Anterior decompression and posterior total laminectomy with fusion for ossification of the cervical posterior longitudinal ligament

analysis of more than ten-year follow-up outcomes: a retrospective cohort study

From Shanghai Changzheng Hospital, Shanghai, China

Correspondence should be sent to X. Chen
cxsorthopedics@163.com

Cite this article:
Bone Jt Open 2024;5(9):
768–775.

DOI: 10.1302/2633-1462.
59.BJO-2024-0041.R1

K. Chen,[1] X. Dong,[2,3] Y. Lu,[4] J. Zhang,[5] X. Liu,[6] L. Jia,[7] Y. Guo,[8] X. Chen[7,9]

[1]Department of Orthopaedics, Shanghai Changhai Hospital, Second Military Medical University, Shanghai, China
[2]Orthopedics Department, Changde Hospital, Xiangya School of Medicine, Central South University (The First People's Hospital of Changde City), Changde, China
[3]Department of Orthopaedics, Suzhou Dushu Lake Hospital, Dushu Lake Hospital Affiliated to Soochow University, Medical Center of Soochow University, Suzhou, China
[4]Department of Anaesthesiology Operating Room, Changzheng Hospital, Shanghai, China
[5]Department of Spinal Surgery Jining First People's Hospital, Shandong First Medical University, Jining, China
[6]Department of Orthopaedics, Shanghai Jing'an District Zhabei Central Hospital, Shanghai, China
[7]Spine Center, Department of Orthopaedics, Shanghai Changzheng Hospital, Second Military Medical University, Shanghai, China
[8]Department of Orthopaedics, The No. 928 hospital of Joint Logistic Support Force, Shanghai, China
[9]Shanghai First Hospital, Shanghai Jiao Tong University, Shanghai, China

Aims

Surgical approaches to cervical ossification of the posterior longitudinal ligament (OPLL) remain controversial. The purpose of the present study was to analyze and compare the long-term neurological recovery following anterior decompression with fusion (ADF) and posterior laminectomy and fusion with bone graft and internal fixation (PLF) based on > ten-year follow-up outcomes in a single centre.

Methods

Included in this retrospective cohort study were 48 patients (12 females; mean age 55.79 years (SD 8.94)) who were diagnosed with cervical OPLL, received treatment in our centre, and were followed up for 10.22 to 15.25 years. Of them, 24 patients (six females; mean age 52.88 years (SD 8.79)) received ADF, and the other 24 patients (five females; mean age 56.25 years (SD 9.44)) received PLF. Clinical data including age, sex, and the OPLL canal-occupying ratio were analyzed and compared. The primary outcome was Japanese Orthopaedic Association (JOA) score, and the secondary outcome was visual analogue scale neck pain.

Results

Compared with the baseline, neurological function improved significantly after surgery in all patients of both groups ($p < 0.001$). The JOA recovery rate in the ADF group was significantly higher than that in the PLF group ($p < 0.001$). There was no significant difference in postoperative cervical pain between the two groups ($p = 0.387$). The operating time was longer and intraoperative blood loss was greater in the PLF group than the ADF group.

Bone & Joint Open

More complications were observed in the ADF group than in the PLF group, although the difference was not statistically significant.

Conclusion

Long-term neurological function improved significantly after surgery in both groups, with the improvement more pronounced in the ADF group. There was no significant difference in postoperative neck pain between the two groups. The operating time was shorter and intraoperative blood loss was lower in the ADF group; however, the incidence of perioperative complications was higher.

Take home message

- Both anterior decompression with fusion (ADF) and posterior laminectomy and fusion (PLF) have been shown to be effective approaches in improving postoperative neurological function for patients with ossification of the posterior longitudinal ligament over ten years.
- ADF may provide better neurological recovery compared with PLF, especially for patients with a canal-occupying ratio ≥ 50%.
- The perioperative complication rate within ADF was higher than PLF, but this difference was not statistically significant.

Introduction

Ossification of the posterior longitudinal ligament (OPLL) of the cervical spine is a common degenerative disease often resulting in spinal cord and nerve compression, and eventually neurological dysfunction.[1,2] The incidence of cervical OPLL in Asians is higher than that in Caucasians,[3] although the prevalence in Caucasians tends to increase more gradually.[4] Conservative therapy is usually recommended for most OPLL patients with no or mild neurological symptoms.[5] However, for patients who develop myelopathy as OPLL progresses, timely surgery is often required.[6–8]

There is no consensus of opinions about the optimal surgical approach for cervical OPLL.[9] Anterior decompression and fusion (ADF) can provide direct decompression on the spinal cord and stabilize the diseased segments.[7,10–12] However, the surgical procedure of ADF is complex and requires high surgical skills.[13] Posterior laminectomy and fusion with bone graft and internal fixation (PLF) is technically less complex, with a relatively low complication rate, but it is often associated with poorer recovery of neurological function due to indirect decompression,[7,14,15] especially for patients with a canal-occupying ratio (COR) of ≥ 50%.[15]

Although several previous studies have compared the clinical outcomes of OPLL patients after ADF and PLF, their follow-up periods are relatively short,[16,17] and it is therefore unclear which surgical approach – ADF or PLF – is more effective in improving long-term postoperative neurological function in OPLL patients. The purpose of the present study was to compare long-term surgical outcomes of ADF and PLF for the treatment of OPLL based on the clinical data obtained from more than ten-year clinical practices and follow-up observations, in the hope that our summary could provide useful suggestions in selecting an optimal surgical treatment for individual OPLL patients.

