Clinical effect analysis of laminectomy alone and laminectomy with instrumentation in the treatment of TOLF: a multicentre retrospective study

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Research Article

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Abstract

Background To explore the clinical effect of laminectomy alone and laminectomy with instrumentation in the treatment of TOLF.

Methods A retrospective study was conducted on the clinical data of 142 patients with TOLF and laminectomy in the Spine surgery of the XXX Medical University from January 2003 to January 2018. According to whether the laminectomy was combined with instrumentation, the patients were divided into two groups: group A (laminectomy alone LA, n = 77) and group B (laminectomy with instrumentation LI, n = 65). Comparison possible influencing factors of demographic variables and operation-related variables between the two groups. In this study, the clinical effects of laminectomy alone and laminectomy with instrumentation in the treatment of TOLF were discussed. Thus to explore the clinical effect of LA and LI in the treatment of TOLF.

Results In terms of demographics, there was a statistically significant difference in BMI between group A and Group B ($P < 0.05$). The differences in Age, Sex, Smoking, Drinking, Heart disease, Hypertension and Diabetes were not statistically significant (P0.05). In terms of preoperative symptoms, there was significant difference in Gait disturbance, Pain in LE,Urination disorder between group A and group B ($P < 0.05$), but there was no significant difference in other variables between the two groups ($P > 0.05$). In terms of operation-related variables, there was significant difference in Preoperative duration of symptoms, Intramedullary signal change on MRI, Dural ossification, Residual rate of cross-sectional spinal canal area on CT, Shape on the sgittal MRI, Operation time, Pre-mJOA, Post-mJOA at 1 year,Leakage of cerebrospinal fluid between group A and group B ($P < 0.05$), but there was no significant difference in other variables between the two groups ($P > 0.05$). The preoperative average JOA score of group A was 6.37, and that of group B was 5.19. In group A, the average JOA score at 6 months, 1 year and 2 years after surgery was 7.87, 8.23 and 8.26, respectively, and the average JOA score improvement rate was 32.79%, 38.32% and 38.53%, respectively. In group B, the average JOA score at 6 months, 1 year and 2 years after surgery was 7.74, 8.15 and 8.29, respectively, and the average JOA score improvement rate was 39.15%, 46.86% and 47.12%, respectively.

Conclusions Currently, there was no consensus on whether instrumentation is needed after laminectomy for TOLF. We found that for patients with long duration of Gait disturbance, Urination disorder, Preoperative duration of symptoms, Intramedullary signal change on MRI, Dural ossification, Residual rate of cross-sectional spinal canal area on CT less than 60%, Shape on the sgittal MRI as Beak and low Pre-mJOA had better clinical effect after LI than that LA, and the incidence of perioperative complications was lower.

Background

Thoracic Ossification of Ligamentum Flavum (TOLF) is a pathological heterotopic Ossification. The affected Thoracic vertebra is mainly concentrated in the lower Thoracic vertebra, successively T10-11, T9-

10, and T11-12. The Ossification often causes thoracic spinal stenosis and produces the corresponding symptoms of spinal cord compression[1–4]. It is a common cause of thoracic myelopathy [5], with an incidence of 3.8%-26% [6]. According to MRT2-weighted images, the TOLF were classified as beak or round type [7], as shown in Fig. 1. Thoracic OLF is usually ineffective under conservative treatment. Because most of the disease progresses slowly, the thoracic spinal cord nerves have been compressed for a long time and become flattened or even atrophy when obvious symptoms often appear. Therefore, surgical decompression should be performed as soon as possible for patients who are suggested to have thoracic OLF [8]. Early detection, early diagnosis and early treatment are very important to the satisfaction of postoperative efficacy. Traditional open surgery includes posterior laminectomy, laminectomy and laminoplasty, among which laminectomy is widely used and has become one of the classic surgical procedures [9–10]. However, there is no clear standard for the combined application of internal fixation after laminectomy. The purpose of this study was to explore the clinical efficacy analysis of LA and LI in the treatment of TOLF.

