Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Clinical Characteristics and Surgical Outcomes of Thoracolumbar Ossification of the Ligamentum Flavum with Concomitant Thoracolumbar Scheuermann's Disease: A Retrospective Study

Zixuan Xu
Peking University Third Hospital
Guanghui Chen
Peking University Third Hospital
Lei Yuan
Peking University Third Hospital
Yuanyu Hu
Peking University Third Hospital
Shuai Jiang
Peking University Third Hospital
Xinhu Guo
Peking University Third Hospital
Woquan Zhong
Peking University Third Hospital
Weishi Li
Peking University Third Hospital
Feifei Zhou
Peking University Third Hospital
Chuiguo Sun
sunchuiguo@163.com

Peking University Third Hospital

Research Article

Keywords: Scheuermann's disease, thoracic ossification of the ligamentum flavum, prognosis, thoracolumbar segment

Posted Date: June 28th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10013254/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Purpose

We found that a lot of patients with thoracolumbar ossification of the ligamentum flavum (TLOLF) had Scheuermann's disease simultaneously. To investigate the clinical characteristics and postoperative prognosis of TLOLF patients with thoracolumbar Scheuermann's disease (TLSD), we conducted this research.

Methods

Patients who underwent surgery for ossification of the ligamentum flavum located in the thoracolumbar region at a single center from 2012 to 2022 were retrospectively reviewed. Patients were divided into a TLSD group and a control group. Baseline characteristics, sagittal spinal parameters, TOLF classification, spinal canal occupying rate, and postoperative recovery rate of neurological function were compared between the two groups.

Results

Patients in the TLSD group had a higher proportion of males (38/50 vs. 16/50, $P < 0.001$), greater thoracolumbar kyphosis (TLK) (14.69 ± 9.66° vs. 7.91 ± 5.43°, $P < 0.001$), a shorter duration of symptoms (7 (22) vs. 21 (51) months, $P = 0.003$), and a higher recovery rate (66.7% (54.2%0 vs. 41.4% (77.1%), $P = 0.003$). No significant differences were observed between the two groups in TOLF classification or spinal canal occupying rate.

Conclusion

TLOLF patients with TLSD had a greater TLK, which might be associated with the acceleration of ossification of the ligamentum flavum, resulting in a shorter disease course and better postoperative prognosis. TLSD does not affect the morphology of TOLF or the spinal canal occupying rate.

Introduction

Thoracic spinal stenosis may be caused by several pathological conditions, including thoracic ossification of the ligamentum flavum (TOLF), thoracic ossification of the posterior longitudinal ligament (TOPLL), thoracic disc herniation (TDH), and osteophyte[1]. Although the proportions of these etiologies vary among regions, TOLF is the most common cause of thoracic myelopathy[2].

TOLF is a heterotopic ossification disorder characterized by the transformation of fibrous tissue into bone within the thoracic ligamentum flavum[3]. Numerous factors contribute to the development of

TOLF, including metabolic disorders such as obesity and dyslipidemia[4, 5], inflammatory factors (e.g., interleukin-6)[6–8], genetic predisposition, and mechanical stress[9–11].

In clinical practice, we observed that many patients with ossification of the ligamentum flavum in the thoracolumbar region (TLOLF) exhibited wedge-shaped deformities of continuous vertebral bodies. We hypothesized that these patients might have thoracolumbar Scheuermann's disease (TLSD). Scheuermann's disease (SD) typically occurs during adolescence and results from abnormal development of the vertebral endplate cartilage, leading to vertebral wedging and kyphotic deformity[12]. Classic SD usually involves the thoracic spine and is diagnosed when at least three consecutive vertebral bodies demonstrate wedge angles greater than 5°[13]. When the apex of kyphosis is located in the thoracolumbar region, the condition is classified as atypical or thoracolumbar SD[12, 13].Therefore, this study aimed to explore the imaging characteristics and postoperative prognosis of TLOLF patients with TLSD.

Materials and Methods

This study was approved by the Ethics Committee of our hospital. We retrospectively reviewed medical records of consecutive patients diagnosed with TLOLF who underwent decompression treatment between 2012 and 2022.