Methods

Consecutive OPLL patients who underwent surgery at our institution (Shanghai Changzheng Hospital) from November 2008 to December 2013 were included in the study. With informed consent from patients or their guardians, patient data were obtained from the electronic medical record database of Changzheng Hospital, a tertiary care hospital in Shanghai City, China. The study protocol was approved by the Ethics Committee of Changzheng Hospital and the Institutional Review Board by following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) for cohort studies. Patients with incomplete clinical data, histories of cervical surgery, compression involving the thoracic cord, and/or receiving a combined anterior and posterior approach were excluded. Altogether, 48 patients (12 females) were included in this study, with a mean age of 55.79 years (SD 8.94). They were followed up by telephone or through clinical outpatient interviews (Figure 1). The distribution of the number of cases of ossification in different segments is shown in Figure 2.

Surgical procedures

The choice of surgical approach was decided by at least two spinal surgeons (XSC, LSJ) after comprehensive considerations of the imaging and clinical findings. ADF was preferred for patients with segmental or localized-type OPLL, and PLF was preferred for patients who were indicated for a posterior surgical approach, especially in OPLL patients with cumulative C2 or more than three segments. In general, ADF was the preferred surgical approach for patients with OPLL, although PLF was chosen if the patient preferred it. All surgical procedures were performed under general anaesthesia as previously described.[18]

ADF was performed with the patient laid in a supine position. A right cervical transverse incision was made to expose the anterior aspect of the vertebral body. The OPLL was excised with a vertebral plate biting forceps and/or a high-speed burr after removal of the disc and/or vertebral body. The cervical spine was the reconstructed using a titanium (Ti) mesh or cage, and internally fixed with the Ti plate and screw system. The cervical spine was immobilized using a neck collar for three months postoperatively. The level of decompression and fusion was determined based on preoperative imaging and neurological findings.

PLF was performed with the patient laid in a prone position, and laminectomy was performed with internal fixation and fusion. Internal fixation was generally performed from C3 to C6 using lateral mass screws, and C2 and C7 were usually fixed with pedicle screws.[18] In one patient from the PLF group, C2 was fixed using isthmus screws, and the spinous process and bilateral laminae of C3-6 (with or without C2 or C7 when necessary) were removed (Figure 3). Finally, the cervical

