

Anterior and Posterior Segmental Decompression and Fusion for Severely Localized Ossification of the Posterior Longitudinal Ligament of the Cervical Spine: Technical Note

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Abstract

The surgical strategy for severely localized ossification of the posterior longitudinal ligament (OPLL) of the cervical spine is still not straightforward. We describe the surgical technique of extended anterior cervical discectomy and fusion (ACDF) with partial resection of OPLL followed by posterior cervical segmental decompression and fusion (PCDF). This study investigated five patients with severely localized OPLL with an occupying ratio more than 60%. Extended ACDF comprising a modified technique with a trans-unco-discal approach and partial oblique corpectomy was first attempted to achieve neural decompression of the spinal cord and nerve roots at the most prominent level of the OPLL. The OPLL was partially resected to reduce the axial occupying ratio or ensure that the OPLL did not exceed the imaginary line between the midpoint between C2 and C7 on sagittal images. PCDF was then performed to achieve satisfactory decompression of neural elements and cervical stability. One patient underwent one-stage surgery and the remaining four patients underwent two-stage surgery. No patients received spinal cerebrospinal fluid (CSF) drainage and demonstrated CSF leakage after surgery. All patients showed acceptable or satisfactory functional recovery. No instrumentation-related complications were encountered. Radiological analysis demonstrated that all except one patient (OPLL associated with ankylosing spinal hyperostosis) revealed improvements in local angle, C2–7 angle and cervical tilt angle. This anterior and posterior segmental decompression and fusion for severely localized OPLL of the cervical spine remains technically demanding in some parts, but can offer satisfactory decompression of neural elements and stabilization of the cervical spine when applied appropriately.

Key words: cervical spine, extended anterior cervical discectomy and fusion, ossification of posterior longitudinal ligament, posterior cervical segmental decompression and fusion, trans-unco-discal approach

Introduction

The majority of cases of cervical ossification of the posterior longitudinal ligament (OPLL) can be treated surgically using posterior decompression such as cervical laminoplasty.^{1–4)} Cervical laminoplasty is not so technically demanding compared with the anterior surgery. Although cervical laminoplasty can efficiently expand the spinal canal, the risk of nerve root tethering may be high, especially in cases

of severely localized OPLL.^{5–7)} The surgical strategy for severely localized OPLL is still not straightforward. Factors such as the number of spinal segments involved, cervical alignment or tilt angle, relationship between OPLL and the C2–7 line (what we call the “K-line”), or occupying ratio of OPLL need to be carefully considered.^{8–11)} Anterior resection of the OPLL with wide corpectomy and anterior fusion may provide a useful option.^{12–16)} However, such anterior surgery may carry surgery-related risks including cerebrospinal fluid (CSF) leakage, spinal cord damage, instrumentation-related trouble, dyspnea or dysphagia after surgery.¹⁷⁾ On the other hand, posterior decompression with relatively long fusion may be another choice for such patients, allowing decompression of

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the spinal cord and correction of spinal alignment to some extent.¹⁸⁾ This posterior surgery may reduce the surgical risks related to anterior cervical surgery, but may still carry a high risk of nerve root tethering or cervical foraminal stenosis.

In this technical note, we present the surgical concept of extended anterior cervical discectomy and fusion (ACDF) with partial resection of the OPLL followed by posterior cervical segmental decompression and fusion (PCDF) for severely localized OPLL of the cervical spine. Extended ACDF may still be relatively technically demanding and may also carry a significant risk of spinal cord damage, but can offer satisfactory or acceptable decompression of not only the spinal cord, but also the nerve roots on both sides. Additional segmental decompression, correction and stabilization can be performed using PCDF.

Surgical Technique

Patient population

This study included five patients (three males, two females) with severely localized OPLL. Average age was 57.2 years (range, 49–77 years). Neurological condition was assessed based on the Neurosurgical Cervical Spine Scale (NCSS).¹⁹⁾ Postoperative functional assessment was conducted at least 3 months after surgery.