Inclusion Criteria

1. Ossification of the ligamentum flavum located in the thoracolumbar region (T10-L2)
2. Postoperative follow-up of at least 2 years
3. Complete medical records and imaging data

Exclusion Criteria

1. Other thoracic spinal lesions: TOPLL, TDH, osteophytes, deformity, tumor, traumatic fracture, and TOLF beyond thoracolumbar segment.
2. Coexisting cervical or lumbar spondylosis
3. History of spinal surgery

Patients were divided into a TLSD group and a control group. TLSD was defined as at least three consecutive thoracolumbar vertebral bodies with wedge angles greater than 5° in thoracolumbar region (Fig. 1). Patients who did not meet these criteria were assigned to the control group. After strict selection, each group included 50 patients. All subjects received posterior en bloc resection of lamina and instrumented fusion by senior surgeons from one professional medical team.

Clinical data collected included demographic characteristics, sagittal spinal alignment parameters, TOLF classification, spinal canal occupying rate, postoperative complications and postoperative modified Japanese Orthopaedic Association (mJOA) recovery rate. The imaging data were measured in the image

system of our institution, named picture archiving and communication system (PACS) by two doctors and the average value was taken as the final result and the intraclass correlation coefficient was good.

Sagittal parameters included sagittal vertical axis (SVA), cervical lordosis (CL), thoracic kyphosis (TK), thoracolumbar kyphosis (TLK), lumbar lordosis (LL), pelvic incidence (PI), sacral slope (SS), and pelvic tilt (PT). Measurement methods were described in Table1.

Table1. The definition and measuring method of coronal and sagittal alignment parameters

Parameters	Definition and measurement
Sagittal Vertical Axis (SVA)	Horizontal distance between the central plumb line of the C7 vertebral body and the posterosuperior corner plumb line of the S1.
Lumbar Lordosis (LL)	Angle between the superior endplate of L1 and the superior endplate of S1.
Thoracic Kyphosis (TK)	Angle between the superior endplate of T4 and the inferior endplate of T12.
Cervical Lordosis (CL)	Angle between the posterior aspect of the C2 vertebral body and the posterior aspect of the C7 vertebral body
Thoracolumbar Kyphosis (TLK)	Angle between the superior endplate of T10 and the inferior endplate of L2.
Pelvic Incidence (PI)	Angle between a line drawn from the midpoint of the sacral plate to the femoral head axis and a line perpendicular to the sacral plate at its midpoint.
Pelvic Tilt (PT)	Angle between a vertical line and a line connecting the midpoint of the sacral plate to the femoral head axis.
Sacral Slope (SS)	Angle between a horizontal line and the superior endplate of the sacrum.

TOLF morphology was classified using the Sato classification (lateral/extended, enlarged, fused, or nodular types) (Fig. 2) and the Kuh classification (beak or round type) (Fig. 3) [14]. Spinal canal occupying rate was assessed in both cross-sectional and sagittal planes (Fig. 4)[15].

The neurological function was evaluated by the thoracic mJOA score, and the recovery rate (RR) was calculated as:

$$\mathrm{RR} = \frac{\text{Postoperative mJOA score} - \text{Preoperative mJOA score}}{11 - \text{Preoperative mJOA score}} \times 100\%$$

Quantitative variables with normal distribution were presented as mean ± standard deviation and were analyzed using independent-sample *t* tests, while skewed variables were presented as median (interquartile range) and were analyzed using the Wilcoxon rank-sum test. Categorical variables were

analyzed using the chi-square test. Statistical analyses were performed using SPSS version 25.0, with $P < 0.05$ considered statistically significant.

Results

Baseline characteristics of both groups are shown in Table 2. Compared with the control group, patients in the TLSD group had a significantly higher proportion of males (38/50 vs. 16/50, $P < 0.001$), shorter symptom duration (7 (22) vs. 18 (40) months, $P = 0.006$), and a higher recovery rate (66.7% (54.2%) vs. 41.4% (77.1%), $P = 0.003$). No significant differences were observed in age, body mass index (BMI), comorbidities, preoperative mJOA score, duration time and blood loss of operation, number of decompressed segments, or proportion of cerebrospinal fluid leakage (CSFL) and epidural hematoma.

Table 2
Demographic characteristics and baseline clinical data of patients in the thoracolumbar Scheuermann's disease group and control group.

