Original Article

Yonsei Med J 2026 May;67(5):419-426
https://doi.org/10.3349/ymj.2025.0100

Yonsei Medical Journal
YMJ
pISSN: 0513-5796 · eISSN: 1976-2437

Screening and Predictive Value of Thoracic Ossification Observed on Lateral Radiography for Myelopathy

Hyun Jun Jang[1], Byung-Jou Lee[2], Kyung Hyun Kim[1], Jin Hoon Park[3], Jeong Yoon Park[1], Sung Uk Kuh[1], Dong Kyu Chin[1], Keun Su Kim[1], and Bong-Ju Moon[1]

[1]Department of Neurosurgery, Spine and Spinal Cord Institute, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul;
[2]Department of Neurosurgery, Inje University Ilsan Paik Hospital, Inje University College of Medicine, Goyang;
[3]Department of Neurosurgery, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea.

Purpose: Ossification of the ligamentum flavum (OLF) is known to compress neural structures, leading to myelopathy. Although computed tomography (CT) is a reliable diagnostic tool, thoracic OLF is often underdiagnosed due to the challenges of routinely performing thoracic imaging in clinical practice. Radiographs offer a more accessible option but lack established criteria for screening clinically significant thoracic OLF.

Materials and Methods: Retrospective study conducted at a single institution, evaluating radiographic and clinical data from patients with thoracic OLF. A total of 142 patients were included: 69 in the myelopathy group, who had myelopathy symptoms due to thoracic OLF, and 73 in the non-myelopathy group, who had OLF observed on CT but no myelopathy symptoms.

Results: The OLF diameter (8.39±2.42 mm vs. 5.96±2.93 mm, p<0.001) and OLF diameter ratio (0.63±0.15 vs. 0.42±0.33, p<0.001) were significantly larger in the myelopathy group compared to the non-myelopathy group. Receiver operating characteristic analysis revealed that an OLF diameter ratio ≥0.58 on lateral radiographs had an area under the curve of 0.817, with 73% sensitivity and 82% specificity for predicting myelopathy.

Conclusion: The OLF diameter ratio measured on lateral radiographs is an effective and non-invasive parameter for identifying thoracic OLF cases with myelopathy symptoms. When the OLF diameter ratio is ≥0.58, clinicians should consider the possibility of myelopathy and perform further diagnostic imaging, such as CT or magnetic resonance imaging, to guide treatment decisions.

Key Words: Thoracic vertebrae, ligamentum flavum, compressive myelopathy, pathological ossification, computed tomography

INTRODUCTION

Ossification of the ligamentum flavum (OLF) is a condition where the ligamentum flavum between the laminae becomes ossified, leading to compression of neural structures such as the spinal cord or nerve roots, and resulting in neurological symptoms.[1,2] The prevalence of OLF is reported to range from 3.8% to 26%, with a study by Ehara, et al. indicating that 67% of cases occur in the lower thoracic region.[3-6] While most cases are asymptomatic and do not require surgery, intervention becomes necessary if myelopathy symptoms develop.[7] Unfortunately, thoracic OLF is sometimes underdiagnosed due to coexisting spinal pathologies such as cervical degenerative myelopathy, lumbar degenerative disease, or both, which can lead to delays in timely surgical intervention.[8-12]

Thoracic OLF can be diagnosed using computed tomography (CT) or magnetic resonance imaging (MRI)[2]; however, in cases with vague symptoms, conducting thoracic CT or MRI in clinical settings can be challenging. Lee, et al.[13] identified clinically significant radiographic parameters for thoracic OLF in a study using CT. Since Kudo, et al.[14] first reported OLF on lateral radiographs, subsequent reports have been limited, and re-

Received: May 2, 2025 **Revised:** November 2, 2025
Accepted: November 20, 2025 **Published online:** March 12, 2026
Corresponding author: Bong-Ju Moon, MD, PhD, Department of Neurosurgery, Spine and Spinal Cord Institute, Gangnam Severance Hospital, Yonsei University College of Medicine, 211 Eonju-ro, Gangnam-gu, Seoul 06273, Korea.
E-mail: bongjumoon@yuhs.ac

A part of this study was presented as a poster at the 2023 Global Spine Congress, Prague, and at the 2025 Korean Neurosurgical Society Spring Meeting.
•The authors have no potential conflicts of interest to disclose.

© Copyright: Yonsei University College of Medicine 2026
This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (https://creativecommons.org/licenses/by-nc/4.0) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

search using radiographs for OLF remains scarce.

This study aims to investigate an adjunctive screening tool for clinically significant thoracic OLF using simple radiographs, with the expectation that this could serve as a criterion for further evaluation, such as thoracic CT or MRI, in clinical practice.

MATERIALS AND METHODS

This retrospective study was conducted at a single tertiary referral center with approval from the Institutional Review Board of Gangnam Severance Hospital, Yonsei University College of Medicine, approved this study with a waiver of informed consent (No. 3-2023-0395). A waiver of informed consent was granted due to the use of anonymized data and the non-interventional nature of the study. Medical records and imaging data were reviewed for patients who visited the outpatient clinic between January 2015 and December 2021. Inclusion criteria were as follows: 1) age between 18 and 80 years; 2) availability of thoracic spine radiographs, CT, MRI, and corresponding clinical data; and 3) presence of OLF in the thoracic spine identified on CT. Patients were excluded if they had: 1) congenital disease, stroke, other neurological disorders, thromboembolic disease, or a history of cancer; 2) ventral spinal lesions such as thoracic disc herniation or posterior longitudinal ligament ossification (OPLL); 3) cervical OPLL or severe lumbar stenosis; 4) unclear radiographs due to bowel gas or rib overlap; or 5) a history of spinal surgery at other levels.

