

# A Magnetic Resonance Imaging Morphometric Study of Lumbar Epidural Fat Distribution: Implications for Lumbar Epidural Lipomatosis

**Haowei Jiang**

Zhejiang University Huzhou Hospital: Huzhou Central Hospital <https://orcid.org/0000-0003-3640-3744>

**Yongli Wang**

Huzhou central hospital

**Jiangbo Nie**

Huzhou Central Hospital

**Mingchao Jin**

Huzhou Central Hospital

**Tianshun Fang**

Huzhou central hospital

**Xuesheng Jiang** (✉ [3256252250@qq.com](mailto:3256252250@qq.com))

Zhejiang University Huzhou Hospital: Huzhou Central Hospital

---

## Research article

**Keywords:** Lumbar Epidural Lipomatosis, MRI, epidural fat, measurement parameters, diagnosis

**Posted Date:** October 19th, 2020

**DOI:** <https://doi.org/10.21203/rs.3.rs-91962/v1>

**License:** © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

---

# Abstract

**Background.** To the best of our knowledge, no published English literatures has provided detailed parameters about the normal epidural fat and other contents in lumbar spinal canal. Our objective was to quantify reference data of epidural fat and the contents of lumbar spinal canal to guide the diagnosis of lumbar epidural lipomatosis.

**Methods.** 178 content lumbar MRI cases were analysis on Picture Archiving and Communication Systems (PACS).

**Results.** the mean anteroposterior ( AP ) diameters  $\pm$  standard deviation(SD) of lumbar vertebral body ( V )  
) $\square$ dural sac ( DS ) $\square$ epidural fat ( EF ) each measured lever on the mid-sagittal MRI and the mean cross-sectional area  $\pm$  SD of lumbar spinal canal ( SC ) $\square$ DS of each measured lever on the axial MRI were showed. The mean AP diameters of V and DS are showed obvious significant difference between men and women ( P  $\square$ 0.05). The mean AP diameters of EF is showed no significant difference between men and women (P  $\square$ 0.05). Also The mean area of lumbar SC (male 316.7 mm<sup>2</sup>, female 306.4 mm<sup>2</sup> ) and DS (male 198.6 mm<sup>2</sup>, female 189.2 mm<sup>2</sup>) are showed obvious significant difference between men and women ( P  $\square$ 0.05). The growth trend of the thickness of epidural fat in lumbar spinal canal is showed.

**Conclusion.** Our investigation provides insight into the anatomy of epidural fat and gives the relevant parameters of lumbar spinal canal and its contents on MRI. MRI is the most sensitive imaging test to diagnose lumbar epidural lipomatosis

## Background

Spinal epidural lipomatosis (SEL) is a well-recognized and complex condition caused by the excessively accumulated fat in spinal epidural space. Since Lee et al.<sup>1</sup> first mentioned this disease in 1975, an increasing number of SEL patients were diagnosed. SEL is usually composed by idiopathic SEL and secondary SEL, the secondary SEL affects the thoracic spine more frequently than it affects the lumbar region, whereas idiopathic SEL most often occurs in the lumbar region.<sup>2</sup> Secondary SEL is often associated with chronic steroid therapy and endocrinopathies. Idiopathic SEL has been associated with obesity<sup>3,4</sup> which representing about 24.5% of reported cases<sup>5</sup>. Also with the development of radiological technology and the increasing number of overweight and obese patients<sup>6</sup>, the number of SEL patients would have an obvious augment. The clinical manifestations of SEL include back pain, lower extremities weakness, paresthesias, ataxia, and less frequent bowel or urinary incontinence,<sup>7</sup> reduced the patients' life quality distinctly. As such, this disease has been taken a high attention in recent years.

The pathogenesis of SEL is still unclear. As we known, epidural fat is an important part filled in spinal epidural space and distributed along the spinal canal, it protects dura and its contents from the effects of detrimental forces inflicted on the vertebral column<sup>8</sup>. However, if the epidural fat enlarges abnormally, it would encroach on the spinal canal and compresses the neural elements, and this process can be clearly

reacted on MRI<sup>9-11</sup>. As mentioned in published studies, SEL is usually occurred in thoracic spinal canal (thoracic epidural lipomatosis TEL) and lumbar spinal canal (lumbar epidural lipomatosis LEL), extremely rare in cervical spinal canal (cervical epidural lipomatosis CEL)<sup>12</sup>. In consideration of the greater space in lumbar spinal canal than in thoracic spinal canal, the percentage of epidural fat in TEL and LEL must be obviously different. But how much the threshold value is can we make a diagnosis for this disease form a MRI image? Many experts<sup>13-15</sup> had done some correlation studies, but few of them gave detailed parameters about the thoracic or lumbar spinal canal and its contents.

In this study, we aim to make a morphometric study to specify a more visualized and accurate measurement for the distribution of lumbar epidural fat. We think those data will give a higher comprehension degree of LEL to spine surgeons.

