How to Avoid Postoperative Remaining Ossification Mass in Anterior Controllable Antedisplacement and Fusion Surgery

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■ OBJECTIVES: **To retrospectively review the cases with ossification of the posterior longitudinal ligament (OPLL) treated with anterior controllable antedisplacement and fusion (ACAF). Patients with postoperative remaining ossification mass (PROM) are analyzed to figure out the causes and preventions of this problem.**

■ METHODS: **A total of 115 patients were included. PROM was identified as remaining OPLL existed in the spinal canal other than included in the vertebral-OPLL complex on postoperative computed tomography. The Japanese Orthopaedic Association scoring system was used to evaluate the neurologic status. Surgery-related complications such as cerebrospinal fluid (CSF) leakage and spinal cord or nerve injury were all recorded. The patients with the PROM group and those without the PROM group were compared.**

■ RESULTS: **There were 14 patients with wide-base OPLL (12.2%) and 10 patients (8.7%) with PROM among the 115 patients with OPLL. The 10 patients with PROM were all with wide-base OPLL. The average improvement rate of Japanese Orthopaedic Association score in patients without PROM was significantly larger than that in patients with PROM (69.5 ± 22.6% vs. 36.7 ± 22.0, $P < 0.01$). Incidence rate of postoperative CSF leakage and neural deterioration were significantly higher in patients with PROM than that in patients without PROM (CSF leakage, 40.0% vs. 5.9%; neural deterioration, 50.0% vs. 3.0%). No other complications were observed.**

■ CONCLUSIONS: **The occurrence of PROM might cause complications and poor neural function recovery in patients treated with ACAF. Surgical techniques should be noted to avoid PROM in ACAF surgery.**

INTRODUCTION

Ossification of the posterior longitudinal ligament (OPLL) of the cervical spine has been recognized as a common cause of cervical myelopathy. There are many decompression techniques reported as the surgical treatment for OPLL, which can be divided into anterior and posterior decompression strategies. However, the surgical management of OPLL continues to be controversial. Compared with a posterior decompression strategy, techniques with the anterior approach were reported to be more efficient in neural function recovery when dealing with K-line (−) patients.[1] However, the incidence rate of complications was reported to be higher than that of posterior decompression surgery.[2]

We have previously reported a novel technique named anterior controllable antedisplacement and fusion (ACAF) as an alternative anterior decompression strategy for the treatment of OPLL, which has gained satisfactory outcomes.[3,4]

Key words
- Anterior controllable antedisplacement and fusion
- Complication
- Ossification of the posterior longitudinal ligament
- Postoperative remaining ossification mass
- Wide-base OPLL

Abbreviations and Acronyms
ACAF: Anterior controllable antedisplacement and fusion
CSF: Cerebrospinal fluid
CT: Computed tomography
IR: Improvement rate
JOA: Japanese Orthopaedic Association
MRI: Magnetic resonance imaging
OPLL: Ossification of the posterior longitudinal ligament
PROM: Postoperative remaining ossification mass
VOC: Vertebral-OPLL complex
WBO: Wide-base OPLL

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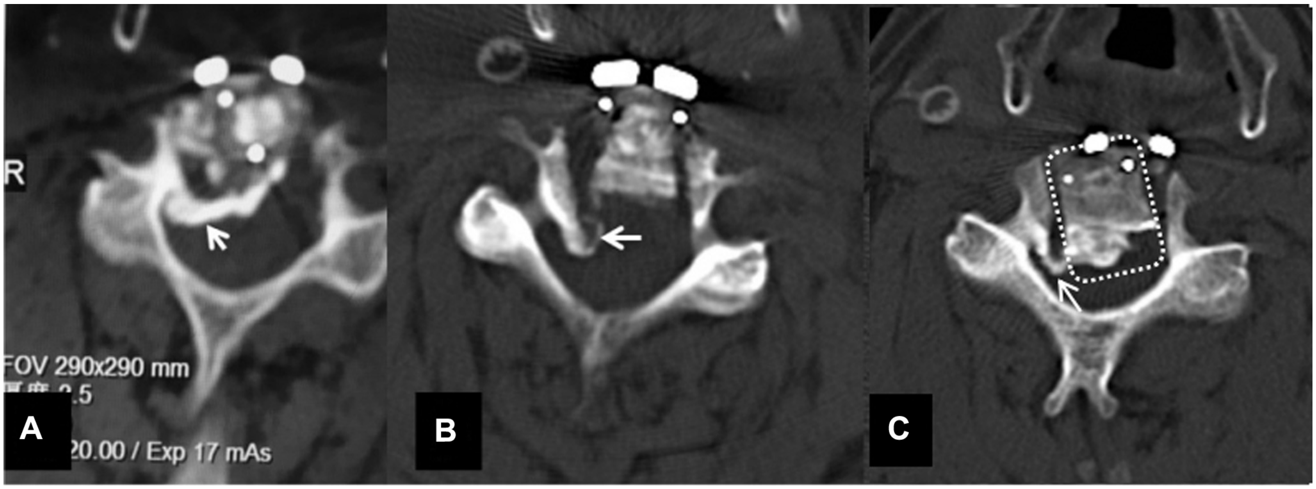

Figure 1. Cross-sectional computed tomography of cases with remaining ossification mass in the cervical canal. The *arrows* indicate the postoperative remaining ossification mass in the spinal canal (**A** and **B**). The *dashed line* indicates the vertebral-OPLL complex (**C**). OPLL, ossification of the posterior longitudinal ligament.

The main procedure of ACAF is bilateral osteotomies on the vertebral bodies. The bilateral osteotomies should be wide enough to include the OPLL. However, patients with wide-base OPLL (WBO) in the cross-section plane may add special difficulties to the anterior decompression.[5] Proper techniques are required to conduct the bilateral osteotomies to include the OPLL. If not, the remaining ossification mass may be left in the cervical canal resulting in insufficient decompression of the neural elements.