Patients with thoracic OLF and clinical signs of myelopathy, defined as a modified Japanese Orthopedic Association (mJOA) score of 17 or less, were classified as the myelopathy group. Patients with thoracic OLF on CT but without clinical signs of myelopathy were classified as the non-myelopathy group.[15,16] In cases where multilevel OLFs were observed, we measured the thickness of the OLF (TOLF) at the thickest level detected on CT to ensure inclusion of the most significant lesion.

Radiologic measurement

Since OLF primarily occurs at the attachment of the ligament between the inferior and superior facets, studies have examined its shape through the foramen.[14] However, there are no reported quantitative measurement methods for OLF on lateral radiographs. Building upon the anatomical study by Xu, et al.,[17] which utilized cadavers to measure the length of the spinal foramen based on the upper endplate of the thoracic disc, we employed this method to quantitatively assess the size of the OLF on lateral radiographs. By referencing the thoracic disc's upper endplate as a consistent anatomical landmark, this technique allowed for precise and standardized measurements of the OLF. This approach enhanced the accuracy of our comparisons between the myelopathy and non-myelopathy groups, providing a reliable metric for evaluating the extent of ossification and its potential impact on the spinal canal.

OLF diameter ratio (OLF diameter/foramen diameter) on lateral radiograph (Fig. 1)

- OLF diameter: the vertical distance measured on a lateral radiograph from the posterior edge of the disc and vertebral body to the most anterior point of the OLF.
- Foramen diameter: the distance measured on a lateral radiograph from the posterior edge of the disc and vertebral body to the most superior point of the facet surface.

OLF area ratio (OLF area/foramen area) on lateral radiograph (Fig. 2)

-Foramen area: the area enclosed by connecting the posterior wall of the vertebral body, the lower margin of the pedicle of the upper vertebral body, the upper margin of the pedicle of the lower vertebral body, and the anterior wall of the facet.
- OLF area: the area of the OLF extending from the facet surface toward the foramen.

TOLF, normal APD (antero-posterior diameter) and TOLF ratio on CT axial image (Fig. 3A)

Measurements were performed on axial CT images at the thickest portion of the OLF, regardless of its shape. The TOLF was determined by drawing a line along the side of the ligament facing the spinal canal and along the laminar side of the ligament's curvature, recording the thickest point. The TOLF ratio was calculated using the formula:

TOLF ratio (%)=TOLF of affected segment/normal APD

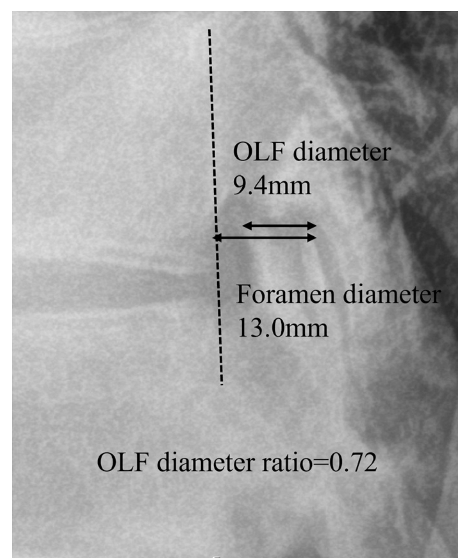

Fig. 1. Measurement methods of OLF diameter and foramen diameter on lateral radiograph. The OLF diameter is defined as the distance from the posterior edge of the disc and vertebral body to the most anterior point of the OLF. The foramen diameter is defined as the distance from the posterior edge of the disc and vertebral body to the most superior point of the facet surface. The OLF diameter ratio is calculated as: (OLF diameter)/(foramen diameter). OLF, ossification of the ligamentum flavum.

.https://doi.org/10.3349/ymj.2025.0100

where the normal APD is the average APD measured just above and below the affected segment at levels without ossification but with the widest distance between the pedicles.

AOLF (area of OLF) and AOLF ratio on CT axial image (Fig. 3B)
The AOLF was measured as the cross-sectional AOLF at its thickest point in the axial view. The AOLF ratio was calculated as follows:

AOLF ratio (%)=AOLF/normal canal area×100.

The normal canal area is the average normal canal area just above and below the affected segment where there is no ossification but where the distance between the pedicles is the widest.

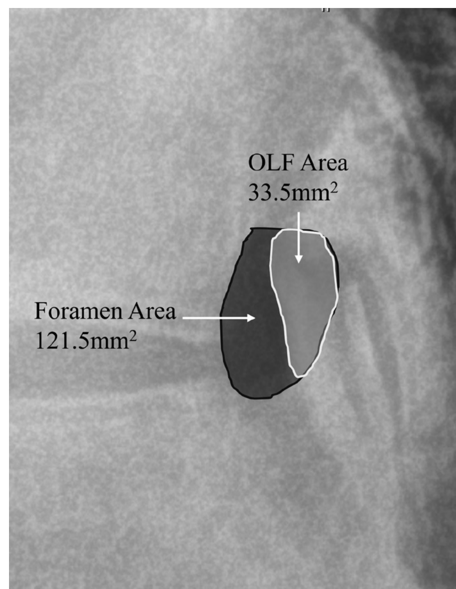

Fig. 2. Measurement methods of OLF area and foramen area on lateral radiograph. The foramen area is the area enclosed by connecting the posterior wall of the vertebral body, the lower margin of the pedicle of the upper vertebral body, the upper margin of the pedicle of the lower vertebral body, and the anterior wall of the facet. The OLF area is defined as the area of OLF extending from the facet surface toward the foramen. The OLF area ratio is calculated as: (OLF area)/(foramen area). OLF, ossification of the ligamentum flavum.

OLF APD, canal ratio on CT axial image (Fig. 3C)
We measured APD of OLF using the paramedian diameter method. This method involves measuring the spinal canal diameter from the midline to the canal boundary at the level of maximum stenosis. The APD ratio was calculated using the formula:

APD ratio (%)=APD/normal APD×100.