Age (years)		**Thoracolumbar Scheuermann's Disease Group (n = 50)**	**Control Group (n = 50)**	**P**
		54.8 ± 11.6	**58.4 ± 8.7**	**0.08**
Sex	Male	38	16	<0.001
	Female	12	34	
Hypertension	Yes	14	19	0.288
	No	36	31	
Diabetes	Yes	6	4	0.505
	No	44	46	
Duration of the medical history (months)		7 (22)	18 (40)	0.006
BMI (kg/m^2)		27.5 ± 4.3	26.2 ± 3.4	0.164
Preoperative mJOA score		7 (3)	6 (3)	0.842
Recovery rate		66.7% (54.2%)	41.4% (77.1%)	0.003
Segments of operation		2 (2)	2 (1)	0.631
Duration of operation (min)		120.3 ± 38.2	117.7 ± 48.7	0.407
Blood loss during operation (ml)		300 (200)	300 (400)	0.369
Cerebrospinal fluid leakage	Yes	13	11	0.807
	No	37	39	
Epidural hematoma	Yes	1	1	1.000
	No	49	49	

As shown in Table 3, patients with TLSD demonstrated significantly greater TLK than those in the control group (14.69 ± 9.66° vs. 7.91 ± 5.43°, $P < 0.001$). However, no significant differences were observed in other sagittal alignment parameters or overall sagittal balance.

Table 3
Comparison of spinal sagittal alignment parameters between the thoracolumbar Scheuermann's disease group and control group.

SVA (cm)	**Thoracolumbar Scheuermann's Disease Group (n = 50)**	**Control Group (n = 50)**	**P**
	1.49 ± 3.80	**0.51 ± 3.89**	**0.619**
CL(°)	11.07 ± 8.14	11.20 ± 11.62	0.961
TK(°)	22.84 ± 8.51	27.28 ± 9.54	0.093
TLK(°)	14.69 ± 9.66	7.91 ± 5.43	<0.001
LL(°)	44.25 ± 13.31	42.66 ± 11.78	0.587
SS(°)	36.50 ± 9.99	36.57 ± 9.43	0.991
PT(°)	10.59 ± 8.22	12.13 ± 12.52	0.600
PI(°)	47.83 ± 11.73	49.01 ± 11.25	0.719
Note:			

sagittal vertical axis (SVA), cervical lordosis (CL), thoracic kyphosis (TK), thoracolumbar kyphosis (TLK), lumbar lordosis (LL), pelvic incidence (PI), sacral slope (SS), pelvic tilt (PT).

Table 4 shows no significant differences between the two groups in spinal canal occupying rate in either sagittal or cross-sectional planes. Additionally, no differences were found in Sato or Kuh classification distributions.

Table 4
Characteristics of thoracic ossification of the ligamentum flavum in the thoracolumbar Scheuermann's disease group and control group.

		Thoracolumbar Scheuermann's Disease Group (n = 50)	Control Group (n = 50)	P
Sato classification	Lateral type	15	1	0.078
	Extensive type	8	17	
	Enlarged type	8	10	
	Fusion type	4	4	
	Nodular type	15	18	
Kuh's classification	Beak type	30	37	0.137
	Round type	20	13	
Spinal cord signal changes	Yes	27	20	0.770
	No	21	29	
Cross-sectional spinal canal occupying rate		52.6 ± 15.9%	55.2 ± 18.4%	0.446
Sagittal spinal canal occupying rate		69.1 ± 16.7%	74.0 ± 11.6%	0.188

Discussion

This study is the first to investigate the clinical characteristics of TLOLF patients with TLSD. Our findings indicated that patients with TLOLF and TLSD had a higher proportion of males (38/50 vs 16/50, P < 0.001), greater TLK (14.69 ± 9.66 vs 7.91 ± 5.43, P < 0.001), shorter symptom duration (7(22) vs 21 (51), P = 0.003), and better postoperative recovery rate (66.7% (54.2%) vs 41.4% (77.1%), P = 0.003).

Scheuermann's disease (SD) is more prevalent in males, with a reported male-to-female ratio of approximately 2:1[16], which is consistent with our findings. The possible underlying reasons include that males have more growth hormone or other hormone secretion related to genetic factors, and they engage in more physically demanding activities, such as large motions of the trunk in flexion/extension[13, 16].