The main purpose of this study is to retrospectively review the cases with OPLL treated with ACAF. Patients with postoperative remaining ossification mass (PROM, Figure 1) are analyzed to figure out the causes and preventions of this problem.

PATIENT AND METHODS

Patient Population

A total of 115 consecutive patients with OPLL treated with ACAF from October 2016 to October 2017 in our institute were included in the study. PROM was identified as remaining ossification of the longitudinal ligament existed in the spinal canal other than included in the vertebral-OPLL complex (VOC) on postoperative computed tomography (CT) (Figure 1). Among all patients, the preoperative CT data were reviewed to identify the patients with WBO. The vertebral canal was divided by 2 sagittal planes crossing the bases of the bilateral uncinate process into 3 portions on the cross-section plane. If the base of the OPLL mass

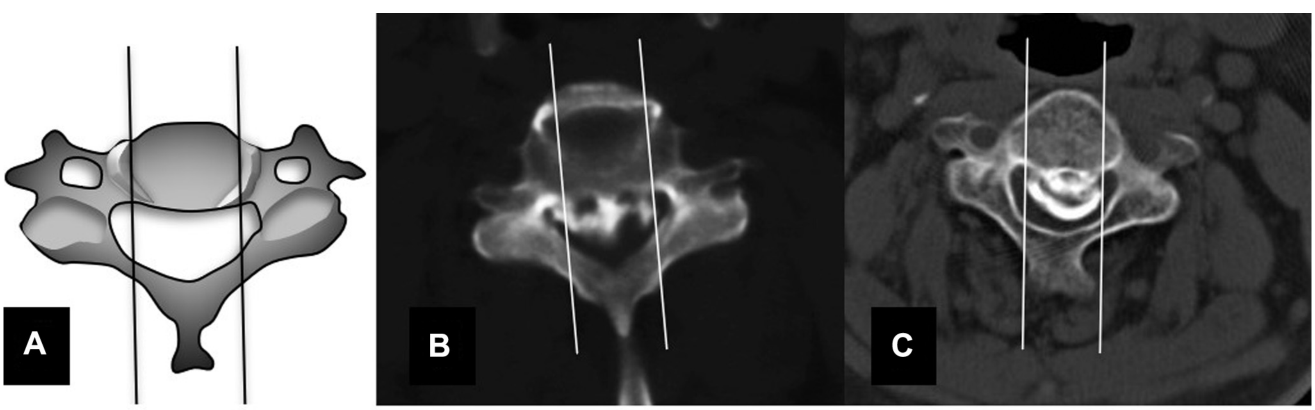

Figure 2. The vertebral canal was divided by 2 sagittal planes crossing the bases of the bilateral uncinate process into 3 portions on the cross-section plane. (**A**) Schematic diagram; (**B, C**) cross-section plane CT scan. If the base of the OPLL mass appears in the 2 lateral portions, the patient was defined as with wide-base OPLL (**B**). CT, computed tomography; OPLL, ossification of the posterior longitudinal ligament.

Table 1. Basic Information of Patients with PROM and without PROM

	With PROM	Without PROM
Age	65.3 ± 11.2 (48–80)	63.5 ± 7.0 (43–78)
Sex	Male 6, female 4	Male 45, female 27
Follow-up period, months	8 ± 3.5 (6–12)	5.4 ± 0.6 (3–12)
Levels with OPLL (number of patients)		
1	0	7
2	3	24
3	6	39
4	1	31
Classification of OPLL (cases)		
Continuous type	5	21
Segmental type	1	29
Mixed type	3	34
Local type	1	17
Complication, number of patients		
Neural deterioration	4	3
Postoperative hematoma	0	0
CSF leakage	4	6
Implant complications	0	0

CSF, cerebrospinal fluid; OPLL, ossification of the posterior longitudinal ligament; PROM, postoperative remaining ossification mass.

appeared in the 2 lateral portions, the patient was defined as with WBO (**Figure 2**).

To minimize inherent errors of the morphometric study, all images were checked independently by 3 spine surgeons. The prevalence rate and radiological characteristics of the cases with WBO and PROM were evaluated to conclude the causes and preventions of this problem.

Clinical Evaluation

Follow-up was conducted in all patients with PROM for at least 3 months. Japanese Orthopaedic Association (JOA) score was used to assess the degree of disability. An improvement rate (IR) of neurologic function was calculated as IR = (postoperative JOA score − preoperative JOA score/17 − preoperative JOA score)/100%. Surgical outcome was defined by the IR as follows: excellent (IR ≥ 75%), good (75% > IR ≥ 50%), fair (50% > IR ≥ 25%), and poor (IR < 25%).

Surgical Technique

The procedure of ACAF surgery was described as follows. After general endotracheal anesthesia, cervical spine is exposed through a right-sided approach. Routine discectomies were carried out in the levels with OPLL and one level superior and inferior to OPLL. Resection of the anterior part of vertebral bodies was conducted according to the thickness of the corresponding OPLL. Intervertebral cages filled with autogenic bone were then inserted at involved levels. Then, the anterior cervical plate and screws were installed. After the placement of the intervertebral cages, anterior cervical plate, and screws (serve for further hoisting of the VOC), the VOC was temporarily stabilized. Bilateral troughs approximately 2 mm wide were created at the bilateral base of uncinate processes. After the VOC was completely isolated from the surrounding bone, it was hoisted via gradually tightening the screws in each vertebra. A drainage tube was placed in the prevertebral space. The skin was closed by ordinary interrupted sutures.

Table 2. The JOA Score of Patients with PROM and without PROM

	With PROM	Without PROM
JOA score		
Before surgery	9.3 ± 0.9 (8–11)	8.2 ± 1.7 (5–14)
Final fellow-up	12.3 ± 1.7 (11–15)	14.7 ± 1.8 (9–16)*
IR (%)	36.7 ± 22.0 (0–71.4)	69.5 ± 22.6 (44.4–88.9)**

Values are expressed as the mean ± standard deviation (range).
IR, improvement rate; JOA, Japanese Orthopaedic Association; PROM, postoperative remaining ossification mass.
*$P < 0.05$, **$P < 0.01$ compared with the data before surgery.