Surgical indications and methods

Surgical indication for extended ACDF followed by PCDF was the neurological condition of severe myelopathy caused by severely localized OPLL with an occupying ratio more than 60% on sagittal images or crossing the imaginary line between the midpoints of C2 and C7 on sagittal images, a line that we call the “K-line”. Extended ACDF was first attempted to achieve neural decompression of the spinal cord and nerve roots. The OPLL was partially resected to reduce the occupying ratio or to ensure the OPLL did not exceed the imaginary line between the midpoints of C2 and C7 on sagittal images. A modified technique using a trans-unco-discal approach with partial oblique corpectomy was applied to safely remove the OPLL (Figs. 1A–1D).^{20–22)} All disc tissue, including herniated disc fragments and osteophytes, was removed meticulously under surgical microscopy. To make a surgical field wider, partial oblique corpectomy was carefully done in the axial and sagittal plane. During the decompression procedure, damage to the anterior vertebral endplates was scrupulously avoided. OPLL was meticulously shaved little-by-little using a high-speed drill. OPLL was carefully resected from medial to lateral side to avoid the venous hemorrhage and finally to confirm decompression of the neural structures. Venous hemorrhage encountered during the resection of OPLL was well controlled by cottonoid

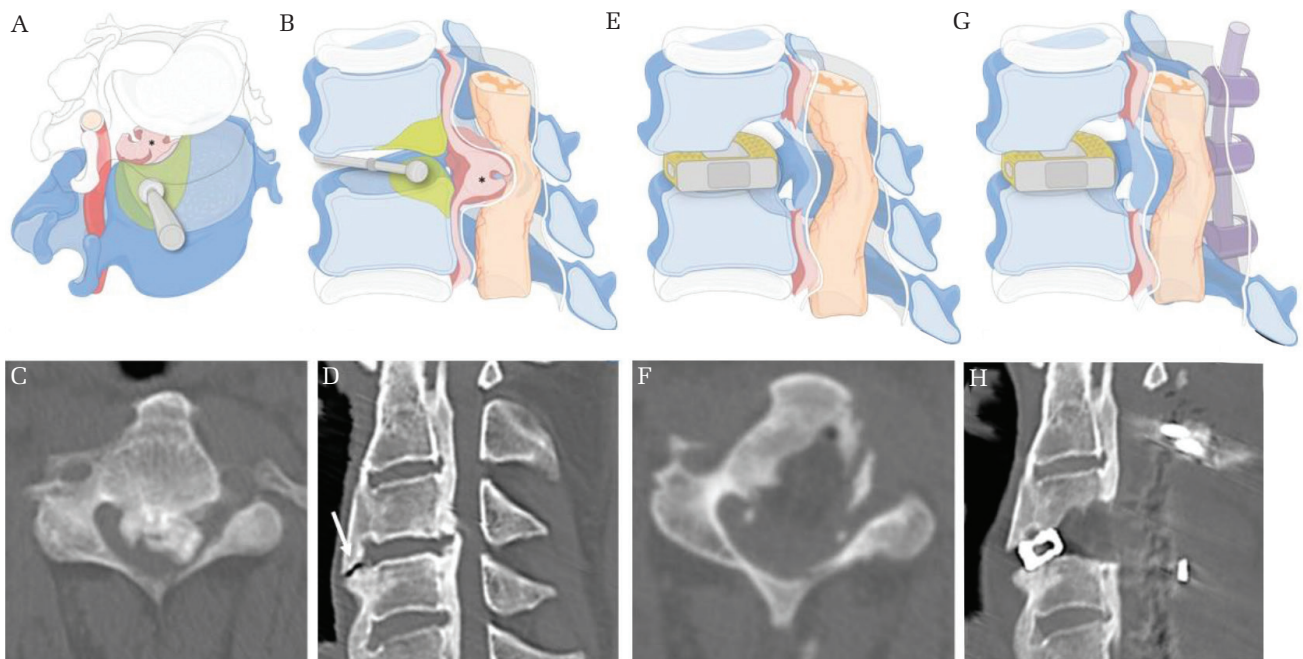


Fig. 1 Schematic drawing with illustrative CT (Case 1) showing the surgical steps including extended ACDF as a modified technique using a trans-unco-discal approach with partial oblique corpectomy (green area) to safely remove the OPLL associated with ankylosing spinal hyperostosis (A–D), resection of the OPLL with fusion using a stand-alone technique (E and F) and PCDF (G and H). Please note the vacuum cleft at C3/4 (→). ACDF: anterior cervical discectomy and fusion, PCDF: posterior cervical segmental decompression and fusion.