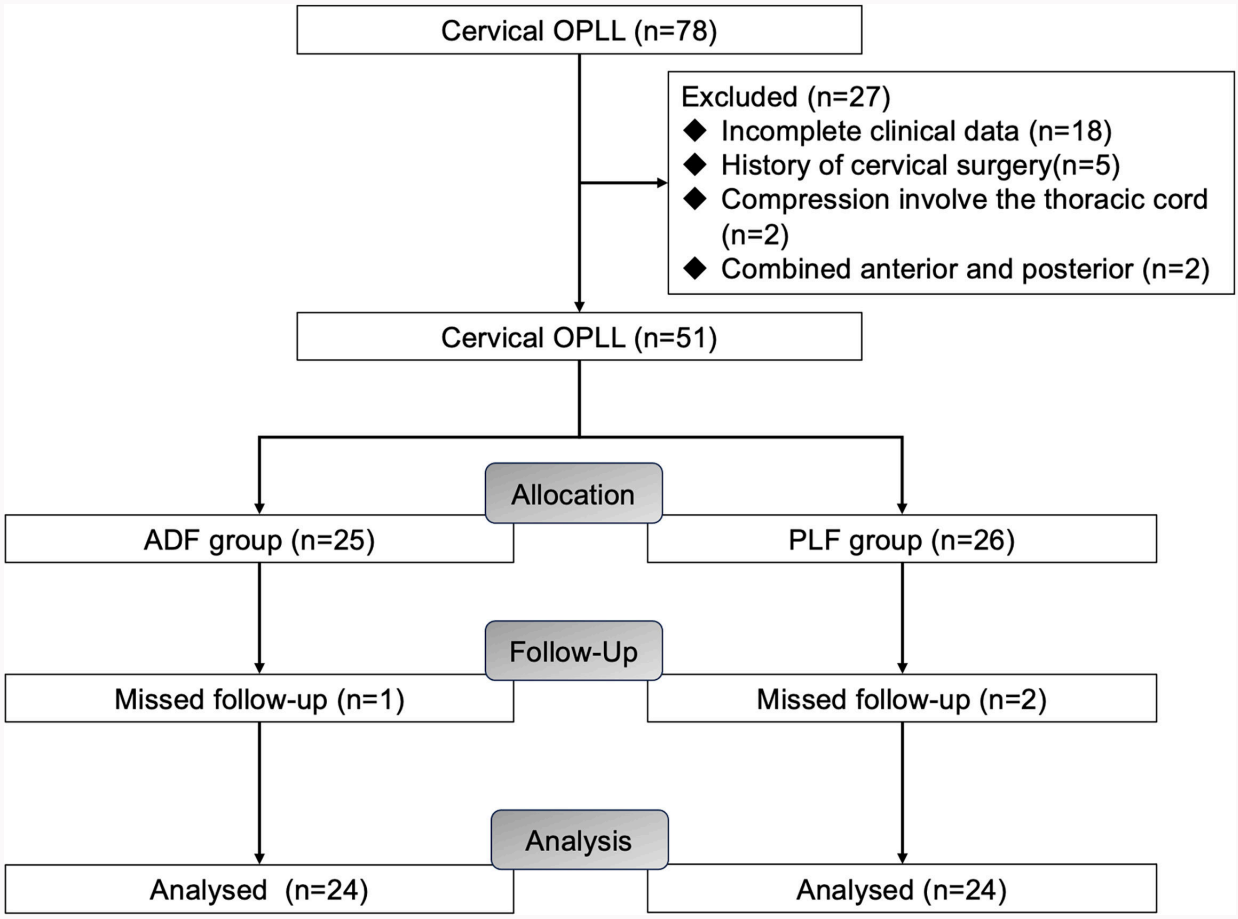

Fig. 1
Enrolment, cohort, treatment, and follow-up processes of the study. ADF, anterior decompression with fusion; OPLL, ossification of the posterior longitudinal ligament; PLF, posterior laminectomy with fusion.

spine was immobilized using a neck collar for three months postoperatively.

All patients received intravenous 500 mg methylprednisolone and proton pump inhibitors for gastric protection, and second-generation cephalosporins for anti-infection, as well as postoperative symptomatic management.

All surgeons involved had received standardized surgical training in our institution for at least four to five years until they became proficient in performing ADF and PLF, including correct identification of the scope of OPLL resection, modification of the margins after laminectomy, and the technique of submerged decompression of the resected vertebral body or upper and lower segments of the lamina. Preoperative surgical planning and subsequent practice were performed by a team comprising two to three surgeons, a nurse, and an anaesthetist. The quality of surgery was monitored and controlled by the senior surgeons (XSC, LSJ) with in the same team to avoid or minimize variability between different surgeons.

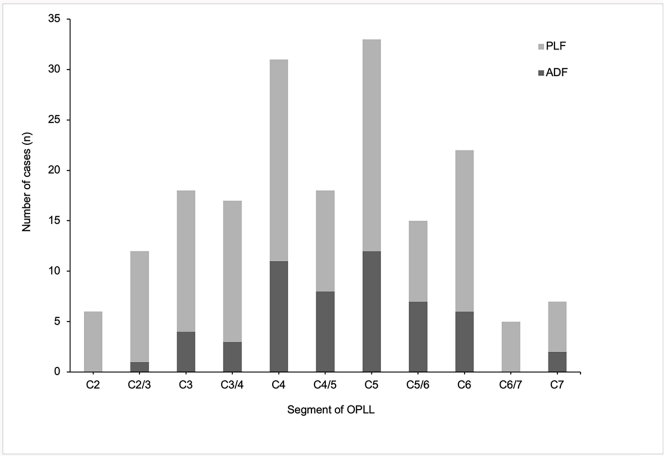

Fig. 2
Cases of ossification of the posterior longitudinal ligamen (OPLL) in different cervical segments in anterior decompression with fusion (ADF) and posterior laminectomy with fusion (PLF) groups.

Outcome measurement

The primary outcome of neurological recovery was evaluated using the Japanese Orthopaedic Association (JOA)[18] score by using the following equation: JOA Recovery Rate (JOA RR) (%) = (Postoperative JOA - Preoperative JOA)/(17 - Preoperative JOA)×100%,[19] in which JOA RR ≥ 75% is defined as excellent, 50 to 74% as good, 25 to 49% as fairly good, and < 25% as poor.[20] Data were analyzed in subgroups according to whether the COR was ≥ 50%. JOA scores and JOA recovery rates were compared between patients with COR < 50% or COR ≥ 50%, respectively. The secondary outcome of postoperative axial

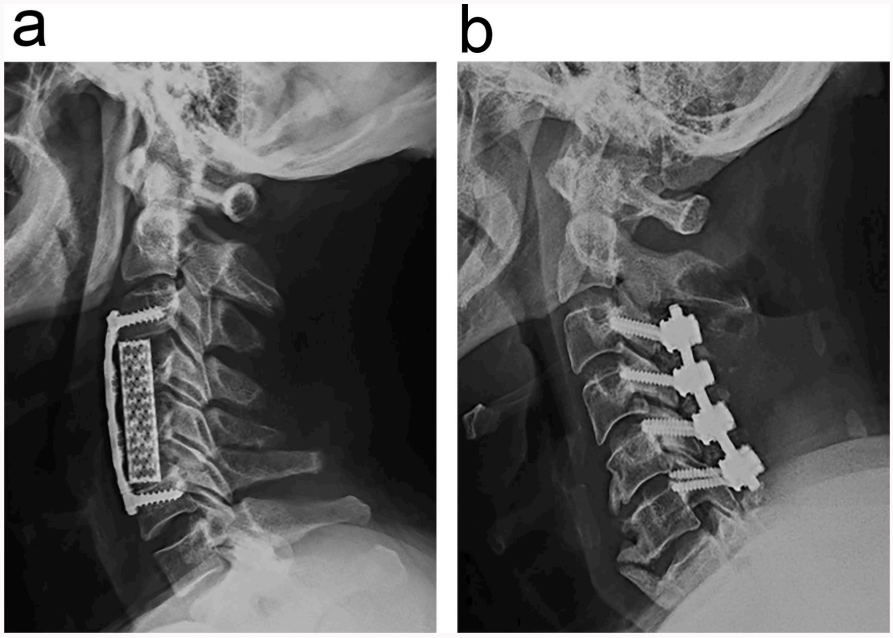

Fig. 3
Lateral radiographs after a) anterior decompression with fusion (49-year-old male two days postoperatively) and b) posterior laminectomy with fusion (47-year-old male two days postoperatively).

neck symptoms was evaluated using the visual analogue scale (VAS). Operating time, intraoperative blood loss, and perioperative complications were evaluated and compared between the two groups. The primary outcome data were collected by telephone or through outpatient clinical interviews. All included patients had been followed up for at least ten years before initiation of the study.