Compared with TOLF patients without SD, patients with TLSD had a greater TLK. However, TLSD had no significant influence on CL, TK, LL, pelvic parameters and overall sagittal balance. S. Y. Chang[9] believed that overactivity of thoracolumbar segment could resulted in TOLF. In another research, patients with TOLF in thoracolumbar region had greater TLK compared with asymptomatic individuals, and the

scholars also believed that large TLK and excessive activity of thoracolumbar segment might contribute to the occurrence of TOLF[17]. It can be seen that the mechanism stress in the thoracolumbar segment has a strong relation to the development of TOLF in this region. In our study, patients in TLSD group had greater TLK (14.69 ± 9.66 vs 7.91 ± 5.43, P < 0.001), so we speculated that lager TLK exerted greater mechanical stress and tensile force on the ligamentum flavum and this might accelerate the development of TOLF. Finally, it would contribute to the acceleration of the illness of patients with TLSD, and result in a shorter duration of symptom (7(22) vs 21(51), P = 0.003).

Patients with TLSD also demonstrated a better postoperative recovery. Previous studies have shown that prolonged preoperative symptom duration is associated with poorer neurological recovery due to irreversible spinal cord damage[18, 19]. We speculated that accelerated symptom progression in TLSD leads to earlier surgical intervention, thereby improving postoperative outcomes.

Importantly, TLSD did not influence the morphology of TOLF or the degree of spinal canal invasion, suggesting that it might influence disease progression rather than ossification pattern. What's more, TLSD seemed not to influence the amount of blood loss and duration time of operation and the incidence rate of postoperative complications.

However, this study also has several limitations. As a retrospective and cross-sectional study, it is difficult to determine when the vertebral wedge deformation occurred in patients with TLSD and the specific effect of TLSD on the development of ossification of ligamentum flavum. Furthermore, follow-up imaging data were insufficient and we cannot fully explore the change of sagittal parameters in patients with TLSD after surgery.

Conclusion

TLOLF patients with TLSD had a greater TLK, which may contribute to accelerate the development of TOLF and lead to earlier symptom onset. Early surgical intervention in these patients may contribute to better postoperative outcomes. TLSD does not affect TLOLF morphology or spinal canal occupying rate. Patients with TLSD should be closely monitored due to rapid disease progression and the potential need for timely intervention.

Declarations

Human Ethics and Consent to Participate declarations

The Ethical Committee of Peking University Third Hospital approved this research (IRB00006761). Written informed consent and consent for participation were obtained.

Clinical trial number

not applicable

Funding:

Natural Science Foundation of Beijing Municipality (Grant Number: 7252164), The National Natural Science Fund of China (Grant Number: 82302745), and Key Clinical Projects of Peking University Third Hospital (No. BYSYZD2024006)

Author Contribution

ZX wrote this article; GC collected the data. LY and SJ analysed the data. YH and WZ polished this manuscript. XG provided guidance on statistics. WL designed the study. FZ and CS guide the entire research.

Data Availability

The data is stored within the research group. If there is a need and it is a reasonable request, please send an email to the corresponding author for inquiries.

References

1. Rujeedawa, T., et al., *Degenerative Thoracic Myelopathy: A Scoping Review of Epidemiology, Genetics, and Pathogenesis.* Global Spine J, 2024. **14**(5): p. 1664-1677.
2. Chen, G., et al., *The prevalence and clinical characteristics of thoracic spinal stenosis: a systematic review.* Eur Spine J, 2020. **29**(9): p. 2164-2172.
3. Zhang, C., et al., *Pathogenesis of thoracic ossification of the ligamentum flavum.* Front Pharmacol, 2024. **15**: p. 1496297.
4. Lin, J., et al., *Significance of body mass index on thoracic ossification of the ligamentum flavum in Chinese population.* Eur Spine J, 2022. **31**(12): p. 3308-3315.
5. Endo, T., et al., *Strong relationship between dyslipidemia and the ectopic ossification of the spinal ligaments.* Sci Rep, 2022. **12**(1): p. 22617.
6. Huang, A.Y., et al., *IL-6 is involved in thoracic ossification of the ligamentum flavum.* PLoS One, 2022. **17**(7): p. e0272357.
7. Park, J.O., et al., *Inflammatory cytokines induce fibrosis and ossification of human ligamentum flavum cells.* J Spinal Disord Tech, 2013. **26**(1): p. E6-12.
8. Yang, X., et al., *LGR5 regulates osteogenic differentiation of human thoracic ligamentum flavum cells by Wnt signalling pathway.* J Cell Mol Med, 2022. **26**(14): p. 3862-3872.