Materials And Methods

Inclusion of patients

A retrospective study was conducted on the clinical data of 142 patients with TOLF and laminectomy in the Spine surgery of the XXX Medical University from January 2003 to January 2018. Inclusion criteria: 1. Patients with OLF undergoing laminectomy; 2. Complete clinical data; 3. The last follow-up of two years or more. Exclusion criteria:1. Combined with anterior disc herniation, obvious compression of spinal cord or nerve root; 2. Combined with other spinal cord related diseases;3. Trauma, inflammation, infection, tumor involving the spine; 4. Patients with severe compression of cervical or lumbar nerves. Of the 142 patients included in the study(male 89, female 53). According to whether the laminectomy was combined with instrumentation, the patients were divided into two groups: group A (laminectomy alone LA, n = 77) and group B (laminectomy with instrumentation LI, n = 65).

Ethics Committee of The XXX Medical University approved the study, and written informed consents were obtained from all patients before they were recorded.

Study Variables

Age, Sex, BMI, Smoking, Drinking, Heart disease, Hypertension, and Diabetes were collected by different staffs at the time of admission. Preoperative symptoms (Gait disturbance, Thoracic and back pain, Numbness in LE, Pain in LE, Sensory deficit in LE, Urination disorder, Sense of constriction in thoracic or abdomen) were recorded in the physical examination was performed. Operation-related variables includeed: Preoperative duration of symptoms, OLF segment, Intramedullary signal change on MRI, Dural ossification, Residual rate of cross-sectional spinal canal area on CT, Shape on the sgittal MRI, Operation time, Blood loss, Pre-mJOA, Post-mJOA, JOA improvement rate.

Operation Method

The same group of surgeons performed the operation. The patient was in the prone position under general anesthesia. Monitoring of electromyography and somatosensory evoked potentials during operation was applied. Operation segment confirmed by C-arm fluoroscopy.Make a posterior median incision along the spinous process,the skin and subcutaneous tissue were separated layer by layer, and the structures of spinous process, lamina and articular process were exposed.(For patients underwent laminectomy with instrumentation, pedicle screws were screwed first.)First, the spinous process and the outer layer of the lamina were bited off, and then the lateral lamina were removed by high-speed grinding drill in the longitudinal direction at the inner edge of the facet joints of the bilateral lamina. Then, the interspace of the lamina was enlarged, and the ligaments between the upper and lower spine were removed,and then used a high-speed grinding drill to scan the middle lamina with normal saline flushing, and did not polish each line too deeply until the ossified tissues were eggshell-like translucent. The remaining thin layer of bone was lifted with towelet forceps, and the inner vertebral plate, ossified ligamentum flavum and dural mater were gently probed with nerve exfoliator to see if there was adhesion. If there was no adhesion, the inner vertebral plate and ossified ligamentum flavum would be removed to achieve full decompression. Continued to nibble on both sides to the outer 1/3of the facet joint, exposed both sides of the dural sac, at this time the dural sac could be completely expanded. In this study, 16 patients (4 cases in group A and 12 cases in group B) were found to have heavy adhesion to the dura mater, which could not be separated.

They were resected together and repaired with local fascia.
After decompression was completed, (The patients who underwent laminectomy and internal fixation installed the pre-bent connecting rod on the pedicle screw and tightened and locked it.), rinse the operation field thoroughly, indwelling negative pressure drainage tube, suture the incision layer by layer, and the operation was finished. All patients were routinely treated with antibiotics within 3 days after operation. 7 days after operation, patients were encouraged to wear braces to move under the ground, and brace protection was maintained for about 3 months.