## **Methods**

### ***Subjects***

This study was approved by the institutional review board of Huzhou Central Hospital. Retrospective analysis of the Chinese patients who presented to the department of orthopedics at our institution between January 23, 2019 and January 23, 2020, requiring lumbar spine MRI scans. For this study, about 112343 patients were taken lumbar MRI examination as a result of medical examination—trauma—backache or any other complaint requiring lumbar investigation, our selection criteria were as follows: 1. normal lumbar MRI without disease like spondylitis, diskitis, disk herniation, epidural hematoma, extradural tumor, pathologic fracture, previous lumbosacral surgery or radiation therapy and any other structural lesions; 2. age is between 20 and 60-year-old; 3. other conditions which may influence the measuring precision and accuracy. Finally, we found out 178 content lumbar MRI cases.

### ***MRI procedure***

The MRI examinations were performed using a 1.5-T superconducting magnet. The following sequences were investigated, focusing on the lumbar spine:

1. Turbo spin-echo T1-weighted sagittal images (repetition time [TR]/echo time [TE], 400ms/11 ms; matrix, 256×192; slice thickness, 4 mm; interslice gap, 10%).
2. Turbo spin-echo T2-weighted axial images (TR/TE, 3480 ms/104 ms; matrix, 320×240; slice thickness, 4 mm; interslice gap, 10%).

### ***Measurements and indexes***

In order to establish a reproducible measurement of the lumbar spinal canal ( SC ) and its contents for each image, we measure the anteroposterior ( AP ) diameters of lumbar vertebral body ( V )—dural sac (

DS) epidural fat (EF) on the mid-sagittal MRI scanning and the cross-sectional area of lumbar SC and DS on the axial plane.

First, to measure the value of AP diameter of DS and EF in the each segments (L1-L1/L2-L2/L2-L3-L3-L3/L4-L4/L4-L5-L5/L5/S1) of lumbar spine in mid-sagittal MRI scanning as Fig 1, we drew a line through two central points of the anterior and posterior edges of vertebra and intervertebral disk, then extent it to the posterior edge of spinal canal in mid-sagittal MRI scanning, record the value of  $V_{DS+EF}$ , the  $SC = DS + EF$ .

Second, to measure the cross-sectional area of normal DS and lumbar SC, we use a built-in area measurement system of Philips Medical Systems to analysis the value of the superior and inferior end plate of L3/L4-L4/L5-L5/S1 intervertebral disc in the axial MRI images as Fig 2 mentioned.

## Statistics

Graphical representation of our data were created using SPSS statistical software program 22.0 (SPSS Inc). The means  $\pm$  SD and Standard's t test (two tailed t-test, The significance level  $\alpha=5\%$ ) were calculated for all parameters.

## Results

In our 178 cases, the mean AP diameters  $\pm$  SD of  $V_{DS+EF}$  of each measured lever on the mid-sagittal MRI were showed in Fig 3. As the parameters showed, the mean AP diameters  $\pm$  SD of  $V_{DS+EF}$  are about  $29.5 \pm 3.1$  mm,  $14.8 \pm 2.6$  mm,  $3.8 \pm 2.3$  mm, the mean AP diameters  $\pm$  SD of  $V_{DS+EF}$  of male are  $31.4 \pm 2.8$  mm,  $14.6 \pm 2.5$  mm,  $3.8 \pm 2.2$  mm, the mean AP diameters  $\pm$  SD of  $V_{DS+EF}$  of female are  $28.0 \pm 2.6$  mm,  $14.9 \pm 2.7$  mm,  $3.7 \pm 2.3$  mm.

The mean cross-sectional area  $\pm$  SD of  $SC_{DS}$  of each measured lever on the axial MRI were showed in Fig 4. The mean area  $\pm$  SD of lumbar  $SC_{DS}$  are  $311.0 \pm 66.3$  mm<sup>2</sup>,  $193.4 \pm 48.8$  mm<sup>2</sup>. the mean area  $\pm$  SD of lumbar  $SC_{DS}$  of male are  $316.7 \pm 70.5$  mm<sup>2</sup>,  $198.6 \pm 53.4$  mm<sup>2</sup>, the mean area of lumbar  $SC_{DS}$  of female are  $306.4 \pm 62.5$  mm<sup>2</sup>,  $189.2 \pm 44.6$  mm<sup>2</sup>.

The mean AP diameters of V and DS are showed obvious significant difference between men and women (P  $\leq 0.05$ ). The mean AP diameters of EF is showed no significant difference between men and women (P  $\geq 0.05$ ). Also The mean area of lumbar SC (male  $316.7$  mm<sup>2</sup>, female  $306.4$  mm<sup>2</sup>) and DS (male  $198.6$  mm<sup>2</sup>, female  $189.2$  mm<sup>2</sup>) are showed obvious significant difference between men and women (P  $\leq 0.05$ ). The growth trend of the mean AP diameters of EF and SC the in lumbar spinal canal is showed in Fig 5.