9. Chang, S.Y., et al., *Sagittal Alignment in Patients with Thoracic Myelopathy Caused by the Ossification of the Ligamentum Flavum: A Retrospective Matched Case-Control Study.* Spine (Phila Pa 1976), 2021. **46**(5): p. 300-306.
10. Ha, K.Y., et al., *Thoracic myelopathy caused by ossification of the yellow ligament in patients with posterior instrumented lumbar fusion.* Eur Spine J, 2012. **21**(12): p. 2443-9.
11. Tsukamoto, N., et al., *Repetitive tensile stress to rat caudal vertebrae inducing cartilage formation in the spinal ligaments: a possible role of mechanical stress in the development of ossification of the spinal ligaments.* J Neurosurg Spine, 2006. **5**(3): p. 234-42.
12. Kaur, S. and R. Lalam, *Scheuermann's Disease.* Semin Musculoskelet Radiol, 2023. **27**(5): p. 522-528.
13. Palazzo, C., F. Sailhan, and M. Revel, *Scheuermann's disease: an update.* Joint Bone Spine, 2014. **81**(3): p. 209-14.
14. Lee, B.J., et al., *Clinically significant radiographic parameter for thoracic myelopathy caused by ossification of the ligamentum flavum.* Eur Spine J, 2019. **28**(8): p. 1846-1854.
15. Wang, L., et al., *Incidence and Risk Factors for Symptomatic Spinal Epidural Hematoma Following Posterior Thoracic Spinal Surgery in a Single Institute.* Global Spine J, 2022. **12**(6): p. 1175-1183.
16. Bezalel, T., et al., *Scheuermann's disease: current diagnosis and treatment approach.* J Back Musculoskelet Rehabil, 2014. **27**(4): p. 383-90.
17. Xu, Z., et al., *Potential Influence of Sagittal Parameters in the Pathogenesis of Patients With the Thoracic Ossification of the Ligamentum Flavum.* Orthop Surg, 2025. **17**(7): p. 1956-1964.
18. Kuh, S.U., et al., *Contributing factors affecting the prognosis surgical outcome for thoracic OLF.* Eur Spine J, 2006. **15**(4): p. 485-91.
19. Kawaguchi, Y., et al., *Variables affecting postsurgical prognosis of thoracic myelopathy caused by ossification of the ligamentum flavum.* Spine J, 2013. **13**(9): p. 1095-107.