Statistical Method

The SPSS software package (Version 20.0; SPSS Inc., Chicago, Illinois, USA) was used for statistical analysis. Analysis of measurements was performed by mean value and standard deviations. The independent sample *t* test was used when the data followed a normal distribution and homogeneity of variance. The Wilcoxon rank sum test was used if the data were not normal distribution or homogeneity of variance. The level of significance was set at $P < 0.05$.

RESULTS

In our series, patients' general data were as listed in **Table 1**, and there were no significant differences between patients with PROM and without PROM. The mean follow-up periods of 5.4 ± 0.6 (3–12) months in the group without PROM and 8 ± 3.5 (6–12) months in the group with PROM were obtained.

The mean JOA score in patients without PROM increased significantly after operation (8.2 ± 1.7 to 14.7 ± 1.8). The average IR at the final follow-up was 69.5% ± 22.6% (**Table 2**). However, the neural function recovery in patients with PROM was less satisfactory. The mean JOA score in patients with PROM increased from 9.3 ± 0.9 preoperatively to 12.3 ± 1.7 at the final follow-up. The average IR was 36.7% ± 22.0%. The average improvement rate of JOA score in patients without PROM was significantly higher than that in patients with PROM ($P < 0.01$) (**Table 2**).

There were total 14 patients with WBO (12.2%) among all patients. Ten patients (8.7%) with PROM were identified in the series with an incidence rate of 71.4% in patients with WBO. The remaining ossification masses of all 10 patients with PROM were found to be located on the right side (**Table 3**).

Table 3. Basic and Clinical Data of the Patients with WBO

					JOA Score							
Cases	Age, Sex	With PROM	Type	OR%	Before ACAF	After ACAF	At Last FU	IR% (at Last FU)	Complications	O-Arm Usage	Oblique Corpectomy Trough	Side of WBO
Case 1	52, M	Yes	Mixed	75	10	13	15	71.4	CSF, Neural deterioration	No	Yes	Right
Case 2	49, F	Yes	Mixed	81	9	6	11	25.0	No	No	Yes	Right
Case 3	51, M	Yes	Mixed	68	10	7	13	42.9	Neural deterioration	No	Yes	Right
Case 4	65, F	No	Continuous	90	8	12	14	66.7	No	No	No	Both
Case 5	58, M	No	Mixed	75	8	14	15	77.8	CSF	Yes	No	Left
Case 6	70, M	No	Mixed	80	10	14	15	71.4	No	Yes	No	Left
Case 7	75, M	Yes	Continuous	86	8	10	11	33.3	CSF	No	Yes	Right
Case 8	63, M	Yes	Continuous	64	9	7	12	37.5	Neural deterioration	No	No	Right
Case 9	75, F	Yes	Continuous	76	10	13	15	71.4	No	Yes	Yes	Right
Case 10	69, M	Yes	Segmental	83	8	9	11	33.3	CSF	No	Yes	Both
Case 11	66, M	No	Segmental	75	9	7	13	50.0	Neural deterioration	Yes	No	Left
Case 12	80, M	Yes	Continuous	79	11	8	11	0	Neural deterioration	No	Yes	Both
Case 13	77, F	Yes	Continuous	80	9	9	10	12.5	CSF	No	Yes	Right
Case 14	63, F	Yes	Local	73	9	11	14	62.5	No	Yes	Yes	Right

ACAF, anterior controllable antedisplacement and fusion; CSF, cerebrospinal fluid; FU, follow-up; IR, improvement rate; JOA, Japanese Orthopaedic Association; OPLL, ossification of the posterior longitudinal ligament; OR, occupation ratio; PROM, postoperative remaining ossification mass; WBO, wide-base OPLL.

Postoperative cerebrospinal fluid (CSF) leakage was observed in 6 patients (5.9%) in the without PROM group and recovered in 1 week without additional treatment. However, there were 4 cases (40%) of CSF leakage in patients with PROM (Table 2). Of these cases, lumbar drainage was performed in 3 patients at the second postoperative day and the CSF leakage of all patients was diminished 2 weeks later. The incidence rate of postoperative neural deterioration was higher in patients with PROM (4 patients, 40%) than that in patients without PROM (3 patients, 3.0%). After proper rehabilitation training and usage of dehydrant and steroid, a gradual recovery was observed in all patients. However, there was still 1 case (case 3) who underwent revision surgery. There was no occurrence of postoperative hematoma. At the 3-month follow-up, there were 107 patients (89.7%) who achieved solid bony fusion. In the latest follow-up, solid bony fusion was observed in all cases without occurrence of pseudarthrosis.

ILLUSTRATIVE CASE

Case 1

A 51-year-old man complained of the painfulness and spastic weakness in both extremities after the traffic incidence. Then, ACAF was performed at C3—C6. A marked recovery of the both upper extremities' strength was obtained. However, the painfulness was still not relieved. In the posterior CT scan and magnetic resonance imaging (MRI), the PROM and insufficient decompression were observed at C4—C6 (Figure 3B and D). After 8-month conservative treatment failed, a revision surgery was asked by the patient and hemilaminectomy at level C4—C6 was performed. After this reoperation, the spinal cord was sufficiently decompressed and symptoms diminished finally (Figure 3).

Case 2

A 49 year-old woman complained of numbness and weakness in right extremity for 8 months. The preoperative CT scan and MRI demonstrated that C3 to C6 multilevel OPLL compressed the spinal cord (Figure 4A, C, F, and H). ACAF was performed from C3 to C6. Although the numbness and weakness were revealed, the patient complained of painfulness in right extremity, after surgery. The postoperative CT scan and MRI revealed that the PROM was at C3/4 and obvious edema of the spinal cord was observed (Figure 4B, D, G, and I). By conservative therapy of 3 weeks, the symptom of pains was diminished. In the 6-month follow-up MRI, the compression of the spinal cord was still persisted, but the edema was relieved (Figure 4E and J).