## Discussion

LEL is characterized by increased deposition of normal adipose tissue in the extradural space and created a direct mechanical compression to the dural sac.<sup>7</sup> The clinical manifestations of this disease depend greatly on the level of canal compromise.<sup>16,17</sup> Different from TEL, most of the generating process of LEL (especially the early stage of LEL) is silently and easy to ignore because of the greater space of the lumbar spinal canal where epidural fat need a significant growth to give an enough stress to the dural sac to cause medical symptoms<sup>18</sup>. So the relevant parameters of normal lumbar spinal canal and its contents need to be clear. For the published studies, Quint et al.<sup>15</sup> measured the data in MR images of 28 normal control patients and found a mean sagittal epidural fat thickness of 4.6 mm (range 3–6 mm) at T7 lever. Borre et al.<sup>14</sup> measured MR images in 2528 patients at S1 lever and gave a MRI grading of LEL. However, as we known, few of English literatures gave detailed parameters about the normal epidural fat of lumbar spinal canal. We did this study and wanted to update the relevant parameters of lumbar epidural fat and contents in lumbar spinal canal to get a higher comprehension degree to LEL.

The diagnosis of LEL needs clinical symptoms, imaging studies and surgical evaluation, particularly the imaging studies. MRI is supposed to the most sensitive and specific tool to assess fatty tissue<sup>19</sup>. LEL cannot be diagnosed on plain x-ray images, but it can help rule out other causes like degenerative disease or tumors. Myelograms and CT scans were used to diagnose LEL before the MRI appeared, myelography is helpful to distinguish the intradural or extradural obstruction at the level of the canal compression. CT scans can differentiate the cause of the compression based on the density of the tissue in the epidural space as adipose tissue has a density ranging between - 80 and - 120 HU on CT scans. But some experts consider the two methods were not specific for SEL and could be misleading<sup>20</sup>. MRI allows excellent resolution of cerebrospinal fluid, spinal cord, and nerve roots, especially EF which has a pathognomonic appearance on MRI ( increased signal intensity on T1-weighted images, and intermediate signal intensity on T2-weighted images )<sup>21</sup>. This advantage made MRI an excellent tool to measure the fat thickness in both axial and sagittal planes and obviate the need of myelography<sup>19</sup>. To improve the repeatability and reliability of this study in our measure method, we chose the MRI image.

Measurement of epidural fat thickness in the mid-sagittal plane is considered a proper means to evaluate epidural fat in the spine.<sup>2</sup> Recent years, a three-round Delphi survey was made to develop a list of radiologic criteria for describing lumbar spinal stenosis and found that only the AP diameter was considered an established and important criterion with a high level of agreement<sup>22</sup>. To get more exact data of the lumbar spinal canal and its contents, we measured the relevant data of AP diameter in mid-sagittal MRI image. Also in consideration of the “Y-sign” which is very characteristic and is only found on axial MR imaging of LEL, we measured the cross-sectional area of normal lumbar SC and DS (the area of EF is disrupt and the shape is irregular in axial MR imaging which made the accurate data difficult to measure, so in this study we didn't measure the parameters.)

From the results of our study, the epidural fat presented along the lumbar spinal canal undulately. According to the parameters, the percentage of normal anteroposterior diameters of DS and EF in lumbar spinal canal is about 78.5% and 20.4% on mid-sagittal MRI and the threshold value of the LEL is about

37.6% based on the threshold AP diameters value of DS in lumbar spinal stenosis is about 7 cm<sup>23</sup>, approximate the value 40% (LEL 0) according to Borre. The mean area  $\pm$  SD of lumbar SC $\square$ DS are 311.0  $\pm$  66.3 mm<sup>2</sup> $\square$ 193.4  $\pm$  48.8mm<sup>2</sup>, which means the percentage of normal area of dural sac is about 62.2%, and the threshold value of the lumbar spinal stenosis is about 32.2% based on the threshold area value of dural sac in lumbar spinal stenosis is about 100 mm<sup>2</sup><sup>24</sup>. Also we can get that the growth trend of EF is decreased gradually with the age grow in normal lumbar spinal canal, and the growth trend of SC don't have significant relation with the age.

The LEL is a rare and complex condition that can lead to severe physical and functional limitation. With the testing technology updating and the deeper understanding to this disease, patients would be increased obviously in future. As such, the anatomy parameters of lumbar epidural fat need more concern, the MRI test is necessary. However, the results of this investigation also should be kept within the context of its limitations. Firstly, the factor of race was not considered. The variation of lumbar epidural fat thickness in this study might, at least in part, originate from this diversity. Secondly, the sample size of this study is limited. Thirdly, our study was limited to a MRI morphometric analysis rather than a cadaveric study.

## Conclusion

In conclusion, our investigation provides insight into the anatomy of epidural fat in lumbar spinal canal and gives the relevant parameters of and its contents on MRI. MRI is the most sensitive imaging test to diagnose LEL.

## Abbreviations

AP (anteroposterior), SD (standard deviation), V (vertebral body), DS (dural sac), EF (epidural fat), SC (spinal canal), EL (epidural lipomatosis)

## Declarations

## Acknowledgements

We gratefully acknowledge the support of all doctors in our department.

## Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

## Ethics approval and consent to participate

The study was approved by the Institutional Review Board of Huzhou Central Hospital. The requirement for informed consent was waived due to the retrospective design of our study.

## Consent for publication

Not applicable.

## Competing interests

There are no conflicts of interest to declare.

## Funding

This work was not supported by Funding

## Contributions

XJ, HJ, and YW contributed to the idea and design of the study. JN, TF, MJ, and HJ contributed to the data collection, data analysis, and drafted the manuscript. All authors contributed to the interpretation of results and manuscript revision. All authors read and approved the final manuscript.

## References

1. M L, J L, SS G, PE H. Spinal cord compression by extradural fat after renal transplantation. *The Medical journal of Australia*. 1975;1(7):201-203.
2. De Cocker L, De Cocker L, Van Rillaer O, Ceuppens J, van Loon J. The Y-sign in spinal epidural lipomatosis. *JBR-BTR*. 2009;92(4):235.
3. S I, N F, K A, et al. Spinal epidural lipomatosis is a previously unrecognized manifestation of metabolic syndrome. *The spine journal : official journal of the North American Spine Society*. 2019;19(3):493-500.
4. AA A-O, RD P, DA L, TL H, KB W, CM B. Idiopathic Spinal Epidural Lipomatosis in the Lumbar Spine. *Orthopedics*. 2016;39(3):163-168.
5. Ohba T, Saito T, Kawasaki N, Maekawa S, Haro H. Symptomatic spinal epidural lipomatosis with severe obesity at a young age. *Orthopedics*. 2011;34(6):233.
6. Kelly T, Yang W, Chen CS, Reynolds K, He J. Global burden of obesity in 2005 and projections to 2030. *Int J Obes (Lond)*. 2008;32(9):1431-1437.
7. K K, J M, W C. Spinal Epidural Lipomatosis: A Review of Pathogenesis, Characteristics, Clinical Presentation, and Management. *Global spine journal*. 2019;9(6):658-665.

8. Reina MA, Franco CD, López A, Dé Andrés JA, van Zundert A. Clinical implications of epidural fat in the spinal canal. A scanning electron microscopic study. *Acta Anaesthesiol Belg.* 2009;60(1).
9. P S, F P, S dP. MRI Diagnosis of Obesity-Related Spinal Epidural Lipomatosis. *The Canadian journal of neurological sciences Le journal canadien des sciences neurologiques.* 2019;1-2.
10. Y G, X Y, Y Y, Y X, G Y. Comparison of relative and absolute values of magnetic resonance imaging in the diagnosis of spinal epidural lipomatosis. *The journal of spinal cord medicine.* 2019;42(4):502-507.
11. MA W, Y Y, C dH, et al. Volumetric evaluation of lumbar epidural fat distribution in epidural lipomatosis and back pain in patients who are obese: introducing a novel technique (Fat Finder algorithm). *BMJ open diabetes research & care.* 2019;7(1):e000599.
12. ST P, AD B, S D, et al. Management of idiopathic spinal epidural lipomatosis: a case report and review of the literature. *Child's nervous system : ChNS : official journal of the International Society for Pediatric Neurosurgery.* 2018;34(4):757-763.
13. Daniel M, Doyon D, Bekkali F, Delvalle A, Francke JP. [MRI of normal spinal epidural fat]. *J Radiol.* 1992;73(12):695-698.
14. Borré DG, Borré GE, Aude F, Palmieri GN. Lumbosacral epidural lipomatosis: MRI grading. *European radiology.* 2003;13(7):1709-1721.
15. Quint DJ, Boulos RS, Sanders WP, Mehta BA, Patel SC, Tiel RL. Epidural lipomatosis. *Radiology.* 1988;169(2):485-490.
16. Patel AJ, Sellin J, Ehni BL, Tatsui CE. Spontaneous resolution of spinal epidural lipomatosis. *Journal of clinical neuroscience : official journal of the Neurosurgical Society of Australasia.* 2013;20(11):1595-1597.
17. Alvarez A, Induru R, Lagman R. Considering symptomatic spinal epidural lipomatosis in the differential diagnosis. *Am J Hosp Palliat Care.* 2013;30(6):617-619.
18. Kawai M, Uda F, Nishioka K, Houshimaru M, Koyama T, Kameyama M. A case of idiopathic spinal epidural lipomatosis presented with radicular pain caused by compression with enlarged veins surrounding nerve roots. *Acta neurologica Scandinavica.* 2002;105(4):322-325.
19. Pinkhardt EH, Sperfeld AD, Bretschneider V, Unrath A, Ludolph AC, Kassubek J. Is spinal epidural lipomatosis an MRI-based diagnosis with clinical implications? A retrospective analysis. *Acta neurologica Scandinavica.* 2008;117(6):409-414.
20. Chan J-Y, Chang C-J, Jeng C-M, Huang S-H, Liu Y-K, Huang J-S. Idiopathic spinal epidural lipomatosis - two cases report and review of literature. *Chang Gung medical journal.* 2009;32(6):662-667.
21. Healy ME, Hesselink JR, Ostrup RC, Alksne JF. Demonstration by magnetic resonance of symptomatic spinal epidural lipomatosis. *Neurosurgery.* 1987;21(3):414-415.
22. Mamisch N, Brumann M, Hodler J, Held U, Brunner F, Steurer J. Radiologic criteria for the diagnosis of spinal stenosis: results of a Delphi survey. *Radiology.* 2012;264(1):174-179.