Satisfaction Evaluation

All patients were followed up by outpatient or telephone at 6 months, 1 year, and 2 years postoperatively. The neurological function was evaluated by the Japanese Orthopaedic Association (JOA) score during the follow-up.Thoracic neurological function JOA score (out of 11) was improved by cervical JOA score (out of 17) [11–12], 4 points on dexterity of hands and 2 points on sensation of upper limbs were removed based on cervical JOA score (Table 1). Japanese Orthopaedic Association recovery rates were calculated as follows: [(postoperative JOA score - preoperative JOA score)/(11 - preoperative JOA score)]×100%. Recovery outcome was ranked as excellent(≥ 75%), good(50%-74%), generally(25%-49%), poor(<25%) [10]. During the follow-up, anterior and lateral X-ray and Three-dimensional CT were taken.

Table 1 .
Modified Japanese Orthopaedic Association (JOA) scoring system for the assessment of thoracic myelopathy. (Total score 11 points)

Functional score	
Motor function: lower limb	
0	Unable to walk.
1	Support was needed to walk on flat ground.
2	Need a cane or aid on flat ground.
3	Walking on flat ground or up stairs did not require support, but the lower limbs were not flexible.
4	Normal.
Sensory function: lower limb	
0	Obvious sensory impairment.
1	Mild sensory impairment or numbness.
2	Normal.
Sensory function: Trunk	
0	Obvious sensory impairment.
1	Mild sensory impairment or numbness.
2	Normal.
Bladder function	
0	Uroschesis.
1	Highly dysuria, laborious, irretention or incontinence.
2	Mild dysuria, frequent urination, hesitation in urination.
3	Normal.

Statistical analysis

All statistical analyses were carried out by SPSS software version 22.0 (IBM, Armonk, NY, USA), and the test level was $\alpha = 0.05$.The measurement data between the two groups were compared by independent sample t-test or non-parametric test according to whether they were in line with normal distribution and homogeneity of variance. Analysis of counting data by chi-square test.Significance was accepted for a p value < 0.05.

Results

All 142 patients (89 males and 53 females) were successfully operated. According to whether the laminectomy was combined with instrumentation, the patients were divided into two groups: group A (laminectomy alone LA, n = 77) and group B (laminectomy with instrumentation LI, n = 65).

All patients were followed up for 2 years or more.
In terms of demographics, there was a statistically significant difference in BMI between group A and Group B ($P < 0.05$). The differences in Age, Sex, Smoking, Drinking, Heart disease, Hypertension and Diabetes were not statistically significant ($P > 0.05$)(Table 2). In terms of preoperative symptoms, there

was significant difference in Gait disturbance, Pain in LE,Urination disorder between group A and group B ($P < 0.05$), but there was no significant difference in other variables between the two groups ($P > 0.05$)（Table 3). In terms of operation-related variables, there was significant difference in Preoperative duration of symptoms, Intramedullary signal change on MRI, Dural ossification, Residual rate of cross-sectional spinal canal area on CT, Shape on the sgittal MRI, Operation time, Pre-mJOA, Post-mJOA at 1 year,Leakage of cerebrospinal fluid between group A and group B ($P < 0.05$), but there was no significant difference in other variables between the two groups ($P > 0.05$)（Table 4).

Table 2
The main demographic variables of the patients with TOLF in 2 groups

Characteristics	Group A (n = 77,54.2%)	Group B (n = 65,45.8%)	P value
Age (years)	59.85 ± 8.74	60.44 ± 6.98	0.586
Sex (male/female)	48/29	41/24	0.928
BMI (kg/m^2)(≤27/＞27)	52/25	32/33	0.027*
Smoking (yes/no)	44/33	35/30	0.694
Drinking (yes/no)	46/31	40/25	0.827
Heart disease (yes/no)	27/50	20/45	0.588
Hypertension (yes/no)	35/42	24/41	0.304
Diabetes (yes/no)	19/58	15/50	0.824
BMI:Body Mass Index			
*The difference possessing statistical significance			
*$P < 0.05$			