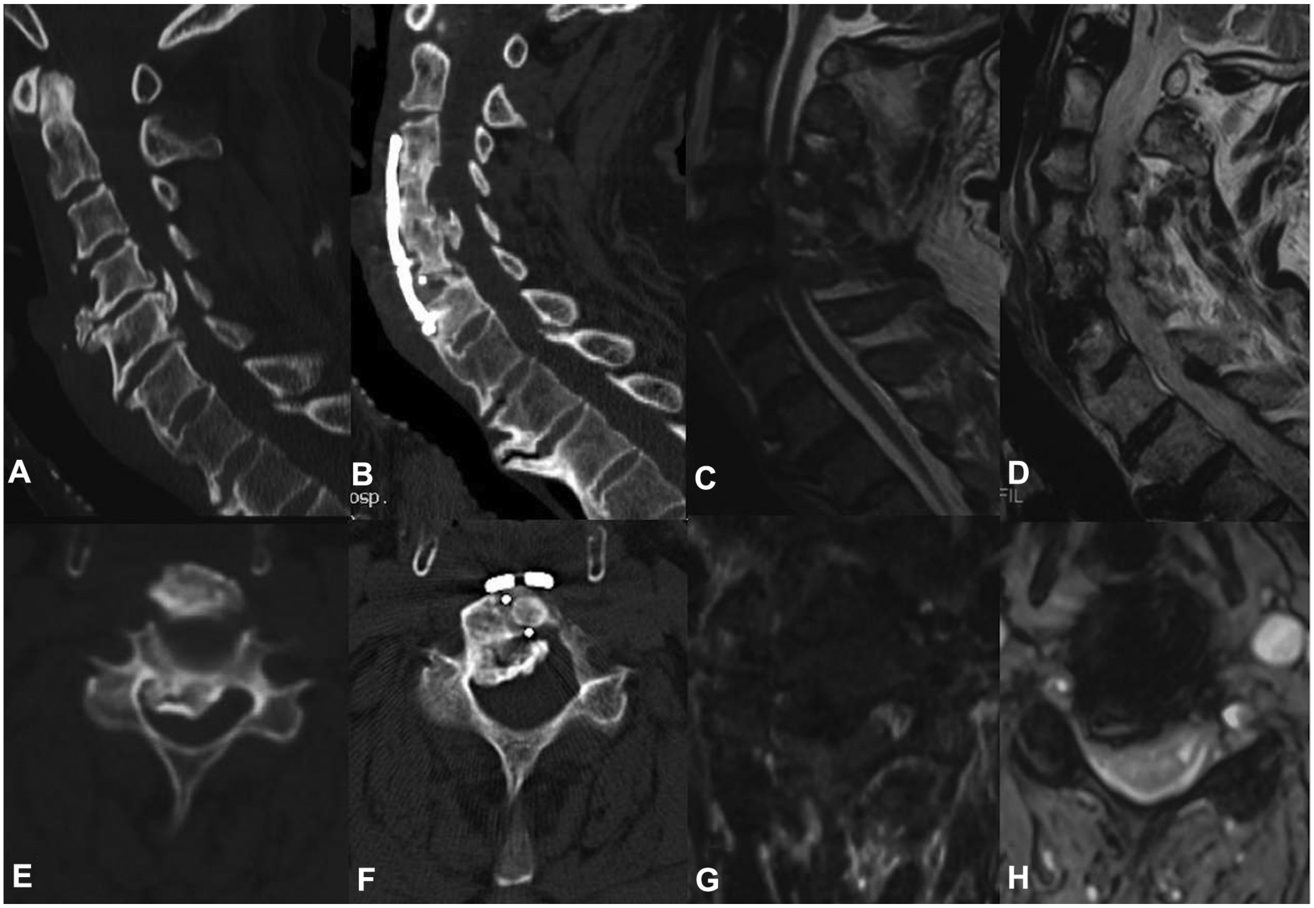

Figure 3. Radiologic data of case 1. (**A**) Preoperative sagittal CT scan showed ossification of the posterior longitudinal ligament from C4 to C5. (**B**) Postoperative sagittal CT scanning showed antedisplacement of the VOC from C4 to C5 and the PROM at C4/5. (**C**) Preoperative sagittal MRI showed compression of the spinal cord from C4 to C5 caused by OPLL. (**D**) Postoperative sagittal MRI showed insufficient antedisplacement of OPLL at levels C4 and C5. (**E**) Preoperative cross-sectional CT scanning showed ossification of the posterior longitudinal ligament at C4. (**F**) Postoperative cross-sectional CT scanning showed antedisplacement of the VOC at the C4 level with postoperative remaining ossification mass in the spinal canal. (**G**) Preoperative cross-sectional MRI showed compression of the spinal cord at C4 caused by OPLL. (**H**) Postoperative cross-sectional MRI showed remaining compression in the spinal cord at the C4 level. CT, computed tomography; MRI, magnetic resonance imaging; OPLL, ossification of the posterior longitudinal ligament; PROM, postoperative remaining ossification mass; VOC, vertebrae-OPLL complex.