Statistical analysis

Count data are expressed as frequency, and quantitative data are expressed as the mean and SD. Count data were analyzed by chi-squared test or Fisher's exact test, and quantitative data were analyzed by independent-samples *t*-test. Differences with a p-value ≤ 0.05 were considered statistically significant. All statistical analyses of data were performed by R software v. 4.2.1 (R Foundation for Statistical Computing, Austria).

Results

There was no statistically significant difference in age, sex, BMI, number of K-line (-) cases, time of symptom onset, spinal canal occupancy, hypertension, diabetes, smoking, alcohol consumption, preoperative JOA score, preoperative VAS score, OPLL spinal COR, and the follow-up duration between ADF and PLF groups (Table I).

The operating time in ADF group was significantly shorter than that of the PLF group ($p < 0.001$, independent-samples *t*-test), and there was also less intraoperative blood loss in ADF group ($p = 0.038$, independent-samples *t*-test) (Table II). Neurological symptoms improved substantially in both groups. The results of independent-samples *t*-test showed that the follow-up JOA scores were significantly higher than the preoperative JOA scores in both groups ($p < 0.001$). The postoperative JOA scores in patients of the ADF group were significantly higher than those in the PLF group ($p = 0.002$), and the postoperative JOA recovery rate in patients of the ADF group was also significantly higher than that in patients of the PLF group ($p < 0.001$). According to the final JOA recovery rate, excellent results were achieved in 11 cases, good results in six cases, fairly good results in six cases, and a poor result in one case in the ADF group, versus one, nine, 12, and two cases, respectively, in the PLF group (excellent + good vs fairly good + poor in both groups; $p = 0.042$, chi-squared test) (Table II). Postoperative axial symptoms were evaluated by VAS score, showing no significant difference between the two groups ($p = 0.387$, independent-samples *t*-test). In addition, no significant difference was observed in VAS score reduction between the two groups ($p = 0.724$, independent-samples *t*-test) (Table II). However, postoperative VAS scores were significantly lower than the preoperative VAS scores in both ADF and PLF groups (both $p < 0.001$, independent-samples *t*-test). The length of hospital stay in ADF group was significantly shorter than that of the PLF group ($p = 0.477$, independent-samples *t*-test) (Table II).

For cases with COR < 50%, the final JOA score and JOA recovery rate in the ADF group were both higher than those in the PLF group. In cases with COR ≥ 50%, the JOA recovery rate in the ADF group was higher than that in the PLF group (Table III).

The incidence of perioperative complications in the ADF group was insignificantly higher than that in the PLF group ($p = 0.120$, chi-squared test). In the ADF group, cerebrospinal fluid (CSF) leakage happened in three cases, internal fixation dislodgement or subsidence in two cases without the need for revision surgery, haematoma in two cases, dysphagia in two cases, and Horner syndrome in one case. In PLF group, C5 palsy occurred in four cases, and infection in one case. Except for the four cases of C5 palsy in PLF group, no postoperative neurological deterioration or injury to the vertebral artery occurred in any other patients (Table IV).

Table I. Demographic details of the included patients.

Characteristic	ADF (n = 24)	PLF (n = 24)	p-value
Mean age, yrs (SD)	52.88 (8.79)	56.25 (9.44)	0.206*
Gender, n (M/F)	18/6	19/5	0.731†
Mean BMI, kg/m² (SD)	24.49 (2.43)	25.75 (3.32)	0.141*
K-line, n (+/-)	17/7	18/6	0.745†
Mean duration of symptoms, mths (SD)	17.51 (22.73)	25.10 (34.60)	0.374*
Mean COR (SD)	44.14 (11.39)	49.35 (11.83)	0.127*
Hypertension, n (%)	5 (20.83)	10 (41.67)	0.119†
DM, n (%)	1 (4.17)	5 (20.83)	0.190‡
Smoking, n (%)	13 (54.17)	9 (37.5)	0.247†
Drinking, n (%)	7 (29.17)	6 (2)	0.745†
Mean follow-up, yrs (SD)	12.40 (1.47)	11.82 (1.35)	0.163*
Mean preoperative VAS score (SD)	3.79 (1.10)	4.13 (1.30)	0.342*
Mean preoperative JOA score (SD)	8.46 (3.08)	8.96 (3.41)	0.596*
Classification of OPLL, n (%)			
Segmental	11 (45.83)	4 (16.67)	
Continuous	3 (12.5)	6 (25)	
Localized	7 (29.17)	0 (0)	
Mixed	3 (12.5)	14 (58.33)	

*Independent-samples *t*-test.
†Chi-squared test.
‡Fisher's exact test.
ADF, anterior decompression with fusion; COR, canal-occupying ratio; DM, diabetes mellitus; JOA, Japanese Orthopaedic Association; OPLL, ossification of the posterior longitudinal ligament; PLF, posterior laminectomy with fusion; VAS, visual analogue scale.