Two investigators measured a single radiograph at 150% magnification using Centricity PACS (GE Healthcare, Milwaukee, WI, USA). Interrater reliability, assessed using the intraclass correlation coefficient (ICC), showed correlation coefficients above 0.8 for all measurements except for the Foramen area and OLF area. ICCs were calculated using a two-way random-effects model, based on an absolute agreement definition, to assess inter-rater reliability. The average of the two measurements was used for analysis.

Statistical analysis

Continuous variables were summarized as mean±standard deviation, and categorical variables as n (%). The normality of continuous variables was assessed using the Shapiro–Wilk test,

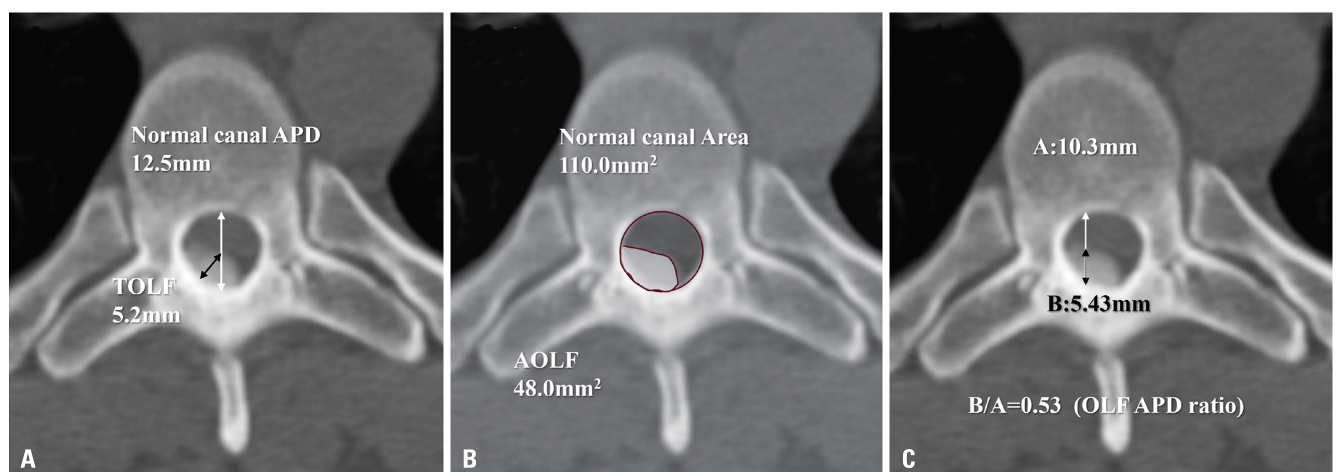

Fig. 3. Various measurement methods of OLF on axial computed tomography images. (A) TOLF: the TOLF is determined by drawing a line along the side of the ligament facing the spinal canal and along the laminar side of the ligament's curvature, recording the thickest point. Normal APD: the average APD measured just above and below the affected segment at levels without ossification, where the distance between the pedicles is widest. (B) AOLF: the cross-sectional AOLF at its thickest point in the axial view. Normal canal area: the average canal area measured just above and below the affected segment where there is no ossification and the distance between the pedicles is widest. (C) OLF APD (antero-posterior) ratio: measurement of the spinal canal diameter from the midline to the canal boundary at the level of maximum stenosis. APD ratio (%)=APD/normal APD×100. OLF, ossification of the ligamentum flavum; TOLF, thickness of OLF; APD, antero-posterior diameter; AOLF, area of OLF.

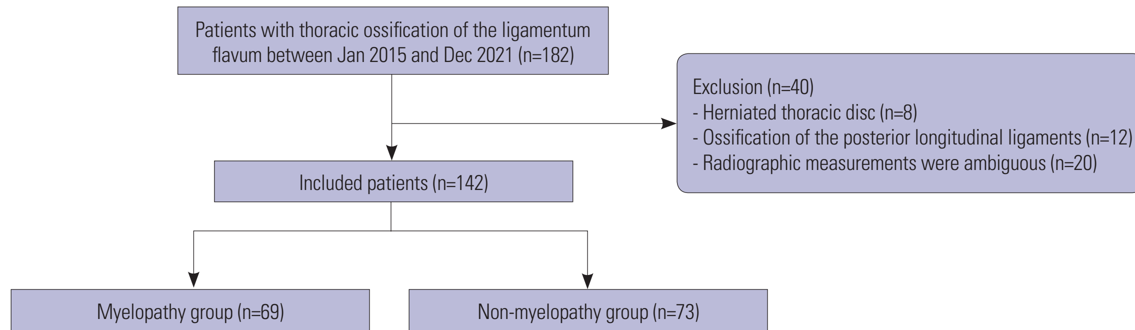

Fig. 4. Flowchart of the patient enrollment process.

Table 1. Patient Demographics of Non-Myelopathy and Myelopathy Groups

	Non-myelopathy (n=73)	Myelopathy (n=69)	*p*
Age (yr)	55.8±12.1	56.9±13.6	0.605
Gender			0.425
Female	29 (39.7)	22 (31.9)	
Male	44 (60.3)	47 (68.1)	
Surgical level			0.454
T7-8	0 (0.0)	1 (1.4)	
T8-9	3 (4.1)	5 (7.2)	
T9-10	17 (23.3)	11 (15.9)	
T10-11	30 (41.1)	30 (43.5)	
T11-12	21 (28.8)	22 (31.9)	
T12-L1	2 (2.7)	0 (0.0)	

Data are presented as mean±standard deviation or n (%).

and all variables were found to follow a normal distribution. Accordingly, Student's t-test was used to compare continuous variables between the myelopathy and non-myelopathy groups, while categorical variables were analyzed using the chi-square test. Pearson correlation analysis was performed to evaluate the relationships among radiographic parameters. For diagnostic performance, receiver operating characteristic (ROC) curves were generated to identify optimal cutoff values using Youden's index (J=sensitivity+specificity-1). The 95% confidence intervals (CIs) for the area under the curve (AUC) and cutoff points were calculated using the DeLong method. Statistical analyses were performed using SPSS version 20 software (IBM Corp., Armonk, NY, USA). All figures and analysis were generated using this software, except for the ROC curves with 95% confidence bands, which were created using Python (version 3.14; Python Software Foundation, Wilmington, DE, USA). This specific visualization and its underlying statistical calculations (including bootstrapping) were performed using the matplotlib and scikit-learn libraries.