DISCUSSION

Consensus has not been reached about the optimal surgical strategy of cervical OPLL.[6-8] Compared with a posterior decompression strategy, techniques with the anterior approach were reported to be more efficient in neural function recovery when dealing with K-line (−) patients.[9,10] However, the incidence rate of complications including CSF leakage, hardware failure, neural injury, or insufficient decompression was reported to be higher than that of posterior decompression surgery.[11,12]

We have previously reported ACAF as an alternative anterior decompression strategy for the treatment of OPLL.[13] In this technique, the procedure of decompression was performed in the anterior of vertebrae, which is definitely secure and avoids entering of the surgical instruments into the spinal canal or injury of the spinal cord. Then the decompression area was transferred from anterior to posterior of vertebrae by hoisting of the VOC ventrally. The hoisted VOC then served as autogenic graft bone to reconstruct the structure of the cervical spine; most of vertebrae were reserved, which contributed to further bony fusion. Satisfactory outcomes of 15 patients with severe multilevel OPLL treated with ACAF were gained in our preliminary study.[14] However, PROM in the cervical canal was observed in the clinical practice, especially in patients with WBO. The PROM protruded into the spinal canal after antedisplacement of the VOC leading to insufficient decompression of the neural elements. This phenomenon can be observed in postoperative CT and MRI. In this retrospective study, 10 of 115 patients with OPLL were identified as with PROM. Although the incidence rate of PROM was relatively low (8.7%), the complication might lead to worse outcome as 4 of the patients with PROM (70.0%) were observed with a poor recovery rate of JOA score after surgery. Although 3 patients with postoperative deteriorated neural function

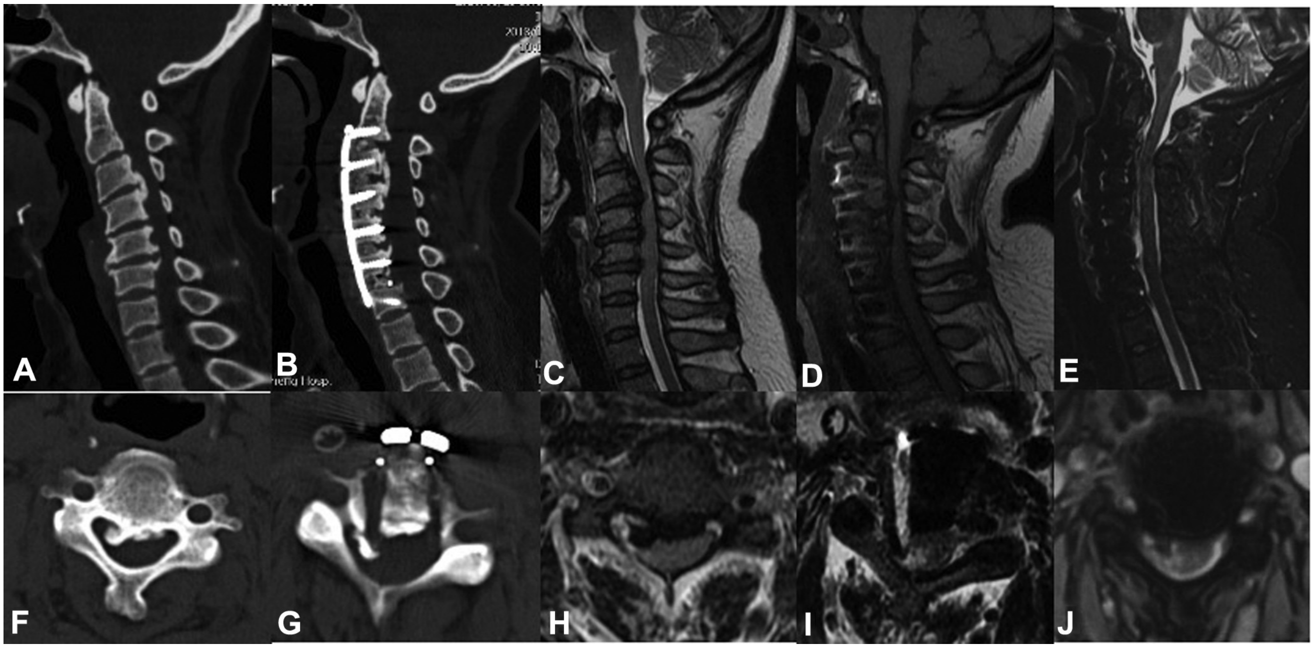

Figure 4. Radiologic data of case 2. (**A**) Preoperative sagittal CT scan showed ossification of the posterior longitudinal ligament from C3 to C6. (**B**) Postoperative sagittal CT scanning showed antedisplacement of the VOC from C3 to C6 and the PROM at C3/4. (**C**) Preoperative sagittal MRI showed compression of the spinal cord from C3 to C6 caused by OPLL. (**D**) Postoperative sagittal MRI showed insufficient antedisplacement of OPLL at C3/4 and obvious edema of the spinal cord. (**E**) Six-month follow-up sagittal MRI showed that the spinal cord was still compressed at C3/4, but the edema diminished. (**F**) Preoperative cross-sectional CT scanning showed ossification of the posterior longitudinal ligament at C3/4. (**G**) Postoperative cross-sectional CT scanning showed antedisplacement of the VOC at C3/4 with postoperative remaining ossification mass in the spinal canal. (**H**) Preoperative cross-sectional MRI showed compression of the spinal cord at C3/4 caused by OPLL. (**I**) Postoperative cross-sectional MRI showed remaining compression and edema at C3/4. (**J**) Six-month follow-up cross-sectional MRI showed that the compression at C3/4 persisted and the edema revealed. CT, computed tomography; MRI, magnetic resonance imaging; OPLL, ossification of the posterior longitudinal ligament; PROM, postoperative remaining ossification mass; VOC, vertebrae-OPLL complex.

achieved muscle strength recovery of the right arm, 1 patient achieved no recovery at the final follow-up and achieved the reoperation.