Table II. Surgical outcomes.

Outcome	ADF (n = 24)	PLF (n = 24)	p-value
Mean operating time, mins (SD)	169.63 (24.82)	230.63 (45.04)	< 0.001*
Mean intraoperative blood loss, ml (SD)	231.25 (190.43)	411.25 (365.34)	0.038*
Mean postoperative JOA score (SD)	14.58 (2.32)	12.38 (2.39)	0.002*
Mean JOA RR, % (SD)	70.90 (26.91)	42.78 (16.62)	< 0.001*
JOA RR outcome: excellent and good/ fairly good and poor, n	17/7	10/14	0.042†
Mean postoperative VAS score (SD)	1.75 (0.68)	1.96 (0.95)	0.387*
Mean VAS score reduction (SD)	2.04 (1.04)	2.17 (1.37)	0.724*
Mean length of hospital stay, days (SD)	8.46 (5.57)	10.00 (8.93)	0.477*

*Independent-samples *t*-test.
†Chi-squared test.
ADF, anterior decompression with fusion; PLF, posterior laminectomy with fusion; JOA, Japanese Orthopaedic Association; RR, recovery rate; VAS, visual analogue scale.

Discussion

The optimal treatment for cervical OPLL is controversial, and a focus of current research.[21,22] There are advantages and disadvantages to both the anterior and posterior approaches. Anterior surgery may provide direct relief of compression on the spinal cord, which can theoretically prevent further progression of the ossification and the possibility of recompression of the spinal cord.[18] The anterior approach is generally considered better than the posterior approach in terms of neurological recovery.[4] However, anterior approach surgery requires more complex surgical skills and runs a higher risk of complications.[23,24] The posterior approach, by contrast, requires relatively simple techniques, but postoperative neurological recovery is not as good as that of the anterior approach because the ossified material remains in situ.[15,18,21,25] According to the long-term follow-up reports in the literature, the neurological function may be reduced in patients receiving posterior surgery, which may require a second-stage anterior surgery.[19,26] Our previous prospective comparative studies have also shown that the anterior approach is significantly more effective than the posterior approach, especially in OPLL patients with at least 50% canal occupancy.[15,18]

It has been shown that PLF can provide long-term stability of the cervical spine,[17,27,28] improve the functional prognosis, and avoid cervical deformity of OPLL patients.[27] In addition, PLF can also reduce deterioration of cervical OPLL.[17] Although most previous studies have demonstrated that PLF is a more suitable option for the treatment of large-scale OPLL, few have discussed the long-term surgical outcomes of these surgical approaches for OPLL based on follow-up data beyond ten years. In the present study, we analyzed and compared neurological improvement between ADF and PLF for OPLL based on our > ten-year postoperative follow-up data. The mean follow-up period was 12.4 years (SD 1.47) for the ADF group and 11.82 years (SD 1.35) for the PLF group.

Our study found that ossified material spinal canal occupancy was 46.74% (mean COR 44.14 (SD 11.39)) in the ADF group and 49.35 (SD 11.83) in the PLF group; p = 0.127), and COR was greater than 50% in 22 cases (45.83%). All patients in this study had severe compression of the OPLL. The patient baseline data in the ADF and PLF groups were comparable (Table I), and all patients achieved good postoperative neurological recovery. The mean postoperative JOA score in the ADF group was significantly higher than that of the PLF group (14.58 vs 12.38, p = 0.002). Based on the JOA score, the mean JOA RR in the ADF group was significantly higher than that of the PLF group (70.9% vs 42.78%, p < 0.001). For patients with a COR ≥ 50%, the JOA RR was also significantly higher in the ADF group, which is in line with the finding of our prospective study (68.1% JOA RR in the ADF group and 38.39% JOA RR in the PLF group),[18] indicating that both ADF and PLF can effectively improve the long-term postoperative

Table III. Surgical outcomes stratified by canal-occupying ratio.

Characteristic	Mean preoperative JOA score (SD)	Mean postoperative JOA score (SD)	Mean JOA RR (SD)
COR < 50%			
ADF (n = 15)	9.07 (3.01)	15.13 (1.85)	73.14 (27.53)
PLF (n = 9)	8 (4.09)	11.89 (3.06)	45.04 (16.27)
p-value	0.470*	0.004*	0.011*
COR ≥ 50%			
ADF (n = 9)	7.44 (3.09)	13.67 (2.83)	67.17 (27.02)
PLF (n = 15)	9.53 (2.92)	12.67 (1.95)	41.43 (17.24)
p-value	0.111*	0.316*	0.009*

*Independent-samples *t*-test.
ADF, anterior decompression with fusion; COR, canal-occupying ratio; JOA, Japanese Orthopaedic Association; PLF, posterior laminectomy with fusion; RR, recovery rate.

Table IV. Complications.