Table 3
The main Preoperative symptoms of the patients with TOLF in 2 groups

Characteristics	**Group A (n = 77,54.2%)**	**Group B (n = 65,45.8%)**	**P value**
Gait disturbance	31	42	0.004*
Thoracic and back pain	12	11	0.710
Numbness in LE	23	29	0.069
Pain in LE	29	14	0.037*
Sensory deficit in LE	56	45	0.637
Urination disorder	20	32	0.004*
Sense of constriction in thoracic or abdomen	21	23	0.298
LE = lower extremity			
*The difference possessing statistical significance			
*P < 0.05			

Table 4
The related risk factors of the patients with TOLF in 2 groups

Characteristics	**Group A (n = 77,54.2%)**	**Group B (n = 65,45.8%)**	**P value**
Preoperative duration of symptoms(months)	19.17 ± 10.36	26.81 ± 12.14	0.013*
OLF segment			0.987
Upper thoracic(T1–4)	7	6	
Middle thoracic (T5–8)	4	3	
Lower thoracic(T9–12)	66	56	
Intramedullary signal change on MRI			<0.001*
Yes	14	52	
No	63	13	
Dural ossification			0.007*
Yes	4	13	
No	73	52	
Residual rate of cross-sectional spinal canal area on CT			<0.001**
≤60%	19	50	
>60%	58	15	
Shape on the sgittal MRI			0.002*
Beak	45	21	
Round	32	44	
Operation time (min)			<0.001**
≤250	51	17	
>250	26	48	
Blood loss (ml)	493.33 ± 164.39	614.81 ± 193.56	0.013*
Pre-mJOA	6.37 ± 1.59	5.19 ± 1.78	0.010*

mJOA:Modified Japanese Orthopaedic Association

*The difference possessing statistical significance

*P < 0.05,**P = 0.000

Characteristics	Group A (n = 77,54.2%)	Group B (n = 65,45.8%)	P value
Post-mJOA			
At 6 months	7.87 ± 1.17	7.74 ± 1.26	0.697
At 1 year	8.23 ± 1.33	8.15 ± 1.06	0.792
At last follow-up	8.26 ± 1.05	8.29 ± 1.17	0.920
JOA improvement rate			
At 6 months	32.79 ± 20.65	39.15 ± 21.14	0.073
At 1 year	38.32 ± 21.49	46.86 ± 20.69	0.018*
At last follow-up	38.53 ± 20.72	47.12 ± 20.71	0.054
Complications			
Wound infected			0.765
Yes	7	5	
No	70	60	
Delayed wound healing			0.426
Yes	9	5	
No	68	60	
Leakage of cerebrospinal fluid			0.013*
Yes	4	12	
No	73	53	
Neurological deficit	Nil	Nil	
Recurrence	Nil	Nil	
Intercostal pain			0.439
Yes	6	3	
No	71	62	
Thrombosis of lower extremities			0.934

mJOA:Modified Japanese Orthopaedic Association

*The difference possessing statistical significance

*P < 0.05,**P = 0.000

Characteristics	Group A (n = 77,54.2%)	Group B (n = 65,45.8%)	P value
Yes	5	4	
No	72	61	
Others			0.426
Yes	9	5	
No	68	60	
mJOA:Modified Japanese Orthopaedic Association			
*The difference possessing statistical significance			
*P < 0.05,**P = 0.000			

No neurological deterioration occurred in two groups. One patient in group B had no improvement in postoperative symptoms, and the preoperative JOA score was 1. There was severe spinal cord degeneration before operation. During the operation, the ossified ligamentum flavum was removed completely, but the spinal cord function was not significantly improved. The JOA score reached 2 points at the last follow-up. One patient in group A presented progressive aggravation of lower extremity symptoms 12 hours after surgery. Epidural hematoma was considered. After emergency debridement, hormone and dehydration drugs were administered, muscle strength gradually recovered, and the patient recovered to preoperative level 1 month after surgery. Cerebrospinal fluid leakage caused by dural tear in group A (n = 4) and group B (n = 12). The preoperative average JOA score of group A was 6.37, and that of group B was 5.19. In group A, the average JOA score at 6 months, 1 year and 2 years after surgery was 7.87, 8.23 and 8.26, respectively, and the average JOA score improvement rate was 32.79%, 38.32% and 38.53%, respectively. In group B, the average JOA score at 6 months, 1 year and 2 years after surgery was 7.74, 8.15 and 8.29, respectively, and the average JOA score improvement rate was 39.15%, 46.86% and 47.12%, respectively. The preoperative JOA score of group B was significantly lower than that of group A, and the preoperative symptom duration of group B was significantly higher than that of group A. However, the JOA score improvement rate in group B was higher than that in group A during postoperative follow-up, especially at 1 year of follow-up, and the difference between group A and Group B was statistically significant ($P < 0.05$) (Fig. 2, Fig. 3)

