis is absolute when the sagittal diameter is 10 mm or smaller and relative when it is 12 mm.[18] All the mean values of transverse axial measurement of the spinal canal were above 16mm, and all levels showed measurement means above 12mm, coinciding with Ullrich C et al.[19] and Kalichman Let al.[20]

There was no significance when comparing the mentioned parameters (in millimeters) among both genders with a p-value> 0.05, which coincides with a previous study in the Turkish population[21]. However, another previous researcher found significant differences between males and females in Spain using X-ray films[22]. These discrepancies in results could be due to ethnic and sampling factors.

As a future perspectives, the results of current study including detailed morphologic measurements could be the base for future promising studies, these may include using current analysis to perform personalized surgical planning for spine procedures, performing comparative studies of different populations including diversity based on geographical distributions, age groups and ethnicity, and incorporating flexion and extension MR

imaging to establish dynamic morphometric analysis related to different postures assessing changes in spinal canal dimensions[23,24].

Limitations to this study included the small sample size, however, further studies are suggested to include a large sample with different age groups to estimate the difference between them and even to compare with a sample of patients diagnosed with lumbar stenosis.

CONCLUSION

The lumbar cross-sectional area dural sac, ligamentous interfacet distant, AP sagittal spinal canal, transverse axial, AP axial dural sac, and AP axial spinal canal showed a non-significant difference in young age group females than in males' measurements in a sample of patients attending MRI units.

Ethics Statement and Conflict of Interest Disclosures

Financial support and sponsorship: All authors have declared that no financial support was received from any organization for the submitted work.

Ethics Consideration: The authors declare that all the procedures and experiments of this study respect the ethical standards in the Helsinki Declaration of 1975, as revised in 2008(5), as well as the national laws. Written informed consent was provided by the patient participant in this study.

This study was approved by the Institutional Research Board and Ethics Committee.

Conflict of interest: No known conflict of interest correlated with this publication.

Availability of data and materials: The data used and/ or analyzed throughout this study are available from the corresponding authors upon reasonable request.

Competing interests: The authors declared that they have no competing interests.

The use of generative AI and AI-assisted technologies: The authors did not use in this article generative AI and AI-assisted technologies.

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