packing or hemostatic agents. To keep a surgical field clean, meticulous hemostasis was repeated during the surgery. To accomplish interbody fusion, a rectangular stand-alone cage was used (Medacta International, Castel San Pietro, Switzerland). Cage trials were used to determine the appropriate size, and a curved shape was preferred. After the cage was filled with a mixture of hydroxyapatite granules and collagen (Refit; HOYA Technosurgical Corporation, Tokyo, Japan), the cage was inserted into the disc space under interbody distraction or cervical traction (Figs. 1E and 1F). Cage position was aligned to the anterior vertical line as much as possible. Anterior cervical plate was not applied in any cases. PCDF was followed to achieve satisfactory decompression of the neural elements and cervical stability (Figs. 1G and 1H). Cervical laminectomy was performed and segmental fusion was conducted using pedicle or lateral mass screws into the cervical spine (Medtronic, Memphis, TN, USA). The sagittal angle of the cervical spine was corrected to achieve a mildly lordotic curve, not an excessively lordotic curve (Figs. 2A and 2B). All surgical procedures were done using a fluoroscopic image guidance. All patients were permitted to walk the next day, and were kept in a hard or soft neck collar for at least 2 weeks postoperatively.

Radiological evaluation

The radiological evaluation included the maximum occupying ratio of the OPLL, local angle, C2–7 angle of the spinal curvature and cervical tilt angle.^{11,12,23,24)}

The maximum occupying ratio of OPLL was estimated using sagittal computed tomography (CT) of the cervical spine before surgery. Local angle, C2–7 angle of spinal curvature and cervical tilt angle were also evaluated before and after surgery. A positive cervical tilt angle was defined as the midpoint of the anterior tubercle of C1 being anterior to the vertical line from the midpoint of the C7 vertebral body. A negative cervical tilt angle was defined as the midpoint of the anterior tubercle of C1 being posterior to the vertical line from the midpoint of the C7 vertebral body. All radiological evaluations were performed using the EGMAIN-EX computerized medical records system (Fujitsu Limited, Tokyo, Japan).

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Postoperative Assessment

The average maximum occupying ratio of the OPLL was 69% (range, 62–75%). One patient underwent one-stage surgery and the remaining four patients underwent two-stage surgery, although two-stage surgery was our basic choice for the reason of surgical