Complications, n (%)	ADF (n = 24)	PLF (n = 24)	p-value
Total	10 (41.67)	5 (20.83)	0.120*
CSF leakage	3 (12.5)	0	0.234†
C5 palsy	1 (4.17)	4 (16.67)	0.348†
Hoarseness	2 (8.33)	0	0.489†
IF dislodgement or subsidence	2 (8.33)	0	0.489†
Haematoma	1 (4.17)	0	> 0.999†
Dysphagia	1 (4.17)	0	> 0.999†
Infection	0	1 (4.17)	> 0.999
Neurological deterioration	0	0	-
Vertebral artery injury	0	0	-

*Chi-squared test.
†Fisher's exact test.
ADF, anterior decompression with fusion; PLF, posterior laminectomy with fusion; CSF, cerebrospinal fluid; IF, internal fixation.

neurological prognosis of OPLL patients, although ADF is superior to PLF in this respect.

Postoperative neck pain was significantly lower than the preoperative baseline value in both ADF and PLF groups (both $p < 0.001$), showing no significant difference between the two groups ($p = 0.387$). Injury to the cervical paraspinal muscles after posterior approach cervical spine surgery may lead to postoperative axial neck pain. Some short-term studies reported that postoperative pain after posterior approach surgery was significantly higher than that after ADF.[17] However, according to our long-term follow-up result, this progressive improvement in pain tended to be comparable to anterior cervical surgery and significantly better than preoperatively. This is mainly because most PLF patients who were included in our study underwent laminectomy and C3-6 internal fixation with submerged decompression below the C2 and C7 plates. This surgical method avoids causing damage to the cervical muscles in C2 and C7 areas, without affecting the thoracic spine.

Another advantage of ADF over PLF is the shorter operating time ($p < 0.001$) and less intraoperative blood loss ($p = 0.038$). This may be because anterior approach surgery requires less time to expose the surgical site and suture than the posterior approach, and the intraoperative bleeding is significantly lower due to less muscle damage. The mean length of hospital stay in the ADF group was shorter than that in the PLF group, but without a statistically significant difference ($p = 0.477$).

A disadvantage of ADF is the relatively high perioperative complication rate compared with PLF ($p = 0.120$). A 2011 systematic review also reported a higher rate of anterior complications compared to posterior surgery.[29] In the present study, CSF leakage was the most common complication in the ADF group. This is primarily because approximately 13% to 15% of OPLL lesions are adherent to the dural sac.[23,30] Intraoperative resection of the ossified material may result in CSF leakage due to dural sac injury. CSF leakage recovered in all cases after application of an artificial spinal dura and postoperative compression dressing; there was no CSF leakage in the PLF group. No intraspinal infection occurred, nor was secondary surgery performed in any case. Hoarseness may be related to laryngeal nerve or tracheal traction irritation. Postoperative hoarseness in two patients improved within three months naturally. Postoperative infection in one patient from the PLF group recovered after conservative treatment. The number of C5 palsy cases after PLF was higher than that after ADF, but the exact mechanism is unclear. All patients with C5 palsy recovered within two years postoperatively. The occurrence of complications did not affect patients' neurological recovery, nor did it significantly increase the length of hospital stay or postoperative patient satisfaction, although it is important to minimize and avoid these complications in ADF surgery. ADF may induce postoperative oedema of the retropharyngeal tissues, leading to severe dysphagia and respiratory complications.[31] PLF may prove to be a preferable option for elderly patients, patients who receive multisegmental surgery, patients with comorbid respiratory disorders, and smokers.[17]

The present study has some limitations. First, it is a retrospective observational study that compared the clinical outcomes after ADF and PLF without a randomized group, which may lead to some selective bias. Larger multicentre prospective randomized studies are required to eliminate this bias. In addition, it is not possible to exclude the impact of different surgeons on the overall outcome, since surgery was performed by multiple surgeons during the > ten-year period, despite the highly standardized surgical procedures in our institution.

Despite these limitations, we believe that this is one of the longest follow-up case studies, covering a mean follow-up period of 12.11 years, which is rarely seen in cervical OPLL surgical research.

Both ADF and PLF have been demonstrated as effective approaches in improving long-term postoperative neurological function in OPLL patients. ADF may provide better neurological recovery compared with PLF, especially in

patients with COR ≥ 50%. The incidence of postoperative neck pain is comparable between ADF and PLF. The perioperative complication rate in the ADF group was higher than that in the PLF group, although the difference was not statistically significant. All these results indicate that ADF is superior to PLF for the treatment of OPLL patients with neurological symptoms, while PDF may prove preferable for patients who are at high risk of anterior-related complications. Further larger-scale and multicentre prospective randomized studies are still needed to verify the findings and conclusion of the present study.