Figures

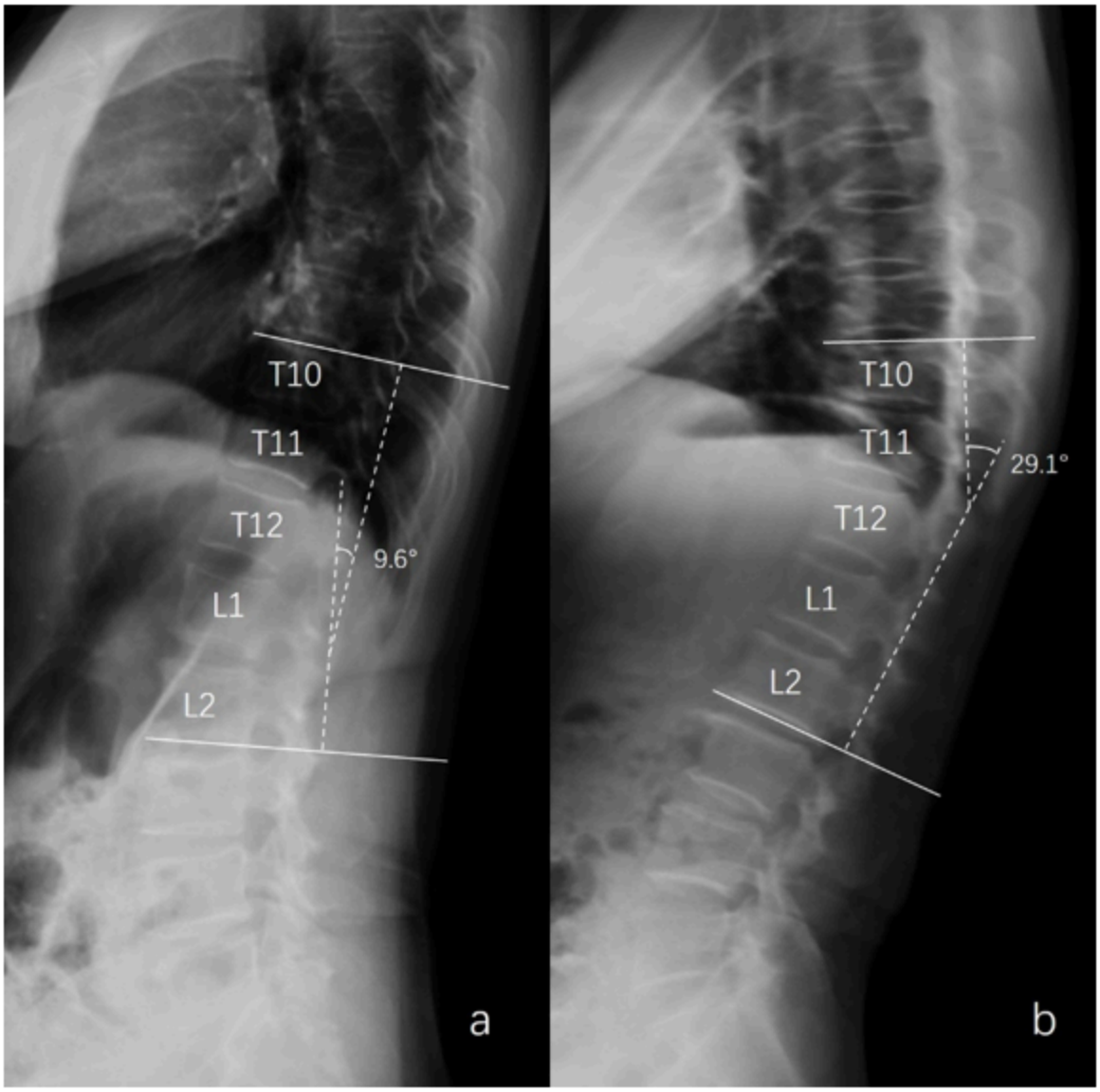


Figure 1

Representative examples of patients in the control group and thoracolumbar Scheuermann's disease (TLSD) group.
(a) A control group patient with wedge angles of T10–L2 vertebral bodies are 0.9°, 1.4°, 3.4°, 2.0°, and 2.4°, respectively; thoracolumbar kyphosis (TLK) angle is 9.6°.
(b) A TLSD group patient with wedge angles of T10–L2 vertebral bodies are 8.7°, 8.2°, 6.1°, 6.7°, and 2.3°, respectively; TLK angle is 9.6°.

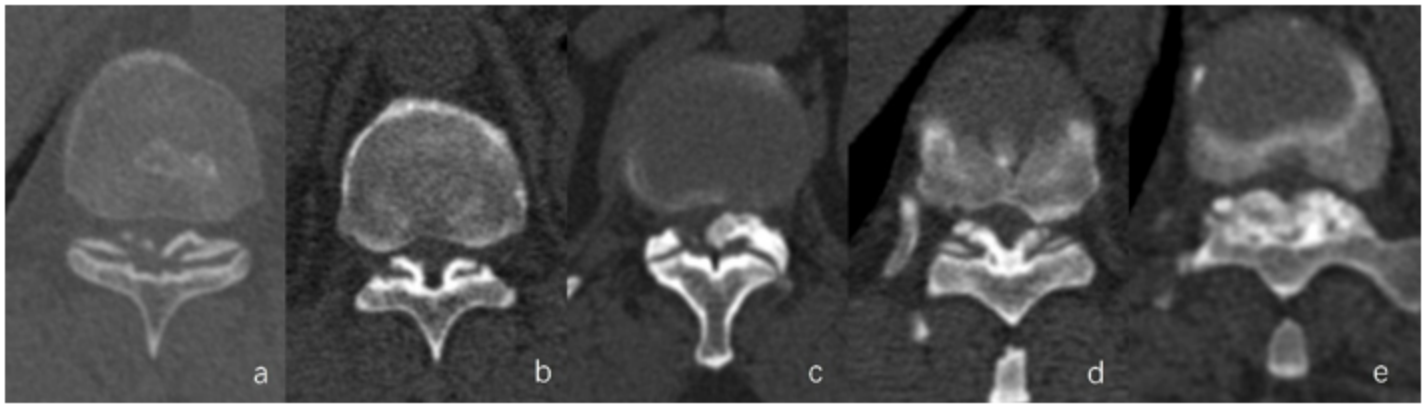


Figure 2

Sato classification of thoracic ossification of the ligamentum flavum (TOLF).
(a) Lateral type; (b) extended type; (c) enlarged type; (d) fused type; (e) nodular type.