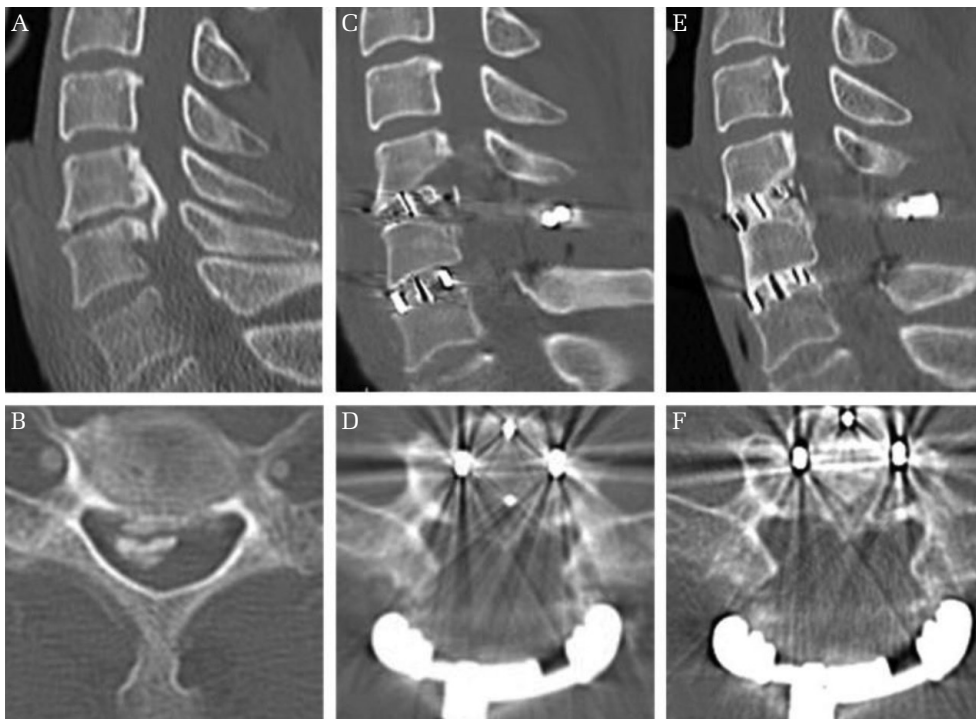


Fig. 2 Illustrative case of 2-level extended ACDF followed by PCDF (Case 3). (A and B) Cervical CT before surgery. (C and D) Cervical CT early after surgery. (E and F) Cervical CT late after surgery. Satisfactory decompression and stabilization of cervical spine was well confirmed. ACDF: anterior cervical discectomy and fusion, PCDF: posterior cervical segmental decompression and fusion.

safety and accuracy. Average total operation time was 497 min (range, 408–629 min). Average total estimated blood loss was 218 mL (range, 100–450 mL). No patients received blood transfusion or spinal CSF drainage, or demonstrated prolonged or transient CSF leakage after surgery. Case summary was demonstrated in Table 1.

Functional outcomes

One patient (Case 5) developed acute hemiparesis on the right side just after ACDF extending to three levels. He underwent posterior decompression of the laminectomy on the same day, followed by posterolateral fusion. Neurological condition in this case was improving and returned to the preoperative condition by 3 weeks after surgery. Otherwise, no significant surgery-related complications were encountered. Finally, all patients showed acceptable or satisfactory functional recovery on the NCSS.

Radiological outcomes

No instrumentation-related complications were seen, including cage migration. Resection of the OPLL by extended ACDF was confirmed using cervical CT. Final alignment was assessed from plain lateral radiographs of the cervical spine. Radiological analysis demonstrated that all except one patient (Case 1, with cervical OPLL associated with ankylosing spinal hyperostosis) revealed improvement of the local angle, C2–7 angle and cervical tilt angle. Average local angle was 6.2° before surgery and improved to 8.4° after surgery. Average C2–7 angle was 2.6° before surgery and improved to 6.4° after surgery. Average cervical tilt angle was 21.2°, improving to 15° after surgery. All patients demonstrated satisfactory decompression on images.

Illustrative Case

In Case 3, a 49-year-old man was presented with gradual onset of gait disturbance and severe manual clumsiness, especially on the right side. Preoperative functional condition was grade 2 for lower extremity function, for upper extremity function, for pain and sensory disturbance, and grade B for performance status. Preoperative CT showed a severely localized OPLL at C5/6, especially on the right side (Figs. 2A and 2B). Maximum occupying ratio of the OPLL before surgery was 71%. Preoperative MRI showed severe stenosis at C5/6 with intramedullary signal change and mild stenosis at C6/7 on the left side (Fig. 3B). He underwent two-stage surgery with extended ACDF and partial OPLL resection followed by PCDF. Total time for the two operations was 7 h 33 min and total estimated blood loss was 100 mL. Postoperative CT early after surgery revealed satisfactory resection of the OPLL (Figs. 2C and 2D), and postoperative CT late after surgery suggested osseous stability of the cervical spine (Figs. 2E and 2F). Plain lateral radiograph of the cervical spine revealed the improvement of local angle, C2–7 angle and cervical tilt angle after surgery (Figs. 3A and 3C). Postoperative MRI showed satisfactory decompression of the spinal cord (Fig. 3D). The postoperative course was uneventful. Neurological function gradually improved after surgery. Functional grade at 6 months postoperatively was grade 3 for lower extremity function, grade 4 for upper extremity function, grade 3 for pain and sensory disturbance, and grade E for performance status.