Wang et al[15] proposed a classification of OPLL as open-base type and non—open-base type according to the shape of ossification on CT axial imaging. Open-base type OPLL was suggested to be a better candidate for anterior decompression surgery than non—open-base type OPLL. The open-base (**Figure 5**) was defined as both lateral margin of ossification mass is within the posterior cortex of vertebral body and do not reach the pedicle. The author concluded that the open-base OPLL provided a space for instrument entrance for cutting ossification mass without compression of the spinal cord.[15] The ACAF technique isolates and hoists the VOC to obtain direct decompression, thus avoiding entering of the surgical instruments into the spinal canal or injury of the spinal cord. To evaluate a safe and effective width of bilateral osteotomies, we conducted an anatomic study showing that the base of the uncinate process can serve as a landmark for the location of longitudinal osteotomies in ACAF. However, patients with OPLL base wider than the bilateral base of the uncinate process may add special difficulties to the anterior decompression. In patients treated with anterior cervical corpectomy with fusion, a sufficient operative view might be achieved during the procedure of osteotomy, which might avoid the occurrence of PROM. However, the incidence of massive hemorrhage and CSF leakage during this surgery were relatively high, especially in cases of multilevel OPLL. Because of these intraoperative situations, the visual field of operation was seriously narrowed, which resulted in insufficient decompression.[16] In contrast, during the procedure of ACAF, although the operative view might not be sufficient, the complications of hemorrhage and CSF leakage relatively rarely occurred. Nevertheless, the technical difficulties of a narrow operative space, insufficient width of osteotomies, and an

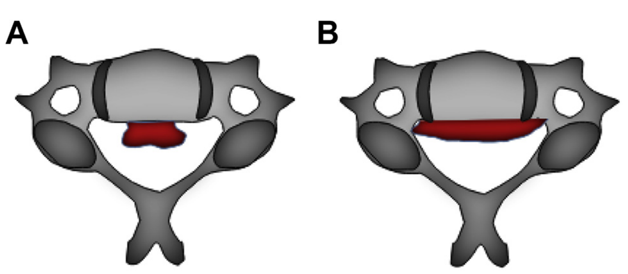

Figure 5. (**A**) Open-base type. (**B**) Non-open-base type.

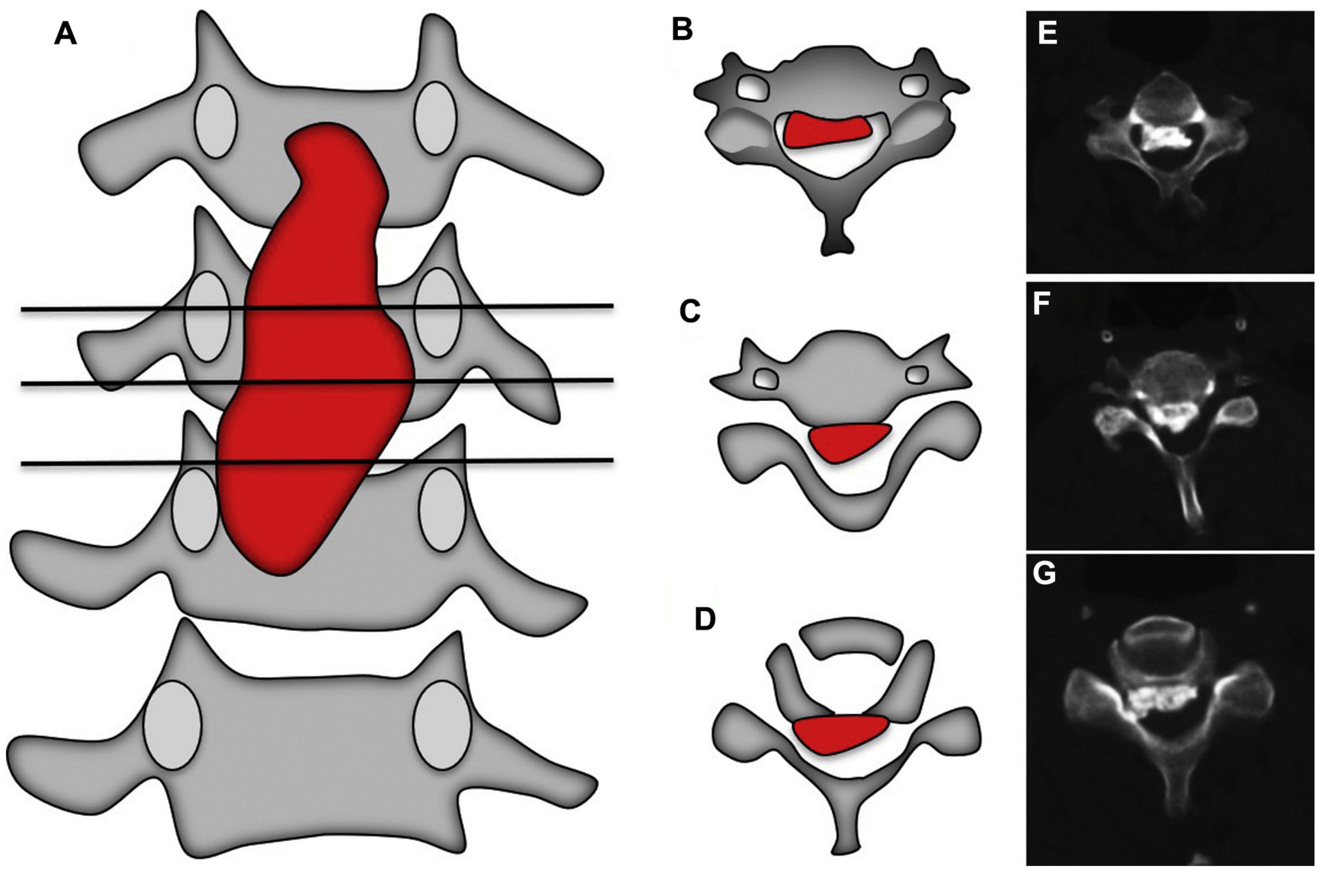

Figure 6. Schematic diagrams and CT scans showing different locations of the OPLL. (**A**) It is important to know where does the WBO lie on the sagittal level: (**D, G**) at the level of intervertebral space; (**B, E**) at the pedicle level (**C, F**); or at the level between intervertebral space and pedicles (**D**, **G**). CT, computed tomography; OPLL, ossification of the posterior longitudinal ligament; WBO, wide-base OPLL.