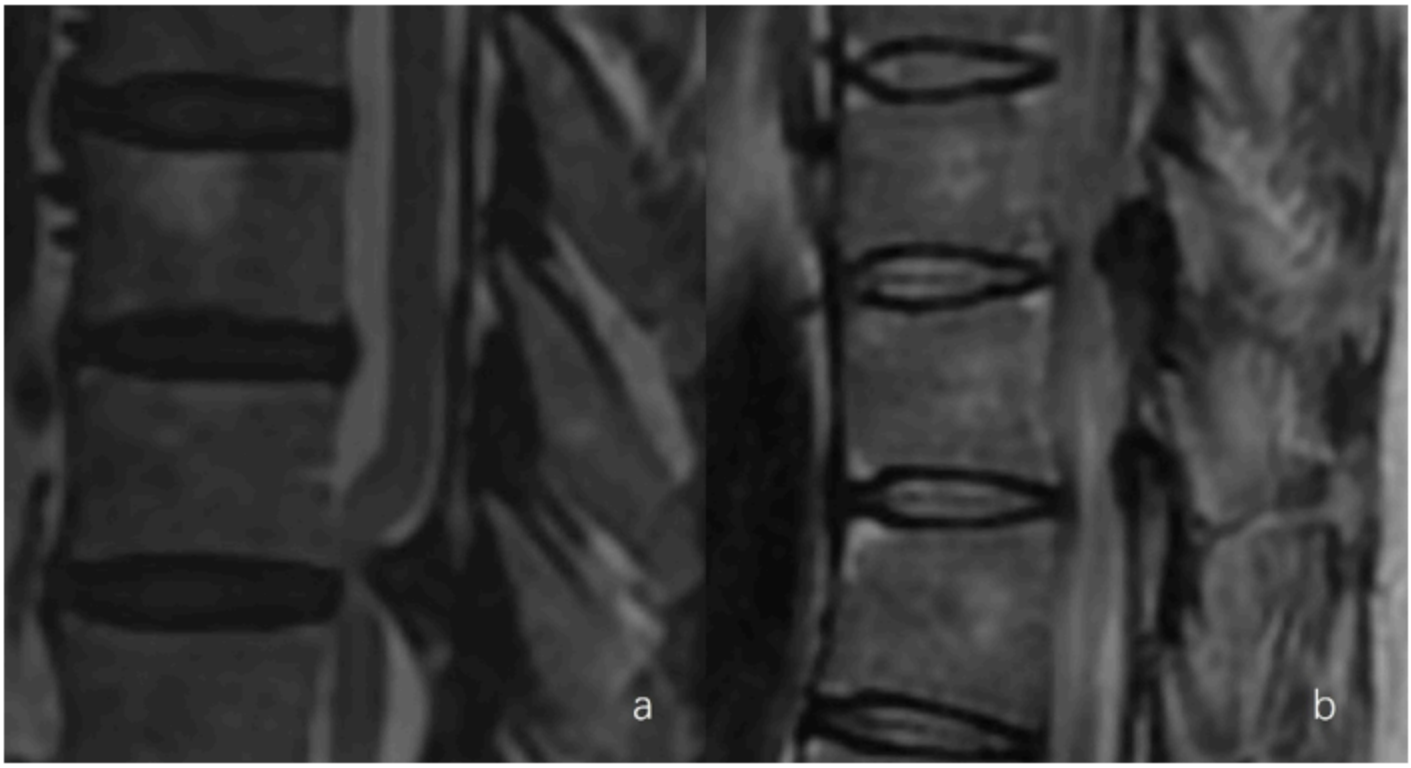


Figure 3

Kuh classification of thoracic ossification of the ligamentum flavum (TOLF).
(a) Beak type; (b) round type.