Discussion

TOLF is a disease with relatively low incidence,with the advent of aging society, TOLF has become one of the main causes of chronic thoracic spinal cord injury[13–14].TOLF is often slow[8], with the highest incidence among people aged 50 ~ 59, and increases with age[15]. Nearly half of the patients complained of pain and numbness in one or both lower limbs[16], which was similar to the symptoms of lumbar disease. In our study, a total of 43 patients complained of lower limb pain and 52 patients complained of lower limb numbness. And thoracic spinal stenosis is often associated with lumbar spinal stenosis or cervical spondylosis, resulting in complex symptoms and signs of patients, and early diagnosis is sometimes difficult.The incidence and pathogenesis of TOLF in the population are not clear, mainly in Asia, which is more reported in Japan[6, 17–18].Wang et al.[19] analyzed 142 patients with TOLF and found that TOLF was related to systemic ossification disease, spinal load change and aging.The conservative effect of TOLF is poor, its treatment is mainly surgery, and there are many kinds of surgical methods, posterior laminectomy has become the most commonly used classical operation, which can remove the ossified ligamentum flavum while completing the decompression of compressed spinal cord, prevent the further deterioration of spinal cord function and restore it to varying degrees.

However, due to the low prevalence rate, few studies had been reported so far, and the safety and efficacy of different surgical methods in the treatment of secondary thoracic myelopathy to TOLF remain unclear, especially whether combined instrumentation should be used after laminectomy had not been definitively concluded. Pedicle screw internal fixation was first used in the surgical treatment of spinal deformity [20]. According to previous literature report, increased spinal mobility after laminectomy alone could cause slight traction or vibration of the injured spinal cord at the level of OLF, which may compromise the recovery of the injured spinal cord. In addition, increased intervertebral range of motion after laminectomy alone could lead to concentration of mechanical stress at the lesion site, which may result in re-extension of OLF, especially at the level of thoracolumbar junction[21–22].

In this study, 65 patients in group B (45.8%), present Gait disturbance, Urination disorder, Preoperative duration of symptoms, Intramedullary signal change on MRI, Dural ossification, Residual rate of cross-sectional spinal canal area on CT, Shape on the sgittal MRI, Pre-mJOA showed significant difference compared with group A, suggested severe thoracic myelosis [10]. High BMI might also lead to severe ossification due to increased mechanical stress and repetitive mild trauma of thoracolumbar OLF. In patients with severe ossified ligamentum flavum, the spinal cord was fragile, and minor traction or vibrations during intraoperative removal of the ligamentum flavum might lead to severe paralysis. In addition, intraoperative instability caused by extensive laminectomy and an increase in kyphosis after laminectomy had been considered as potential causes for postoperative neurological deterioration (however, there were no cases of kyphosis during the follow-up period of this study) [23]. Last but not least, it has been reported that application of instrumentation after laminectomy dose good to postoperative recovery of the injured spinal cord due to thoracic myelopathy, and prevents re-extension of OLF[24–25]. In our study, we found that the JOA score improvement rate of group B at 1 year follow-up was significantly different from that of group A. This might be because the spinal activity of group B had little interference with postoperative spinal cord recovery. These results showed that laminectomy with instrumentation had a significant clinical effect on myelopathy caused by severe ossification of ligamentum flavum. Especially for TOLF patients with extensive laminectomy.