RESULTS

A total of 142 patients were included: 69 in the myelopathy group and 73 in the non-myelopathy group (Fig. 4). There were no significant differences between the two groups in terms of age, gender, or surgical level. Among the 142 patients, there was one case at T7-8, eight cases at T8-9, 28 cases at T9-10, 60 cases at T10-11, 43 cases at T11-12, and two cases at T12-L1, indicating a higher concentration of patients in the lower thoracic region (Table 1).

Comparison of CT and X-ray parameters between groups

Interrater reliability for all radiographic parameters was assessed using the ICC, with specific values presented in Table 2. Overall, reliability ranged from good to excellent. Parameters measured on CT demonstrated consistently higher agreement (all ICCs>0.90) compared to those measured on X-ray. X-ray parameters also showed high reliability (most ICCs>0.85), with the exception of OLF area (ICC=0.76) and Foramen area (ICC=0.79), which demonstrated good reliability. In the measurement of OLF diameter on X-ray, the myelopathy group had a significantly larger OLF diameter (5.96±2.93 mm vs. 8.39±2.42 mm, p<0.001) and OLF diameter ratio (0.42±0.33 vs. 0.63±0.15, p<0.001) compared to the non-myelopathy group, while there was no significant difference in foramen diameter (13.35±2.41 mm vs. 13.36±1.61 mm, p=0.977). In the OLF area measurement, no significant differences were observed in OLF area (63.37±45.18 mm^2 vs. 75.17±49.93 mm^2, p=0.141) and foramen area (169.04±47.55 mm^2 vs. 155.29±49.35 mm^2, p=0.093). Using CT-based measurement methods, the myelopathy group had significantly higher values for TOLF, TOLF ratio, AOLF, AOLF ratio, and OLF APD ratio compared to the non-myelopathy group (Table 2).

Correlation of X-ray and CT parameters

The OLF diameter ratio measured on X-ray showed significant moderate correlations with key CT parameters. Specifically, the OLF diameter ratio had a positive correlation with the TOLF ratio (r=0.31, p<0.001), indicating that higher OLF diameter ratios on X-ray are associated with greater transverse ossification seen on CT scans. Additionally, significant correlations were observed between the OLF diameter ratio and both the AOLF ratio (r=0.32, p<0.001) and the OLF APD ratio (r=0.29, p<0.001). These results suggest that the OLF diameter

.https://doi.org/10.3349/ymj.2025.0100

ratio on X-ray accurately reflects the degree of ossification measured by CT, highlighting its value as a non-invasive and easily accessible parameter for assessing the severity of thoracic OLF (Table 3).

Analysis of X-ray and CT parameters for predicting the need for surgical intervention in thoracic OLF

Using ROC curve analysis, we identified the most accurate parameters for distinguishing OLF cases that require surgical intervention. Among the X-ray measurements, the OLF diameter ratio emerged as the most precise parameter, achieving an AUC of 0.817 (95% CI, 0.732–0.902) with a cutoff value of 0.58. This parameter demonstrated a sensitivity of 72.5% and a specificity of 82.2%. This indicates that the OLF diameter ratio measured on X-ray is a reliable and non-invasive metric for predicting the necessity of surgical treatment in patients with thoracic OLF. Among the CT measurements, the TOLF ratio was the most accurate parameter, consistent with findings from previous studies. It achieved an AUC of 0.852 (95% CI, 0.786–0.917) with a cutoff value of 0.425, showing a sensitivity of 75.4% and a specificity of 90.4%. While CT measurements like the TOLF ratio provide high accuracy, the emphasis on the OLF diameter ratio underscores the potential of X-ray measurements as a valuable screening tool due to their accessibility and cost-effectiveness (Fig. 5 and Table 4).

DISCUSSION

The results of this study indicate that the OLF diameter ratio measured on lateral thoracic spine radiographs is an effective parameter for identifying OLF cases that require surgical intervention. We employed two measurement methods on X-rays: one based on the OLF diameter (length) and the other based

Table 2. Comparison of Radiographic Parameters between Groups

	ICC (95% CI)†	Non-myelopathy (n=73)	Myelopathy (n=69)	*p*
X-ray				
OLF diameter (mm)	0.92 (0.88–0.95)	5.96±2.93	8.39±2.42	<0.001*
Foramen diameter (mm)	0.89 (0.85–0.92)	13.35±2.41	13.36±1.61	0.977
OLF diameter ratio	0.94 (0.91–0.96)	0.42±0.33	0.63±0.15	<0.001*
OLF area (mm^2)	0.76 (0.68–0.82)	63.37±45.18	75.17±49.93	0.141
Foramen area (mm^2)	0.79 (0.72–0.84)	169.04±47.55	155.29±49.35	0.093
OLF area ratio	0.85 (0.80–0.89)	0.35±0.23	0.45±0.29	0.020*
CT				
TOLF (mm)	0.96 (0.94–0.98)	5.06±1.49	6.85±1.67	<0.001*
Normal canal APD (mm)	0.95 (0.92–0.97)	14.55±1.15	14.19±1.28	0.085
TOLF ratio	0.97 (0.95–0.98)	0.33±0.10	0.48±0.11	<0.001*
AOLF (mm^2)	0.90 (0.86–0.93)	57.27±20.47	81.91±30.99	<0.001*
Normal canal area (mm^2)	0.91 (0.87–0.94)	192.99±33.60	197.06±41.78	0.522
AOLF ratio	0.93 (0.90–0.95)	0.30±0.10	0.42±0.13	<0.001*
OLF APD ratio	0.92 (0.88–0.95)	0.51±0.17	0.68±0.18	<0.001*