23. Kumar K, Nath RK, Nair CP, Tchang SP. Symptomatic epidural lipomatosis secondary to obesity. Case report. *Journal of neurosurgery*. 1996;85(2):348-350.
24. Waldt S, Gersing A, Brügel M. Measurements and classifications in spine imaging. *Semin Musculoskelet Radiol*. 2014;18(3):219-227.

## Figures

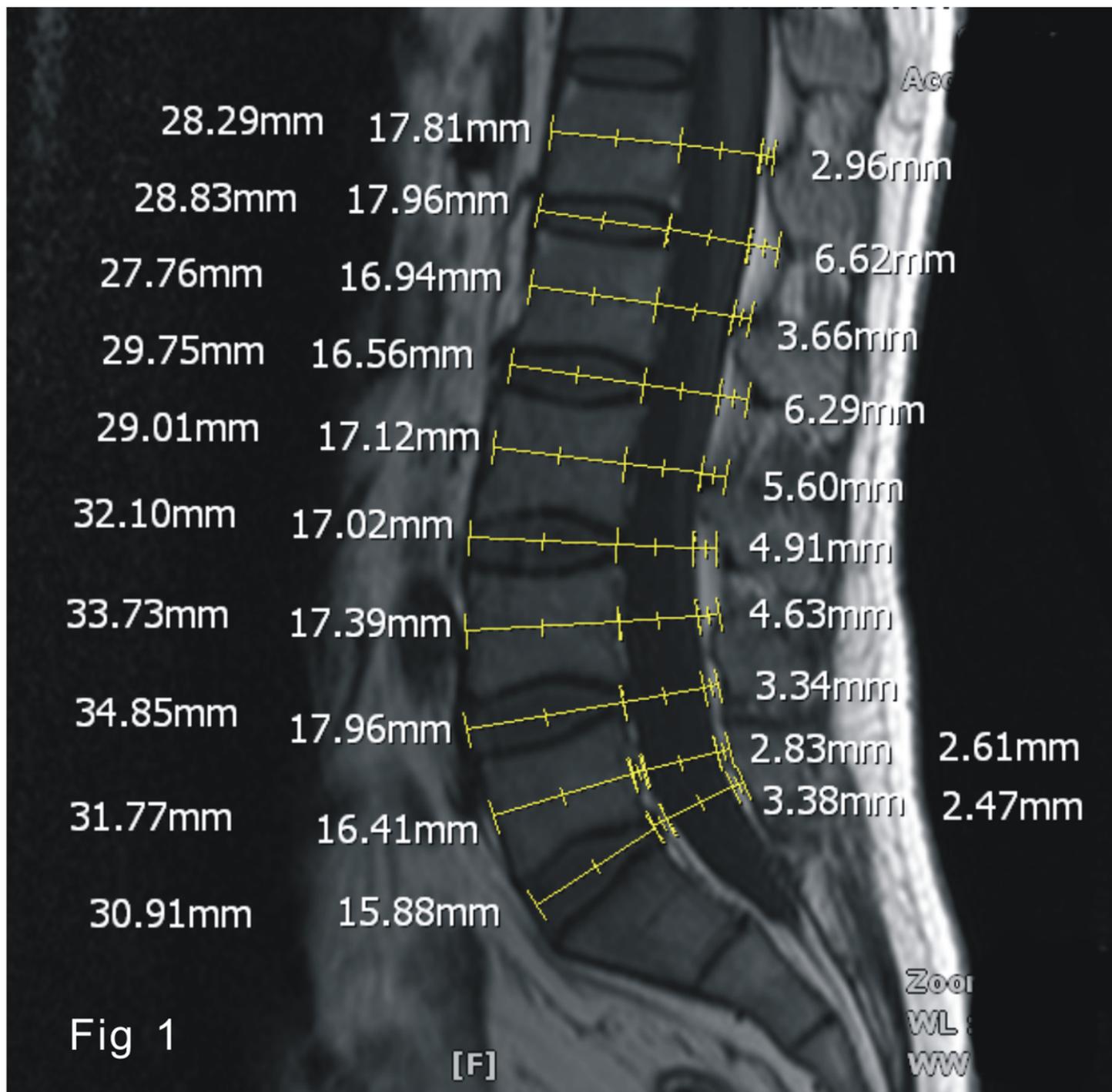


Figure 1

Sketch map of the measure method about AP diameters in this study.