Laminectomy with instrumentation for TOLF is a major development trend. There were some limitations in this study.First, the maximum time limit of neurological recovery after ossification of ligamentum flavum in thoracic vertebrae is not clear, and the follow-up period of 2 years in our study may be insufficient.Second,this study is a retrospective study, and it is a single-center and small sample size study, and the sample size is small, so we look forward to a large sample size and multi-center study to further confirm our conclusions. Despite these limitations, we believed that this study had important guidance in clinical work, especially in the implementation of surgical procedures.

Conclusions

Currently, there was no consensus on whether instrumentation is needed after laminectomy for TOLF. We found that for patients with long duration of Gait disturbance, Urination disorder, Preoperative duration of symptoms, Intramedullary signal change on MRI, Dural ossification, Residual rate of cross-sectional spinal canal area on CT less than 60%, Shape on the sgittal MRI as Beak and low Pre-mJOA had better clinical effect after LI than that LA, and the incidence of perioperative complications was lower.

Abbreviations

TOLF: Thoracic ossification of ligamentum flavum; **LA**:laminectomy alone; **LI**:laminectomy with instrumentation; **CT**:Computed Tomography; **MRI**:Magnetic Resonance Imaging; **mJOA**:Modified Japanese Orthopaedic Association.

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Ethics Board of the 3rd Hospital of Hebei Medical University.

The written informed consent was obtained from all patients included in this study.

Competing interests

The authors declare that they have no competing interests.

Funding

Not applicable.

Authors' contributions

DLY conceived and designed the study. ZWW, ZW and YHZ collected Data.WYD and DLY set up the dataset.DLY,WZW and JYS analyzed the data. ZWW wrote the paper. All authors read and approved the final manuscript.

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Not applicable.

References

1. Inamasu J, Guiot BH. A review of factors predictive of surgical outcome for ossification of the ligamentum flavum of the thoracic spine. J Neurosurg Spine. 2006;5(2):133–139.
2. Kawaguchi Y, Yasuda T, Seki S, et al. Variables affecting postsurgical prognosis of thoracic myelopathy caused by ossification of the ligamentum flavum. Spine J. 2013;13(9):1095–1107.
3. Yayama T, Uchida K, Kobayashi S, et al. Thoracic ossification of the human ligamentum flavum: histopathological and immunohistochemical findings around the ossified lesion. J Neurosurg Spine. 2007;7(2):184–193.
4. Ono K, Yonenobu K, Miyamoto S, Okada K. Pathology of ossification of the posterior longitudinal ligament and ligamentum flavum. Clin Orthop Relat Res. 1999;(359):18–26.
5. 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(8):1846–1854.
6. 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(1):51–56.
7. Kuh SU, Kim YS, Cho YE, et al. Contributing factors affecting the prognosis surgical outcome for thoracic OLF. Eur Spine J. 2006;15(4):485–491.
8. Shiokawa K, Hanakita J, Suwa H, Saiki M, Oda M, Kajiwara M. Clinical analysis and prognostic study of ossified ligamentum flavum of the thoracic spine. J Neurosurg. 2001;94(2 Suppl):221–226.
9. Zhao Y, Xue Y, Shi N, et al. The CT and intraoperative observation of pedicel-ossification tunnel in 151 cases of thoracic spinal stenosis from ossification of ligamentum flavum. Eur Spine J. 2014;23(6):1325–1331.
10. Kang KC, Lee CS, Shin SK, Park SJ, Chung CH, Chung SS. Ossification of the ligamentum flavum of the thoracic spine in the Korean population. J Neurosurg Spine. 2011;14(4):513–519.
11. Yukawa Y, Kato F, Ito K, et al. Postoperative changes in spinal cord signal intensity in patients with cervical compression myelopathy: comparison between preoperative and postoperative magnetic resonance images. J Neurosurg Spine. 2008;8(6):524–528.
12. Sato T, Kokubun S, Tanaka Y, Ishii Y. Thoracic myelopathy in the Japanese: epidemiological and clinical observations on the cases in Miyagi Prefecture. Tohoku J Exp Med. 1998;184(1):1–11.
13. Kow CY, Chan P, Etherington G, Rosenfeld JV. Acute traumatic cord injury associated with ossified ligamentum flavum. J Clin Neurosci. 2016;30:165–166.
14. 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(2):112–118.