ICC, intraclass correlation coefficient; CT, computed tomography; OLF, ossification of the ligamentum flavum; TOLF, thickness of OLF; APD, anteroposterior canal diameter; AOLF, area of OLF.
Data are presented as mean±standard deviation.
*p<0.05; †ICC values represent interrater reliability. ICCs were calculated using a two-way random-effects model based on an absolute agreement definition.

Table 3. Correlation between Parameters Measured on CT and X-Ray

	X-ray			CT		
	OLF diameter	OLF diameter ratio	OLF area ratio	TOLF ratio	AOLF ratio	OLF APD ratio
X-ray						
OLF diameter	1					
OLF diameter ratio	0.88***	1				
OLF area ratio	0.45***	0.53***	1			
CT						
TOLF ratio	0.31***	0.15	0.07	1		
AOLF ratio	0.32***	0.25***	0.26***	0.58***	1	
OLF APD ratio	0.29***	0.23*	0.17	0.54***	0.62***	1

CT, computed tomography; OLF, ossification of the ligamentum flavum; TOLF, thickness of OLF; APD, anteroposterior canal diameter; AOLF, area of OLF.
*p<0.05; ***p<0.001.

on the OLF size (area). In practice, the length-based OLF diameter method demonstrated high inter-rater reliability, as it used clear reference points such as the facet surface, the posterior margin of the vertebral body, and the endpoint of the OLF. However, measuring the OLF area proved challenging due to the poor visibility of the normal foramen, leading to variability among observers and lower reliability. As a result, we consider the area-based method less suitable as a measurement tool.

Additionally, thoracic radiographs often present measurement challenges, particularly in the upper and mid-thoracic regions, where structures such as ribs can obscure the foramen.[18]

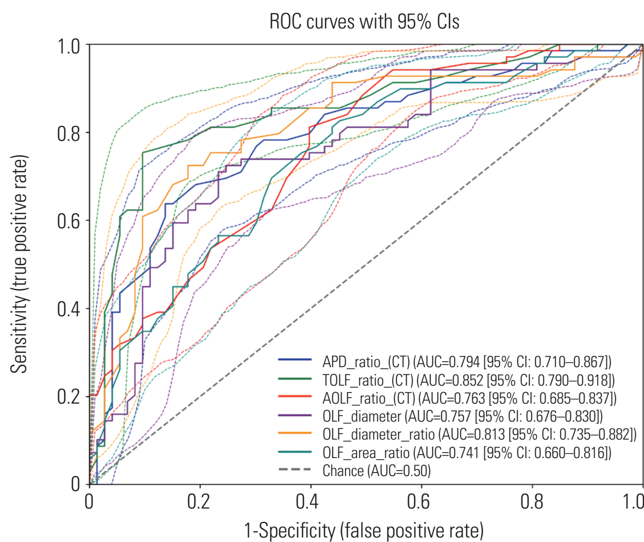

Fig. 5. ROC curves of X-ray and CT parameters for predicting surgical intervention in thoracic OLF. The ROC curves compare the diagnostic performance of different X-ray and CT parameters in predicting the need for surgical intervention in thoracic OLF. The curves display the sensitivity and specificity for each parameter. Among the X-ray parameters, the OLF diameter ratio shows the highest accuracy. For CT parameters, the TOLF ratio demonstrates the best diagnostic performance, as indicated by the AUC. The corresponding dotted lines indicate the 95% CIs, which were calculated using a bootstrapping method. The diagonal dashed line represents the line of no discrimination (AUC=0.50). ROC, receiver operating characteristic; CI, confidence interval; APD, anteroposterior canal diameter; CT, computed tomography; AUC, area under the curve; OLF, ossification of the ligamentum flavum; TOLF, thickness of OLF; AOLF, area of OLF.

Although this measurement method may be limited in those areas, it remains applicable in most cases, as approximately 67% of thoracic OLF lesions occur in the lower thoracic spine. Moreover, when performing lumbar spine radiographs, it is possible to capture the lower thoracic region, indicating that this method has broad clinical applicability. Using CT measurement parameters, we reconfirmed that the parameters from previous studies are highly effective tools for predicting myelopathy.[19,20] As expected, CT measurements demonstrated higher sensitivity, specificity, and AUC values compared to X-rays. Our correlation analysis showed that while X-ray parameters (e.g., OLF diameter ratio) had statistically significant correlations with CT parameters (e.g., AOLF ratio or TOLF ratio), the coefficients were weak to moderate ($r \approx 0.3$–0.4). This suggests that although a relationship exists ($p<0.05$), X-ray values are not reliable proxies for CT values. We interpret this to mean that the 2D (X-ray) and 3D (CT) parameters measure distinct, independent aspects of the complex OLF pathology. Therefore, they provide complementary, rather than redundant, information (Fig. 6).