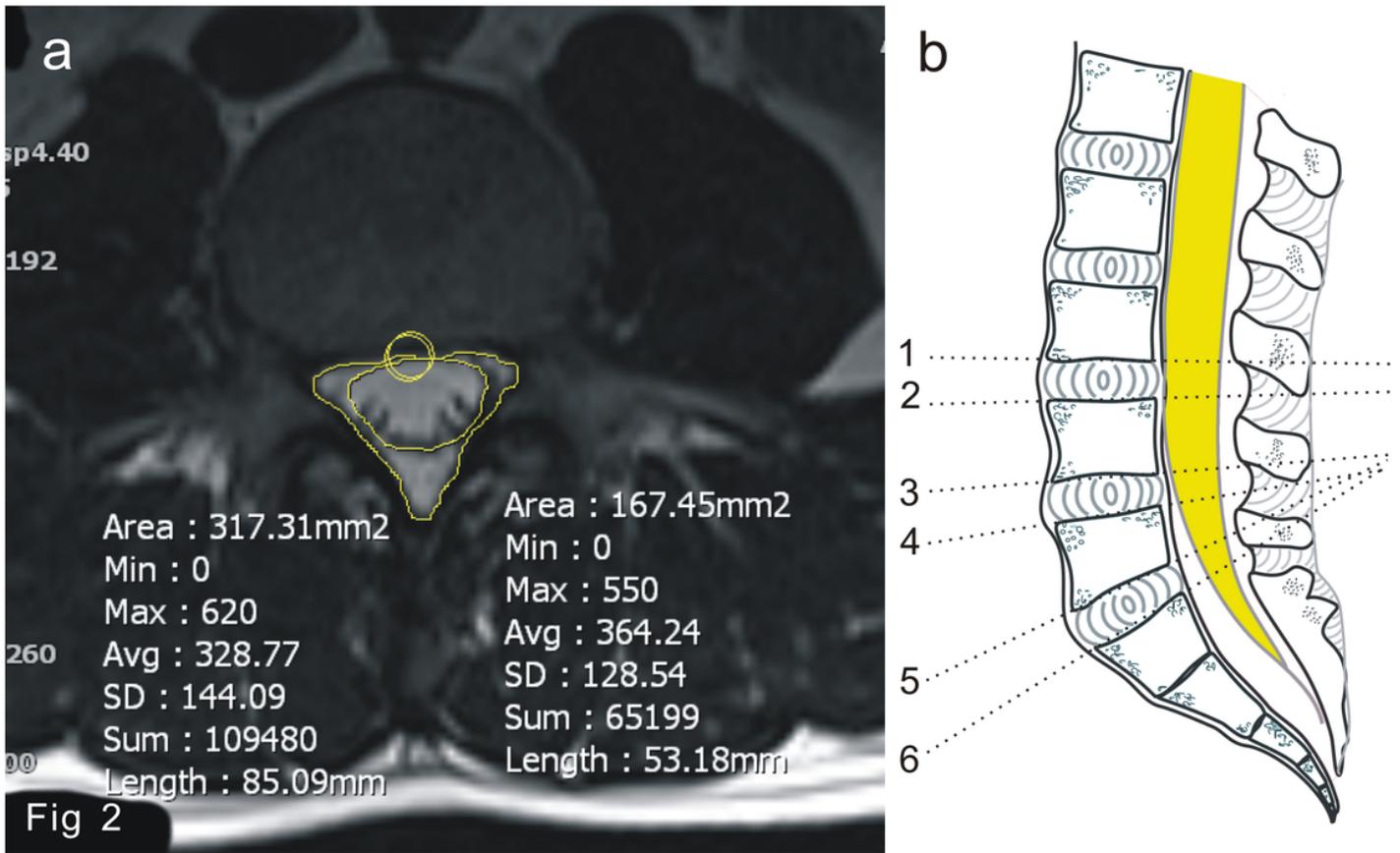
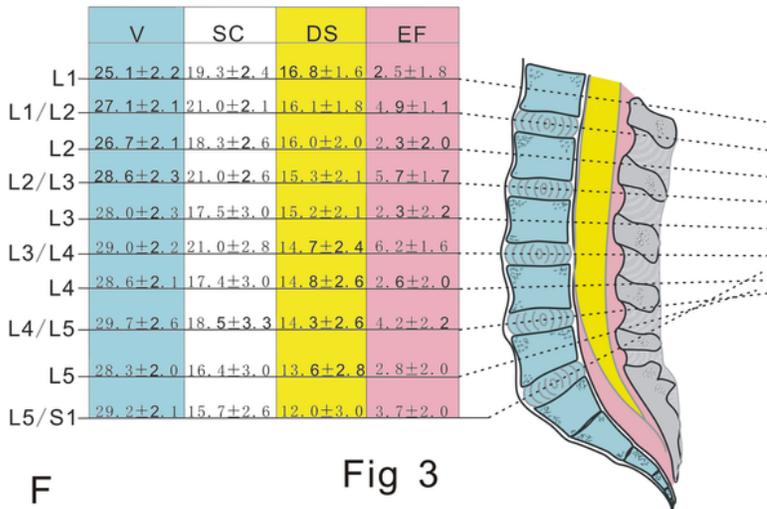
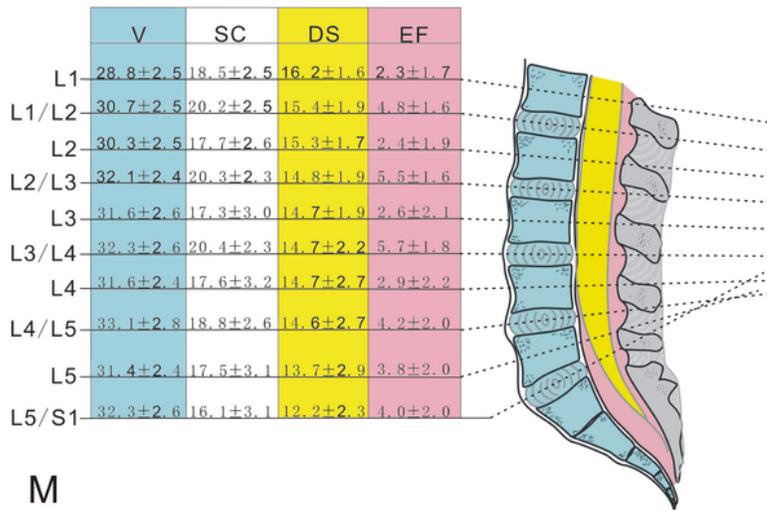
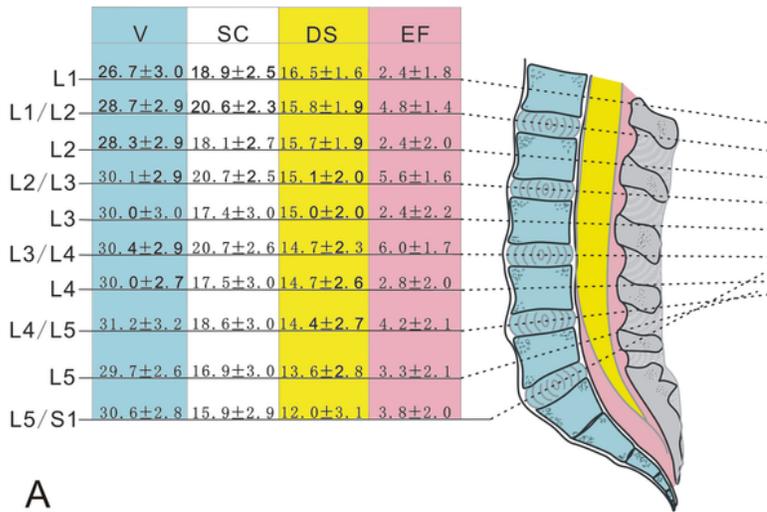