15. Lang N, Yuan HS, Wang HL, et al. Epidemiological survey of ossification of the ligamentum flavum in thoracic spine: CT imaging observation of 993 cases. Eur Spine J. 2013;22(4):857–862.
16. Fujimoto K, Kanchiku T, Imajo Y, et al. Neurologic findings caused by ossification of ligamentum flavum at the thoracolumbar junction. J Spinal Cord Med. 2017;40(3):316–320.
17. Ben Hamouda K, Jemel H, Haouet S, Khaldi M. Thoracic myelopathy caused by ossification of the ligamentum flavum: a report of 18 cases. J Neurosurg. 2003;99(2 Suppl):157–161.
18. Ahn DK, Lee S, Moon SH, Boo KH, Chang BK, Lee JI. Ossification of the ligamentum flavum. Asian Spine J. 2014;8(1):89–96.
19. Wang Z L, Yuan H F, Ding H Q, et al.The clinical causes of the thoracic ossification of ligamentum flavum. Chinese Journal of Surgery. 2006;44(20):1376–1380.
20. Bao H, Shu S, Yan P, et al. Fifteen Years and 2530 Patients: The Evolution of Instrumentation, Surgical Strategies, and Outcomes in Adolescent Idiopathic Scoliosis in a Single Institution. World Neurosurg. 2018;120:e24-e32.
21. Kanno H, Takahashi T, Aizawa T, Hashimoto K, Itoi E, Ozawa H. Recurrence of ossification of ligamentum flavum at the same intervertebral level in the thoracic spine: a report of two cases and review of the literature. Eur Spine J. 2018;27(Suppl 3):359–367.
22. Ando K, Imagama S, Ito Z, et al. Progressive relapse of ligamentum flavum ossification following decompressive surgery. Asian Spine J. 2014;8(6):835–839.
23. Wang H, Ma L, Xue R, et al. The incidence and risk factors of postoperative neurological deterioration after posterior decompression with or without instrumented fusion for thoracic myelopathy. Medicine (Baltimore). 2016;95(49):e5519.
24. Yamazaki M, Okawa A, Fujiyoshi T, Furuya T, Koda M. Posterior decompression with instrumented fusion for thoracic myelopathy caused by ossification of the posterior longitudinal ligament. Eur Spine J. 2010;19(5):691–698.
25. Ando K, Imagama S, Ito Z, et al. Predictive factors for a poor surgical outcome with thoracic ossification of the ligamentum flavum by multivariate analysis: a multicenter study. Spine (Phila Pa 1976). 2013;38(12):E748-E754.

Figures

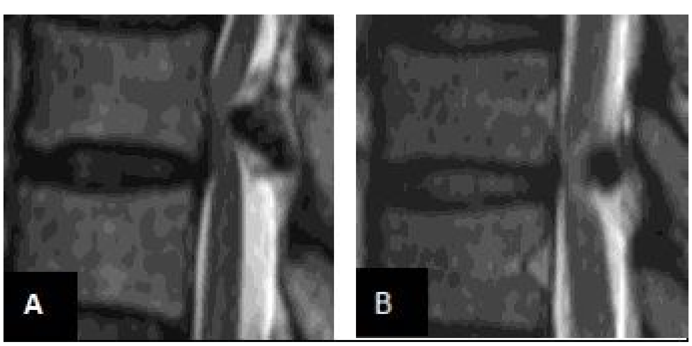

Figure 1

The shape on the sgittal MRI of TOLF. Sagittal T2-weighted MR images demonstrating morphological classifications of TOLF: A beak type and B round type.