References

1. **Head J**, **Rymarczuk G**, **Stricsek G**, **et al**. Ossification of the posterior longitudinal ligament: surgical approaches and associated complications. *Neurospine*. 2019;16(3):517–529.
2. **Koyanagi I**, **Iwasaki Y**, **Hida K**, **Imamura H**, **Fujimoto S**, **Akino M**. Acute cervical cord injury associated with ossification of the posterior longitudinal ligament. *Neurosurgery*. 2003;53(4):887–891.
3. **Matsunaga S**, **Sakou T**. Ossification of the posterior longitudinal ligament of the cervical spine: etiology and natural history. *Spine (Phila Pa 1976)*. 2012;37(5):E309–14.
4. **Kalb S**, **Martirosyan NL**, **Perez-Orribo L**, **Kalani MYS**, **Theodore N**. Analysis of demographics, risk factors, clinical presentation, and surgical treatment modalities for the ossified posterior longitudinal ligament. *Neurosurg Focus*. 2011;30(3):E11.
5. **Yoshii T**, **Morishita S**, **Egawa S**, **et al**. Prospective investigation of surgical outcomes after anterior decompression with fusion and laminoplasty for the cervical ossification of the posterior longitudinal ligament: a propensity score matching analysis. *J Clin Med*. 2022;11(23):7012.
6. **Ogawa Y**, **Toyama Y**, **Chiba K**, **et al**. Long-term results of expansive open-door laminoplasty for ossification of the posterior longitudinal ligament of the cervical spine. *J Neurosurg Spine*. 2004;1(2):168–174.
7. **Iwasaki M**, **Okuda S**, **Miyauchi A**, **et al**. Surgical strategy for cervical myelopathy due to ossification of the posterior longitudinal ligament: part 2: advantages of anterior decompression and fusion over laminoplasty. *Spine (Phila Pa 1976)*. 1976;32(6):654–660.
8. **Le HV**, **Wick JB**, **Van BW**, **Klineberg EO**. Ossification of the posterior longitudinal ligament: pathophysiology, diagnosis, and management. *J Am Acad Orthop Surg*. 2022;30(17):820–830.
9. **Mizuno J**, **Nakagawa H**. Outcome analysis of anterior decompressive surgery and fusion for cervical ossification of the posterior longitudinal ligament: report of 107 cases and review of the literature. *Neurosurg Focus*. 2001;10(4):E6.
10. **Matsuoka T**, **Yamaura I**, **Kurosa Y**, **Nakai O**, **Shindo S**, **Shinomiya K**. Long-term results of the anterior floating method for cervical myelopathy caused by ossification of the posterior longitudinal ligament. *Spine (Phila Pa 1976)*. 2001;26(3):241–248.
11. **Yoshii T**, **Hirai T**, **Sakai K**, **et al**. Anterior cervical corpectomy and fusion using a synthetic hydroxyapatite graft for ossification of the posterior longitudinal ligament. *Orthopedics*. 2017;40(2):e334–e339.
12. **Meyer SA**, **Wu J-C**, **Mummaneni PV**. Laminoplasty outcomes: is there a difference between patients with degenerative stenosis and those with ossification of the posterior longitudinal ligament? *Neurosurg Focus*. 2011;30(3):E9.
13. **Boody BS**, **Lendner M**, **Vaccaro AR**. Ossification of the posterior longitudinal ligament in the cervical spine: a review. *Int Orthop*. 2019;43(4):797–805.
14. **Ogawa Y**, **Chiba K**, **Matsumoto M**, **et al**. Long-term results after expansive open-door laminoplasty for the segmental-type of ossification of the posterior longitudinal ligament of the cervical spine: a comparison with nonsegmental-type lesions. *J Neurosurg Spine*. 2005;3(3):198–204.
15. **Sakai K**, **Okawa A**, **Takahashi M**, **et al**. Five-year follow-up evaluation of surgical treatment for cervical myelopathy caused by ossification of the posterior longitudinal ligament: a prospective comparative study of anterior decompression and fusion with floating method versus laminoplasty. *Spine (Phila Pa 1976)*. 2012;37(5):367–376.
16. **Yoshii T**, **Morishita S**, **Inose H**, **et al**. Comparison of perioperative complications in anterior decompression with fusion and posterior decompression with fusion for cervical ossification of the posterior longitudinal ligament: propensity score matching analysis using a nation-wide inpatient database. *Spine (Phila Pa 1976)*. 2020;45(16):E1006–E1012.
17. **Yoshii T**, **Sakai K**, **Hirai T**, **et al**. Anterior decompression with fusion versus posterior decompression with fusion for massive cervical ossification of the posterior longitudinal ligament with a ≥50% canal occupying ratio: a multicenter retrospective study. *Spine J*. 2016;16(11):1351–1357.
18. **Cao B**, **Chen J**, **Yuan B**, **et al**. Comparison of the outcome after anterior cervical ossified posterior longitudinal ligament en bloc resection versus posterior total laminectomy and fusion in patients with ossification of the cervical posterior longitudinal ligament: a prospective randomized controlled trial. *Bone Joint J*. 2023;105-B(4):412–421.
19. **Kawaguchi Y**, **Nakano M**, **Yasuda T**, **Seki S**, **Hori T**, **Kimura T**. Anterior decompressive surgery after cervical laminoplasty in patients with ossification of the posterior longitudinal ligament. *Spine J*. 2014;14(6):955–963.
20. **Fujimori T**, **Iwasaki M**, **Okuda S**, **et al**. Long-term results of cervical myelopathy due to ossification of the posterior longitudinal ligament with an occupying ratio of 60% or more. *Spine (Phila Pa 1976)*. 2014;39(1):58–67.
21. **Feng F**, **Ruan W**, **Liu Z**, **Li Y**, **Cai L**. Anterior versus posterior approach for the treatment of cervical compressive myelopathy due to ossification of the posterior longitudinal ligament: a systematic review and meta-analysis. *Int J Surg*. 2016;27:26–33.
22. **Zhang J**, **Liang Q**, **Qin D**, **et al**. The anterior versus posterior approach for the treatment of ossification of the posterior longitudinal ligament in the cervical spine: a systematic review and meta-analysis. *J Spinal Cord Med*. 2021;44(3):340–349.
23. **Belanger TA**, **Roh JS**, **Hanks SE**, **Kang JD**, **Emery SE**, **Bohlman HH**. Ossification of the posterior longitudinal ligament. Results of anterior cervical decompression and arthrodesis in sixty-one North American patients. *J Bone Joint Surg Am*. 2005;87-A(3):610–615.
24. **Fujiyoshi T**, **Yamazaki M**, **Kawabe J**, **et al**. A new concept for making decisions regarding the surgical approach for cervical ossification of the posterior longitudinal ligament: the K-line. *Spine (Phila Pa 1976)*. 2008;33(26):E990–3.
25. **Chiba K**, **Ogawa Y**, **Ishii K**, **et al**. Long-term results of expansive open-door laminoplasty for cervical myelopathy--average 14-year follow-up study. *Spine (Phila Pa 1976)*. 2006;31(26):2998–3005.
26. **Tokuhashi Y**, **Ajiro Y**, **Umezawa N**. A patient with two re-surgeries for delayed myelopathy due to progression of ossification of the posterior longitudinal ligaments after cervical laminoplasty. *Spine (Phila Pa 1976)*. 2009;34(2):E101–5.
27. **Anderson PA**, **Matz PG**, **Groff MW**, **et al**. Laminectomy and fusion for the treatment of cervical degenerative myelopathy. *J Neurosurg Spine*. 2009;11(2):150–156.
28. **Lee CH**, **Lee J**, **Kang JD**, **et al**. Laminoplasty versus laminectomy and fusion for multilevel cervical myelopathy: a meta-analysis of clinical and radiological outcomes. *J Neurosurg Spine*. 2015;22(6):589–595.
29. **Liu T**, **Xu W**, **Cheng T**, **Yang HL**. Anterior versus posterior surgery for multilevel cervical myelopathy, which one is better? A systematic review. *Eur Spine J*. 2011;20(2):224–235.
30. **Mizuno J**, **Nakagawa H**, **Matsuo N**, **Song J**. Dural ossification associated with cervical ossification of the posterior longitudinal ligament: frequency of dural ossification and comparison of neuroimaging modalities in ability to identify the disease. *J Neurosurg Spine*. 2005;2(4):425–430.
31. **Singh K**, **Marquez-Lara A**, **Nandyala SV**, **Patel AA**, **Fineberg SJ**. Incidence and risk factors for dysphagia after anterior cervical fusion. *Spine (Phila Pa 1976)*. 2013;38(21):1820–1825.