However, the sensitivities of the OLF diameter and OLF diameter ratio measured on radiographs were both 0.725, which are lower than their specificities of 0.753 and 0.822, respectively. We believe the lower sensitivity compared to specificity can be explained as follows: if the OLF grows thinly along the lateral side toward the foramen, it may appear larger on a lateral radiograph; however, it may be too thin to compress the central spinal cord effectively (Fig. 7). To enable three-dimensional measurement of the OLF, we would need to estimate its actual shape using anterior-posterior (AP) or oblique views. However, in this study, we were unable to devise a measurement method using AP or oblique views. We anticipate that utilizing AP or oblique images could significantly improve sensitivity and specificity, and we believe that this could be achieved through rapidly advancing technologies such as artificial intelligence.[21]

The limitations of this study include the small number of cases in each group, its retrospective and cross-sectional design, and the exclusive use of lateral radiographs. As a result, clinical outcomes were not tracked over time, and although the mJOA score was used to define myelopathy, its individual sub-

Table 4. ROC Curve Analysis of X-Ray and CT Parameters for Predicting the Need for Surgical Intervention in Thoracic OLF

Variables	AUC	*p*	Cutoff value	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
X-ray							
OLF diameter	0.757 (0.675–0.838)	<0.001	7.480	0.725 (0.613–0.821)	0.753 (0.639–0.842)	0.742 (0.629–0.832)	0.746 (0.633–0.835)
OLF diameter ratio	0.817 (0.732–0.902)	<0.001	0.575	0.725 (0.613–0.821)	0.822 (0.711–0.902)	0.808 (0.698–0.892)	0.753 (0.640–0.841)
OLF area ratio	0.764 (0.669–0.858)	<0.001	0.365	0.826 (0.712–0.910)	0.548 (0.421–0.670)	0.664 (0.541–0.768)	0.761 (0.633–0.853)
CT							
TOLF ratio	0.852 (0.786–0.917)	<0.001	0.425	0.754 (0.633–0.848)	0.904 (0.812–0.961)	0.892 (0.786–0.952)	0.781 (0.671–0.870)
AOLF ratio	0.813 (0.739–0.886)	<0.001	0.315	0.812 (0.703–0.889)	0.603 (0.474–0.719)	0.699 (0.579–0.799)	0.733 (0.603–0.830)
OLF APD ratio	0.741 (0.660–0.822)	<0.001	0.625	0.638 (0.512–0.747)	0.863 (0.759–0.933)	0.829 (0.712–0.909)	0.687 (0.566–0.788)

ROC, receiver operating characteristic; AUC, area under the curve; CT, computed tomography; OLF, ossification of the ligamentum flavum; PPV, positive predictive value; NPV, negative predictive value; CI, confidence interval; TOLF, thickness of OLF; APD, anteroposterior canal diameter; AOLF, area of OLF.

.https://doi.org/10.3349/ymj.2025.0100

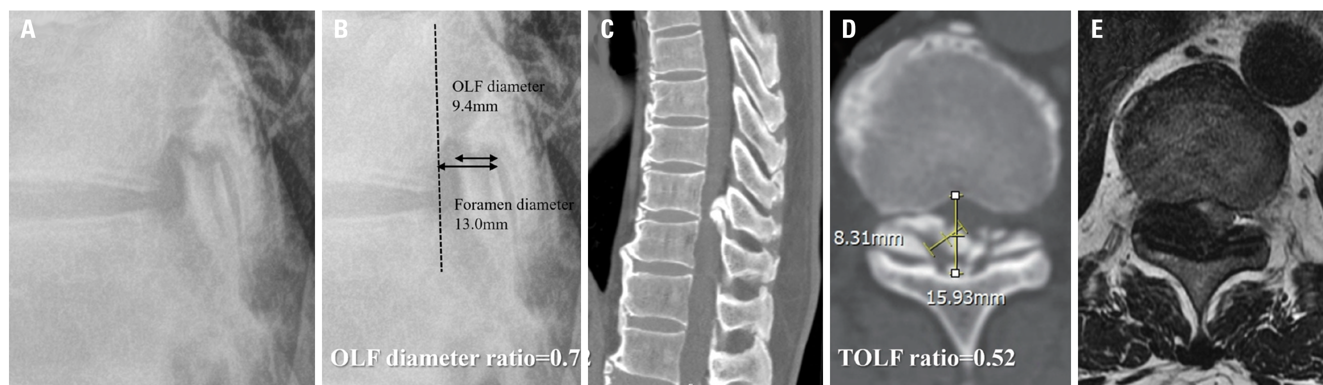

Fig. 6. Illustrative case of the myelopathy group. (A) OLF growing from the facet toward the vertebral body is observed in the T11/12 foramen. (B) The OLF diameter is measured at 9.4 mm, and the foramen diameter is 13.0 mm, resulting in an OLF diameter ratio of 0.72. (C) OLF is clearly visible on the sagittal CT image. (D) On the CT axial image, the TOLF is measured at 8.31 mm, and the canal APD is 15.93 mm, yielding a TOLF ratio of 0.52. (E) The MRI axial image shows significant cord compression and signal changes in the spinal cord. OLF, ossification of the ligamentum flavum; CT, computed tomography; TOLF, thickness of OLF; APD, anteroposterior canal diameter.