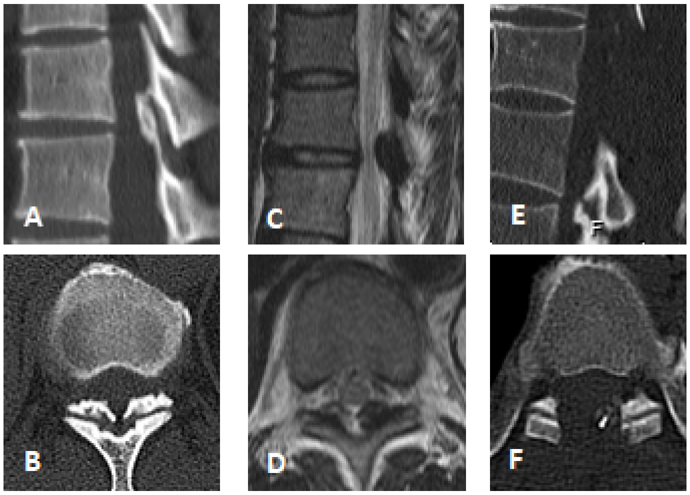

Figure 2

Laminectomy alone. A 55-year-old female patient, ossification of ligamentum flavum and compression degeneration of spinal cord could be seen on CT (figure A, B) and MRI (figure C, D) before operation. We performed OLF resection with LA (Fig. E, F). During the 2-year follow-up, the preoperative JOA score increased from 7 to 8.5 (JOA score improvement rate was 37.5%).

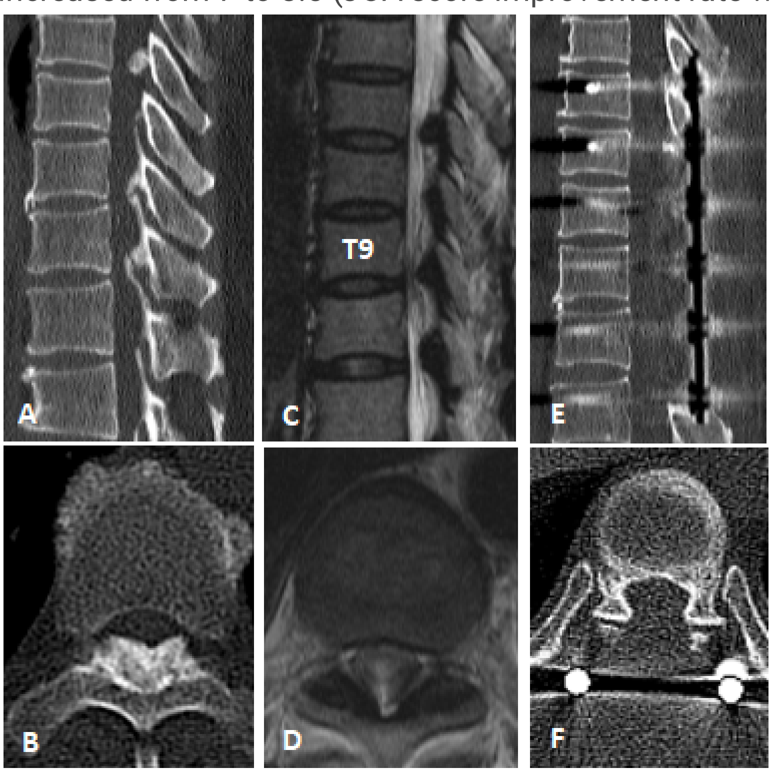

Figure 3

Laminectomy with instrumentation. A 62-year-old male patient, ossification of ligamentum flavum and compression degeneration of spinal cord were seen in CT (figure A, B) and MRI (figure C, D) before operation. We performed OLF resection with LI (Fig. E, F). During the 2-year follow-up, the preoperative JOA score increased from 4 to 8 (JOA score improvement rate was 57.1%).