Author information

K. Chen, MD, Orthopaedic Surgeon, Department of Orthopaedics, Shanghai Changhai Hospital, Second Military Medical University, Shanghai, China.

X. Dong, MD, Research Fellow, Orthopedics Department, Changde Hospital, Xiangya School of Medicine, Central South University (The First People's Hospital of Changde City), Changde, China; Department of Orthopaedics, Suzhou Dushu Lake Hospital, Dushu Lake Hospital Affiliated to Soochow University, Medical Center of Soochow University, Suzhou, China.

Y. Lu, MB, Research Fellow, Department of Anaesthesiology Operating Room, Changzheng Hospital, Shanghai, China.

J. Zhang, MM, Research Fellow, Department of Spinal Surgery Jining First People's Hospital, Shandong First Medical University, Jining, China.

X. Liu, MM, Research Fellow, Department of Orthopaedics, Shanghai Jing'an District Zhabei Central Hospital, Shanghai, China.

L. Jia, MD, Orthopaedic Surgeon, Spine Center, Department of Orthopaedics, Shanghai Changzheng Hospital, Second Military Medical University, Shanghai, China.

Y. Guo, MD, Research Fellow, Department of Orthopaedics, The No. 928 hospital of Joint Logistic Support Force, Shanghai, China.

X. Chen, MD, Orthopaedic Surgeon, Spine Center, Department of Orthopaedics, Shanghai Changzheng Hospital, Second Military Medical University, Shanghai, China; Shanghai First Hospital, Shanghai Jiao Tong University, Shanghai, China.

Author contributions

K. Chen: Data curation, Formal analysis, Writing – original draft, Investigation.
X. Dong: Data curation, Formal analysis, Visualization.
Y. Lu: Data curation, Visualization, Writing – original draft.
J. Zhang: Data curation.
X. Liu: Formal analysis.
L. Jia: Supervision.
Y. Guo: Conceptualization, Funding acquisition.
X. Chen: Conceptualization, Resources, Supervision, Writing – review & editing.

K. Chen, X. Dong, and Y. Lu are joint first authors.

Funding statement

The authors disclose receipt of the following financial or material support for the research, authorship, and/or publication of this article: this work was supported by Key R & D Projects in Hainan Province (ZDYF2023SHFZ127).

ICMJE COI statement

The authors disclose receipt of the following financial or material support for the research, authorship, and/or publication of this article: this work was supported by Key R & D Projects in Hainan Province (ZDYF2023SHFZ127).

Data sharing

The data that support the findings for this study are available to other researchers from the corresponding author upon reasonable request.

Acknowledgements

We thank Professor Shunxing Zhang for the time spent reviewing our manuscript to make corrections or revisions in terms of the English grammar, syntax, and wording.

Ethical review statement

This study protocol was approved by the ethics committee of Changzheng Hospital, Shanghai, China.

Open access funding

The open access fee for this article was funded by Key R & D Projects in Hainan Province (ZDYF2023SHFZ127).