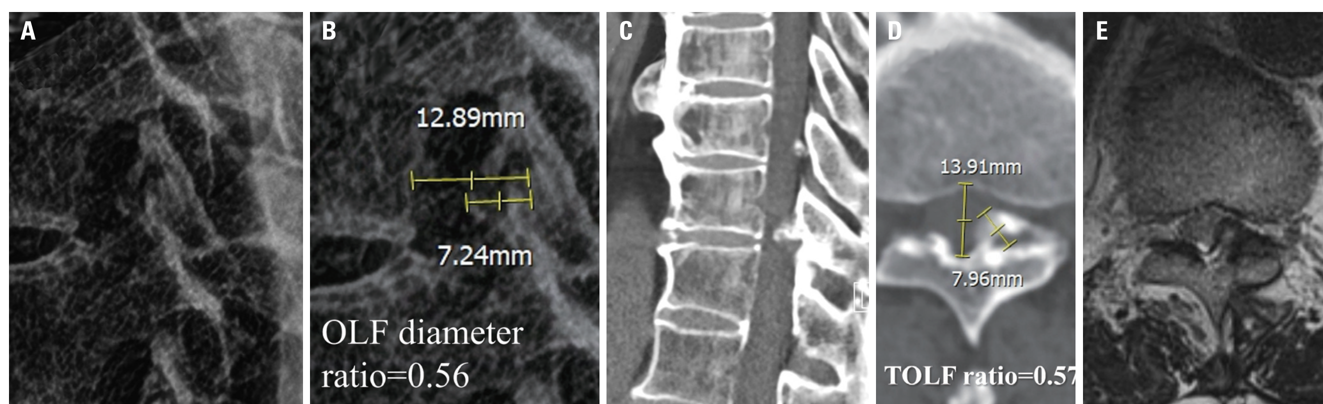

Fig. 7. Illustrative case of the non-myelopathy group with a large OLF diameter ratio. (A) OLF growing from the facet toward the vertebral body is observed in the T10/11 foramen. (B) The OLF diameter is measured at 7.24 mm, and the foramen diameter is 12.89 mm, resulting in an OLF diameter ratio of 0.56. (C) OLF is visible on the sagittal CT image. (D) On the CT axial image, the TOLF is measured at 7.96 mm, and the canal APD is 13.91 mm, yielding a TOLF ratio of 0.57. (E) The MRI axial image shows no cord compression or signal changes, and the patient exhibited no myelopathy symptoms. OLF, ossification of the ligamentum flavum; CT, computed tomography; TOLF, thickness of OLF; APD, anteroposterior canal diameter.

components—motor, sensory, and bladder function—were not separately analyzed. Moreover, clinical parameters such as symptom duration, neurological severity, and postoperative outcomes were not evaluated in relation to radiologic findings. These limitations hinder the ability to directly correlate imaging parameters with functional status or surgical necessity. Further investigation incorporating longitudinal clinical data will be necessary to validate the screening utility of radiographic measurements. Additionally, OLF is known to be more prevalent in Chinese, Japanese, and Korean populations, suggesting the potential involvement of genetic factors.[5,22-24] Since this study was conducted exclusively on Korean patients, its findings may not be generalizable to other ethnic groups. Moreover, the method used in this study may be highly limited in cases of mid-thoracic or upper-thoracic lesions, as other anatomical structures, such as ribs, can obstruct the measurements.

Thoracic radiographs have always faced issues of measurement ambiguity due to structures like ribs, leading to relatively fewer studies on thoracic pathology compared to cervical or lumbar lesions. Our analysis of interrater reliability showed that CT-based parameters yielded higher ICC values than X-ray-based parameters. This finding is expected, given that CT provides superior spatial resolution and cross-sectional views, minimizing the structural overlap that is inherent to 2D radiography. This allows for clearer and more reproducible landmark identification. Notably, the reliability for area measurements (OLF area and Foramen area) on X-ray was lower than for linear or ratio-based measurements. This is likely due to the inherent ambiguity in manually tracing the irregular boundaries of an area on a 2D projection, which is more susceptible to interobserver variability. Nonetheless, all parameters achieved ICC values indicative of good to excellent reliability, confirming the robustness of the measurements used in this study.

However, as revealed in this study, when an OLF occupying more than 58% of the thoracic foraminal AP diameter is observed, there is a 73% sensitivity that myelopathy may be present at that level. Therefore, detailed physical examinations and proactive imaging studies such as CT or MRI should be con-

sidered. More importantly, we consider that accurate medical history-taking, and physical examinations are crucial to avoid missing cases of myelopathy.

In conclusion, in the lower thoracic region, if the OLF diameter on a lateral radiograph is 7.48 mm or greater, or if the OLF diameter ratio is 0.58 or greater, clinicians should suspect the presence of myelopathy due to OLF. In such cases, thorough physical examinations and proactive consideration of additional diagnostic tests are strongly recommended.

AUTHOR CONTRIBUTIONS

Conceptualization: Hyun Jun Jang, Kyung Hyun Kim, and Byung-Jou Lee. Data curation: Hyun Jun Jang, Jeong Yoon Park, and Keun Su Kim. Formal analysis: Hyun Jun Jang, Jeong Yoon Park, and Bong-Ju Moon. Investigation: Hyun Jun Jang, Jeong Yoon Park, and Keun Su Kim. Methodology: Hyun Jun Jang, Kyung Hyun Kim, and Byung-Jou Lee. Project administration: Byung-Jou Lee, Sung Uk Kuh, and Dong Kyu Chin. Resources: Hyun Jun Jang, Jeong Yoon Park, and Keun Su Kim. Supervision: Byung-Jou Lee, Sung Uk Kuh, and Dong Kyu Chin. Validation: Hyun Jun Jang, Jeong Yoon Park, and Bong-Ju Moon. Visualization: Bong-Ju Moon. Writing—original draft: Hyun Jun Jang and Bong-Ju Moon. Writing—review & editing: Byung-Jou Lee, Kyung Hyun Kim, Jin Hoon Park, and Sung Uk Kuh. Approval of final manuscript: all authors.