Discussion

The patients with cervical OPLL are usually clinically silent or show only gradually progressive symptoms,

Table 1 Case summary

Case	Age/Sex	NCSS		Surgery	Radiological evaluation						
		Preop	Postop		Occupying ratio of OPLL (%)	Local angle		C2–7 angle		Cervical tilt angle	
				Number of fusion		Preop	Preop	Postop	Preop	Postop	Preop
1	49/M	2:3:2:B	3:4:3:C	3	75	10	9	0	0	28	31
2	58/F	3:3:2:C	5:4:3:E	2	68	4	10	2	10	8	6
3	49/M	2:2:2:B	3:4:3:E	2	71	9	11	7	12	21	10
4	77/F	2:2:2:A	3:3:3:B	3	69	7	11	0	5	29	14
5	53/M	3:4:3:E	4:4:3:E	3	62	1	1	4	5	20	14
Average				2.6	69	6.2	8.4	2.6	6.4	21.2	15.0

NCSS: neurosurgical cervical spine scale, OPLL: ossification of the posterior longitudinal ligament, Preop: preoperative, Postop: postoperative.

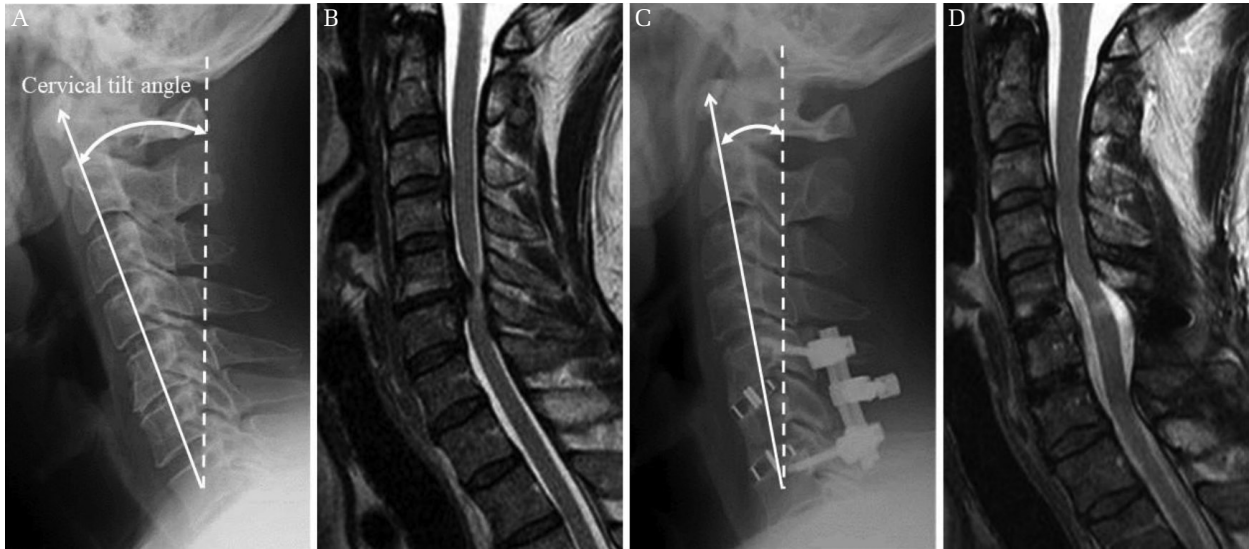


Fig. 3 Illustrative case of 2-level extended ACDF followed by PCDF (Case 3). (A) Plain lateral radiograph of cervical spine before surgery. (B) T₂-weighted MR sagittal image before surgery. (C) Plain lateral radiograph of cervical spine after surgery. (D) T₂-weighted MR sagittal image after surgery. Radiological parameters including cervical tilt angle were improved after surgery. ACDF: anterior cervical discectomy and fusion, PCDF: posterior cervical segmental decompression and fusion.