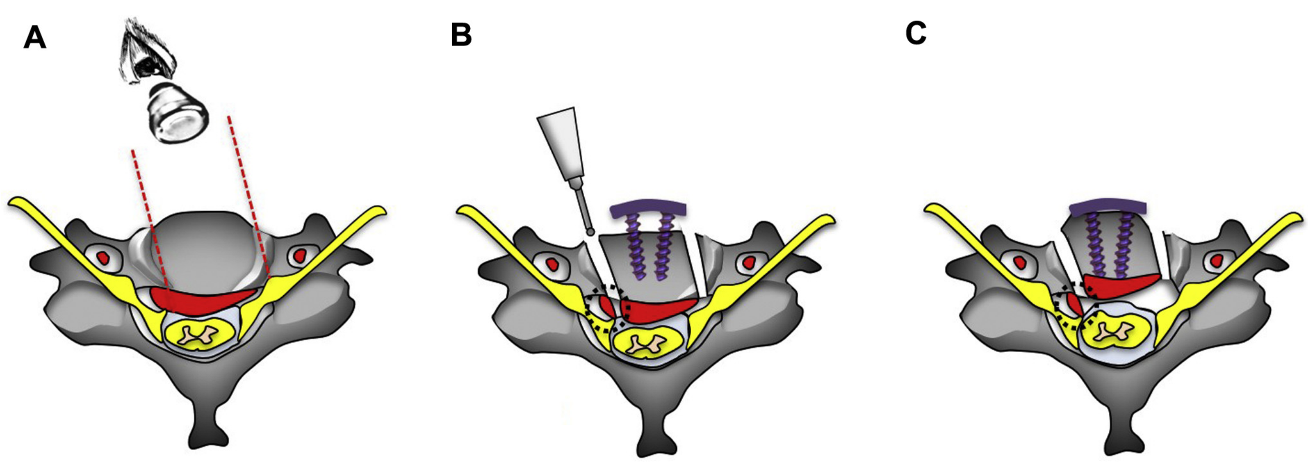

Figure 7. Schematic diagrams showing the significance of prevention of creating an oblique corpectomy trough. (**A**) Oblique osteotomy trough is more frequently created when the surgeon wears a magnifying surgical loupe. (**B**) The oblique trajectory of bilateral troughs could lead to failure of including OPLL into the VOC at the level of WBO. (**C**) PROM (*dashed circle*) was protruded into the spinal canal leading to compression of the neural elements after antedisplacement of the VOC. OPLL, ossification of the posterior longitudinal ligament; PROM, postoperative remaining ossification mass; VOC, vertebral-OPLL complex; WBO, wide-base OPLL.