Figure 2

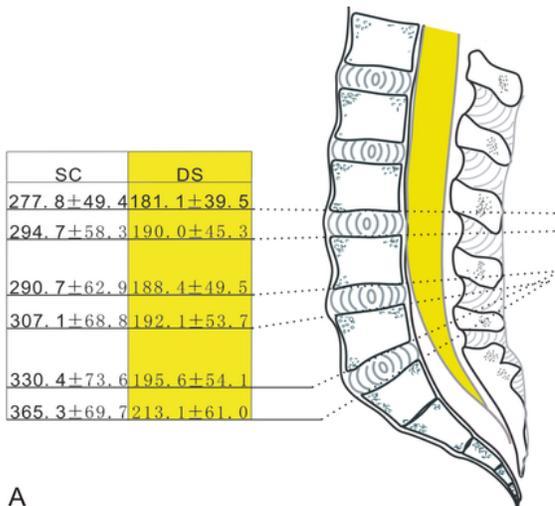
Sketch map of the measure method about cross-sectional areas in this study.



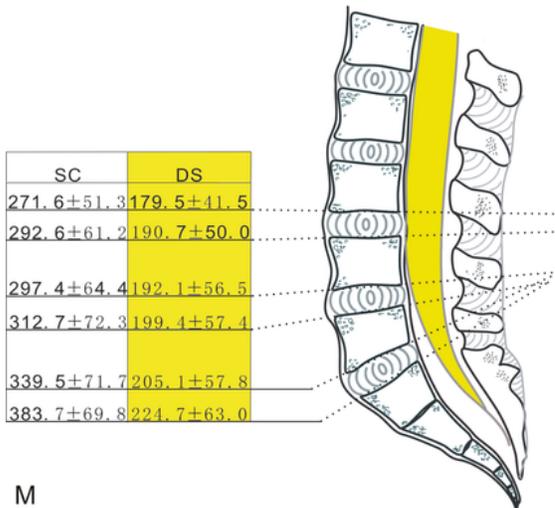
**Fig 3**

**Figure 3**

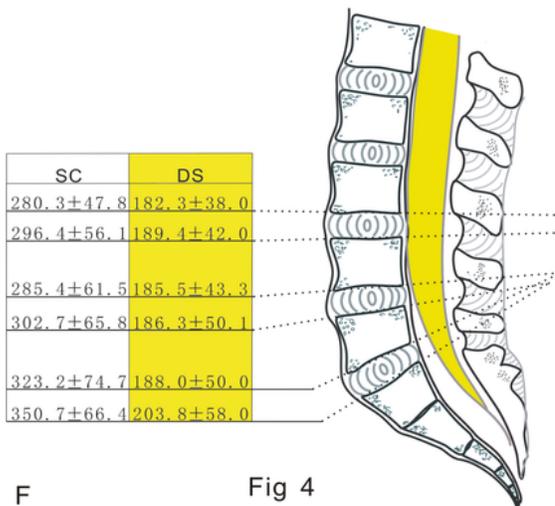
The mean AP diameters ± SD of V□DS□EF of each measured lever on the mid-sagittal MRI (Numbers are in millimeters).