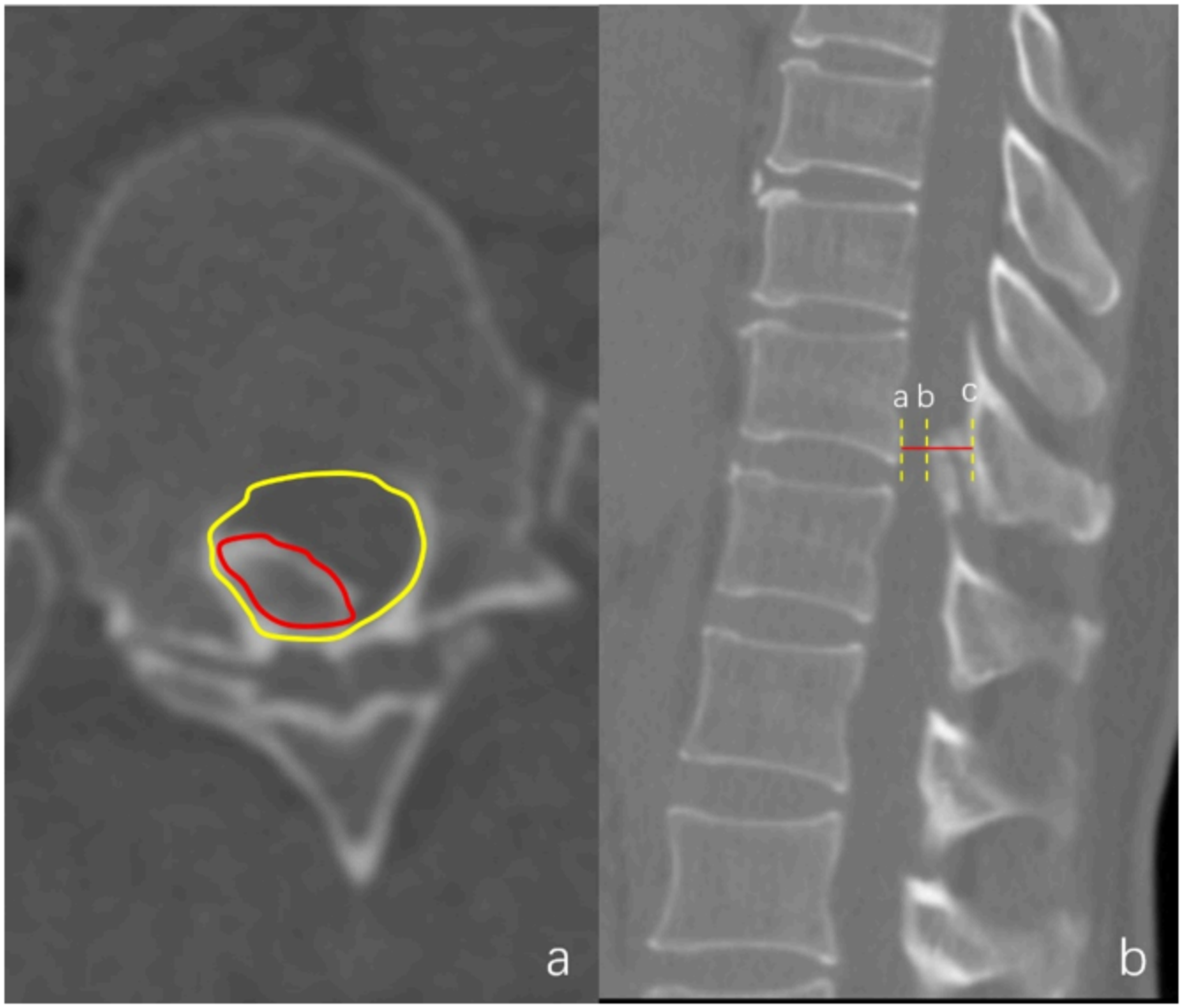


Figure 4

Measurement of spinal canal occupying rate.
(a) Cross-sectional occupying rate: the red area represents the ossified ligamentum flavum, and the yellow area represents the spinal canal; the occupying rate is calculated as the red area divided by the yellow area.
(b) Sagittal occupying rate: line *ac* represents the sagittal length of the spinal canal, and line *bc* represents the sagittal length of TOLF; the occupying rate is calculated as *bc/ac*.