ORCID iDs

Hyun Jun Jang https://orcid.org/0000-0001-6063-3510
Byung-Jou Lee https://orcid.org/0000-0002-4030-3618
Kyung Hyun Kim https://orcid.org/0000-0002-1338-5523
Jin Hoon Park https://orcid.org/0000-0002-0903-3146
Jeong Yoon Park https://orcid.org/0000-0002-3728-7784
Sung Uk Kuh https://orcid.org/0000-0003-2566-3209
Dong Kyu Chin https://orcid.org/0000-0002-9835-9294
Keun Su Kim https://orcid.org/0000-0002-3384-5638
Bong-Ju Moon https://orcid.org/0000-0003-1681-9734

REFERENCES

1. Ahn DK, Lee S, Moon SH, Boo KH, Chang BK, Lee JI. Ossification of the ligamentum flavum. Asian Spine J 2014;8:89-96.
2. Feng FB, Sun CG, Chen ZQ. Progress on clinical characteristics and identification of location of thoracic ossification of the ligamentum flavum. Orthop Surg 2015;7:87-96.
3. Ehara S, Shimamura T, Nakamura R, Yamazaki K. Paravertebral ligamentous ossification: DISH, OPLL and OLF. Eur J Radiol 1998; 27:196-205.
4. Ikegawa S. Genetics of ossification of the posterior longitudinal ligament of the spine: a mini review. J Bone Metab 2014;21:127-32.
5. Guo JJ, Luk KD, Karppinen J, Yang H, Cheung KM. Prevalence, distribution, and morphology of ossification of the ligamentum flavum: a population study of one thousand seven hundred thirty-six magnetic resonance imaging scans. Spine (Phila Pa 1976) 2010;35:51-6.
6. Moon BJ, Kuh SU, Kim S, Kim KS, Cho YE, Chin DK. Prevalence, distribution, and significance of incidental thoracic ossification of the ligamentum flavum in Korean patients with back or leg pain : MR-based cross sectional study. J Korean Neurosurg Soc 2015; 58:112-8.
7. Fujimori T, Nakajima N, Sugiura T, Ikegami D, Sakaura H, Kaito T, et al. Epidemiology of symptomatic ossification of the posterior longitudinal ligament: a nationwide registry survey. J Spine Surg 2021;7:485-94.
8. Fushimi K, Miyamoto K, Hioki A, Hosoe H, Takeuchi A, Shimizu K. Neurological deterioration due to missed thoracic spinal stenosis after decompressive lumbar surgery: a report of six cases of tandem thoracic and lumbar spinal stenosis. Bone Joint J 2013;95-B:1388-91.
9. Kim BS, Kim J, Koh HS, Han SY, Lee DY, Kim KH. Asymptomatic cervical or thoracic lesions in elderly patients who have undergone decompressive lumbar surgery for stenosis. Asian Spine J 2010;4: 65-70.
10. Pantazis G, Tsitsopoulos P, Bibis A, Mihas C, Chatzistamou I, Kouzelis C. Symptomatic ossification of the ligamentum flavum at the lumbar spine: a retrospective study. Spine (Phila Pa 1976) 2008; 33:306-11.
11. Park JY, Chin DK, Kim KS, Cho YE. Thoracic ligament ossification in patients with cervical ossification of the posterior longitudinal ligaments: tandem ossification in the cervical and thoracic spine. Spine (Phila Pa 1976) 2008;33:E407-10.
12. Takeuchi A, Miyamoto K, Hosoe H, Shimizu K. Thoracic paraplegia due to missed thoracic compressive lesions after lumbar spinal decompression surgery: report of three cases. J Neurosurg 2004; 100:71-4.
13. Lee BJ, Park JH, Jeon SR, Rhim SC, Roh SW. Clinically significant radiographic parameter for thoracic myelopathy caused by ossification of the ligamentum flavum. Eur Spine J 2019;28:1846-54.
14. Kudo S, Ono M, Russell WJ. Ossification of thoracic ligamenta flava. AJR Am J Roentgenol 1983;141:117-21.
15. Kato S, Oshima Y, Oka H, Chikuda H, Takeshita Y, Miyoshi K, et al. Comparison of the Japanese Orthopaedic Association (JOA) score and modified JOA (mJOA) score for the assessment of cervical myelopathy: a multicenter observational study. PLoS One 2015;10:e0123022.
16. Benzel EC, Lancon J, Kesterson L, Hadden T. Cervical laminectomy and dentate ligament section for cervical spondylotic myelopathy. J Spinal Disord 1991;4:286-95.
17. Xu Y, Gao M, Cai Y, Wang Y, Zhijun L, Zhang Y, et al. Anatomic measurement and clinical significance of the middle and lower thoracic segments in normal adults. Int J Morphol 2020;38:1090-5.
18. Wáng YXJ, Du EZ, Gong J, Cheng X. Interpretation of osteoporotic vertebral deformity on frontal view radiographs of the chest and abdomen: a pictorial review. Quant Imaging Med Surg 2021;11:423-42.
19. Hirabayashi S. Ossification of the ligamentum flavum. Spine Surg Relat Res 2017;1:158-63.
20. Hur H, Lee JK, Lee JH, Kim JH, Kim SH. Thoracic myelopathy caused by ossification of the ligamentum flavum. J Korean Neurosurg Soc 2009;46:189-94.
21. Alowais SA, Alghamdi SS, Alsuhebany N, Alqahtani T, Alshaya AI, Almohareb SN, et al. Revolutionizing healthcare: the role of artificial intelligence in clinical practice. BMC Med Educ 2023;23:689.
22. Takeuchi Y, Matsumoto T, Takuwa Y, Hoshino Y, Kurokawa T, Shibuya N, et al. High incidence of obesity and elevated serum immunoreactive insulin level in patients with paravertebral ligamentous ossification: a relationship to the development of ectopic ossification. J Bone Miner Metab 1989;7:17-21.
23. Miyasaka K, Kaneda K, Sato S, Iwasaki Y, Abe S, Takei H, et al. Myelopathy due to ossification or calcification of the ligamentum flavum: radiologic and histologic evaluations. AJNR Am J Neuroradiol 1983;4:629-32.
24. Hanakita J, Suwa H, Nagayasu S, Nishi S, Ohta F, Sakaida H. [Clinical analysis of ossified thoracic ligaments and thoracic disc hernia]. Neurol Med Chir (Tokyo) 1991;31:936-42. Japanese

.https://doi.org/10.3349/ymj.2025.0100