A



M

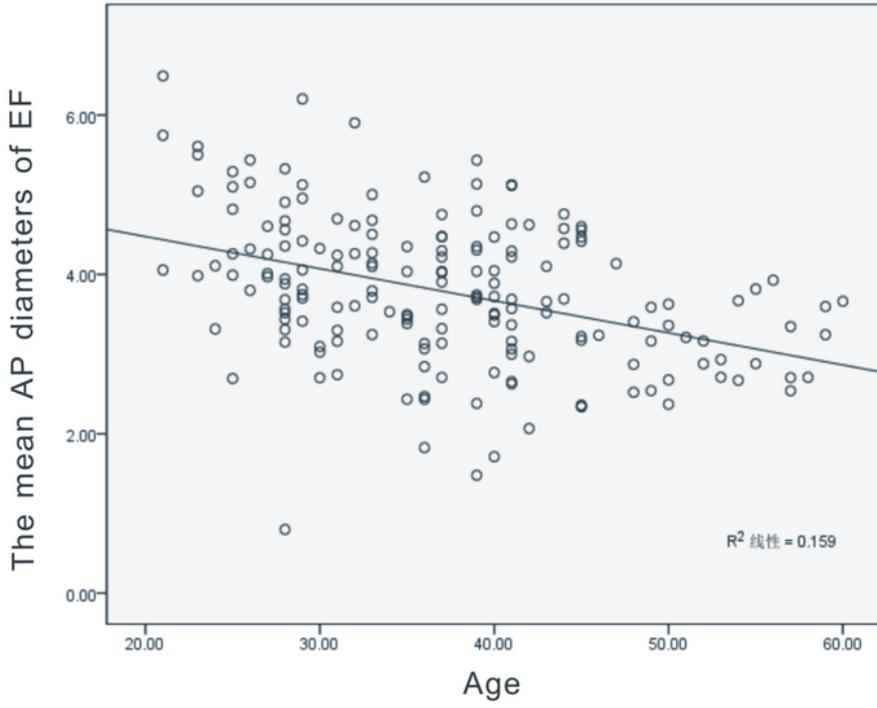


F

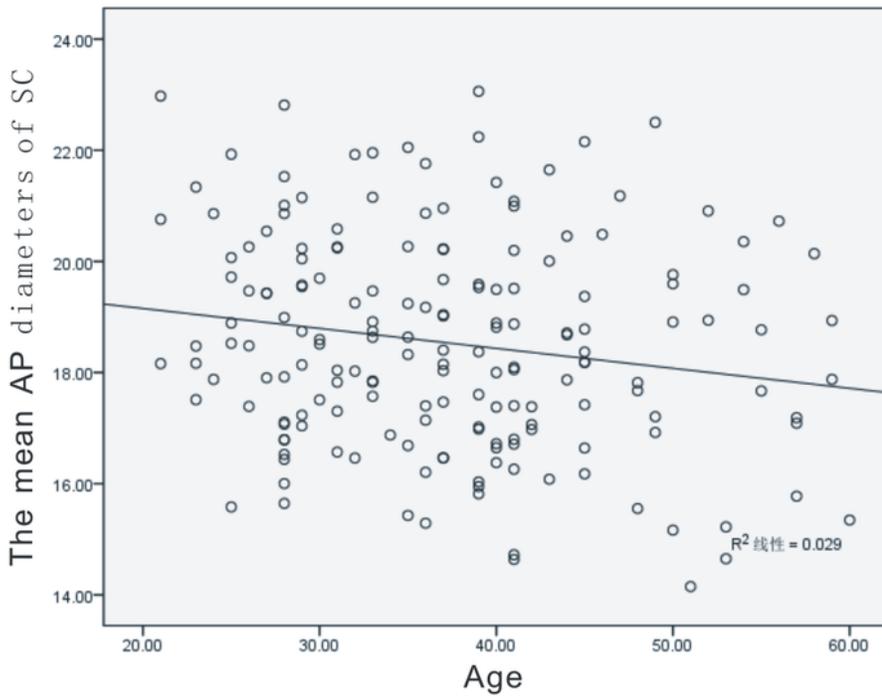
Fig 4

### Figure 4

The mean cross-sectional area ± SD of SC□DS of each measured lever on the axial MRI (Numbers are in square millimeters).



A



B

## Fig 5

Figure 5

The growth trend of the mean AP diameters of EF and SC the in lumbar spinal canal.