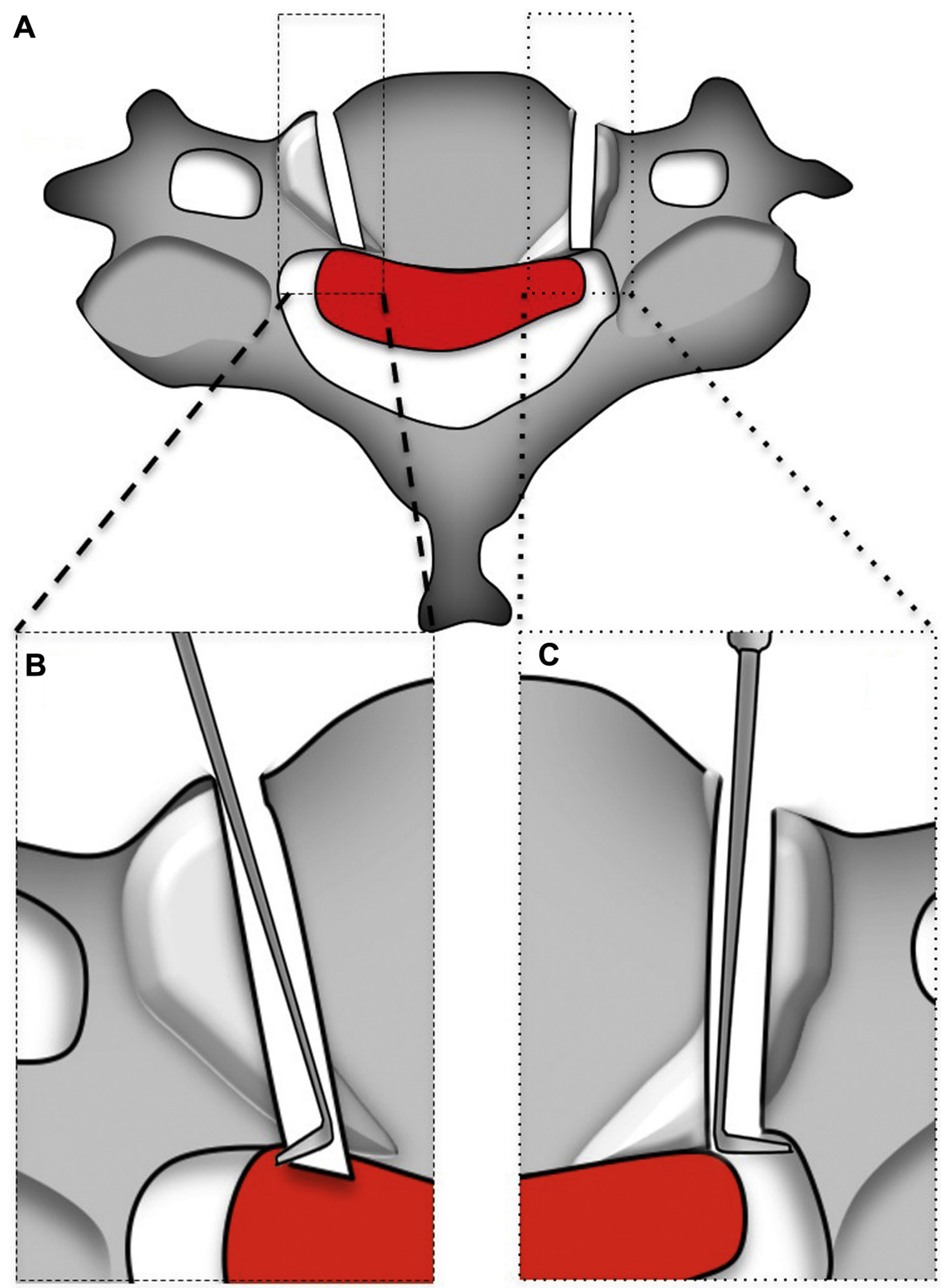

Figure 8. Schematic diagrams showing the tips to identify if OPLL is included in the VOC. (**A**) After removal of the posterior wall of the vertebral body at the bottom of the troughs, 2 situations could be met (left and right). (**B, C**) A nerve hook is used to detect if OPLL is included in the VOC. OPLL, ossification of the posterior longitudinal ligament; VOC, vertebral-OPLL complex.

oblique corpectomy trough caused this complication in ACAF. In this study, 10 patients with PROM were all with WBO, and the incidence rate was 71.4%. This result suggested us to pay special attention to the patients with WBO during ACAF. We herein demonstrate some technical notes used to avoid this important complication of ACAF.

Preoperative Measurement of the Anatomic Parameters

The preoperative planning is with paramount importance in ACAF surgery. The thickness of the OPLL mass in each level is measured to determine how much of the corresponding anterior vertebral body will be resected. The width of the VOC to be created is determined by measuring the widest part of the OPLL mass. The distance between the OPLL and the corresponding pedicles, vertebral arteries, and uncinate process is also important information for facilitation of the surgical process.

Special attention should be paid to the cases with WBO. After reading the preoperative CT scan, it is important to know where does the WBO lie on the sagittal level, at the level of intervertebral space, at the pedicle level, or at the level between intervertebral space and pedicles (**Figure 6**). If the WBO appears at the pedicle level, osteotomy for the isolation of the VOC should be conducted between the OPLL and pedicle. If the WBO appears at the levels other than the pedicle level, osteotomy could be more lateral to include the OPLL. Surgeons should carefully review the CT scan of the patient and keep in mind the location of the WBO.

Base of the Uncinate Process as a Landmark for Bilateral Osteotomies

After preoperative planning of ACAF, we have a clear idea of the width of OPLL and distance between the OPLL, vertebral arteries, and pedicles. However, it is our big concern how to locate the bilateral pedicles and vertebral arteries to facilitate choosing the optimal place to conduct the osteotomies. According to our previous study,[17] the medial border of pedicles was consistent with the lateral base of the uncinate process from C3 to C5 with a distance of approximately 3 mm in both genders. The distance between the base of the uncinate process and vertebral arteries is consistently around 6.5 in male and 5.6 in female. Using the base of the uncinate process as a landmark for bilateral osteotomies can ensure a wide enough distance between bilateral osteotomies and maintain a safe distance from vertebral arteries and pedicles.

Avoid Creating an Oblique Corpectomy Trough

Previous reports indicated that the proper orientation of decompression is a key point for the anterior procedure to avoid creating an oblique corpectomy trough. It is also important in ACAF. The oblique osteotomy trough is more frequently found when the surgeon wears a magnifying surgical loupe, and it can be avoided by using a microscope, which is always oriented perpendicular to the operative plane. The oblique osteotomy trough did not interfere with hoisting of vertebrae in the beginning. However, the oblique osteotomy trough would become an impingement in the last prior of vertebrae hoisting (**Figure 7**).

Limitation of the Depth of the Bilateral Troughs

During thinning of the corticocancellous bone at the bottom of the bilateral troughs, a nerve hook should be used frequently to identify the location of the posterior wall of the vertebral body through the intervertebral space, to ensure that the troughs have not broken through the posterior wall of the vertebral body and gone into the OPLL. Kerrison rongeurs are used to remove the posterior vertebral wall at the bottom of the troughs from the disc level to the vertebra level. After removal of the posterior wall of vertebrae at the bottom of the troughs, a nerve hook is used to detect if OPLL is included in the VOC (**Figure 8**). The existence of OPLL at the bottom or to the lateral of the trough suggests that the trough is not wide enough. In this circumstance, further osteotomies should go wider instead of deeper to prevent creating a PROM.

Usage of Intraoperative CT

Previous studies demonstrated that intraoperative CT is useful for the intraoperative evaluation of adequate decompression during technically demanding anterior cervical surgeries and can provide informative feedback to surgeons to improve their performance. The usage of intraoperative CT in ACAF surgery might help finding PROM before hoisting of the VOC. Intraoperative CT was not routinely used in ACAF in our institute. Compared with 8 cases with PROM without using intraoperative CT, the other 2 cases achieved better neurologic recovery by using intraoperative CT. Meanwhile, intraoperative CT was used in 4 cases in the WBO patients without PROM.

In this study, 10 patients developed PROM. Because of the persistence of postoperative neural deterioration, revision surgery was performed in 1 patient and final recovery of neurologic function was achieved. In a previous report, the neural deterioration of the anterior approach was 10%[18] and the reoperation incidence rate was 12% to 26%.[6,19] However, the neural deterioration and reoperation incidence of ACAF was 6.1% and 0. 88%, respectively, which is far lower than the conventional anterior approach.

The present study had some limitations. The number of patients was limited and the follow-up period was relatively short. A study with more cases and longer follow-up duration should be performed. In addition, this is a retrospective controlled study in a single center; a multicenter prospective randomized controlled study should be performed.

CONCLUSIONS

This study reviewed a complication of PROM in ACAF surgery. The results of this study showed that the incidence of PROM in cases with WBO was very high (71.4%), and it might cause poor neural function recovery. To avoid PROM in ACAF surgery, several effective technical notes were given, such as preoperative measurement of the anatomic parameters, using proper landmarks for bilateral osteotomies, and preventing creating an oblique corpectomy trough.

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