but sometimes show acute symptoms after even apparently minor trauma. Surgical intervention is usually necessary for patients with moderate or severe neurological symptoms. However, determining the optimal surgical strategy for OPLL is not straightforward. Occupying ratio, longitudinal extension of the OPLL itself, the anatomical relationship of the OPLL and C2–7 line or cervical alignment needs to be taken into serious consideration to make the surgery safer and more successful.^{8–11} In this technical note, we presented the surgical concept of anterior and posterior segmental decompression and fusion using extended ACDF followed by PCDF for severely localized OPLL of the cervical spine. Extended ACDF with partial resection of the OPLL may reduce the surgical risk or disadvantage of standard anterior corpectomy such as postoperative cerebrospinal fluid leakage or relatively long and wide fusion, although this method may still be technically demanding. PCDF may also reduce the surgical risk of standard posterior decompression alone, with or without relatively long fusion. The surgical strategy presented here is intended to combine the advantages of both anterior and posterior surgery, and to reduce the disadvantages of them.

Anterior approach

Anterior resection of the OPLL is theoretically ideal for severely localized OPLL, allowing direct reduction of the ossification and decompression of the spinal cord and nerve roots.^{12–16} Anterior decompression

of the cervical OPLL was first popularized by Japanese orthopedic surgeons and neurosurgeons. Abe et al.¹² described 12 cases in which cervical OPLL was successfully treated surgically using anterior cervical decompression and fusion using autologous iliac bone graft in 1981. Mizuno et al.^{15,16} suggested that the anterior approach is effective for decompressing the cervical cord with OPLL, especially for 1- or 2-level OPLL, although slight, asymptomatic kyphotic deformity may be encountered late after surgery. Iwasaki et al.^{3,8} suggested that anterior decompression and fusion for cervical OPLL is technically demanding and shows a higher incidence of surgery-related complications, but anterior surgery is preferable to cervical laminoplasty in cases where the occupying ratio of OPLL is greater than 60%. An anterior cervical approach may be desirable for severely localized OPLL, but may carry a high risk of surgery-related complications. Kimura et al.¹⁷ conducted a retrospective, multi-institutional study to assess the perioperative complications of anterior decompression and fusion in patients with cervical OPLL. Upper-extremity paresis was seen in 20 out of 150 patients (13.3%), five of whom had still not returned to preoperative levels by 6 months after surgery. Patients with upper-extremity paresis showed a significantly higher occupying ratio of the OPLL, greater blood loss, longer operation times, fusion of a greater number of segments, and a higher rate of CSF leakage than those without paresis. Independent risk factors for upper-extremity paresis were a high

occupying ratio of OPLL and a high volume of blood loss during surgery. They suggested that patients with a high occupying ratio of OPLL are at higher risk of developing neurological deterioration.

Posterior approach

Posterior decompression such as cervical laminectomy or laminoplasty may be another choice, allowing effective expansion of the spinal canal with relatively few complications, although the surgical technique of posterior decompression in cases of severely localized OPLL may be more technically demanding than in the usual cases of degenerative cervical spine.¹⁻⁴⁾ Posterior decompression alone may lead to postoperative worsening of the neurological symptoms due to posterior shift of the spinal cord itself or nerve root tethering, especially in cases of severely localized OPLL.⁵⁻⁷⁾ Kato et al.²⁾ assessed the long-term results of cervical laminectomy in treating cervical OPLL in a retrospective study. They identified late deterioration in 23% of subjects. Iwasaki et al.³⁾ reviewed surgical data from 66 patients who underwent laminoplasty for cervical OPLL. They demonstrated that surgical outcomes were significantly poorer in patients with an occupying ratio of OPLL greater than 60%. Multiple regression analysis showed that the most significant predictor of poor outcome after laminoplasty was a hill-shaped OPLL, lower preoperative neurological score, postoperative cervical alignment and older age of the patient. Masaki et al.⁹⁾ compared the surgical outcomes of cervical OPLL between a patient group with anterior decompression and fusion and a patient group with laminoplasty. They demonstrated that the surgical outcomes of anterior surgery were superior to those of laminoplasty. They suggested that hypermobility of vertebrae at the cord compression level is a risk factor for poor outcome after laminoplasty. They recommended that anterior surgery should be the first choice for significant OPLL and a hypermobile cervical spine, and proposed that posterior fusion would be desirable for stabilizing the spine and decreasing damage to the spinal cord in cases of laminoplasty. Posterior decompression with relatively long fusion of the cervical spine is another choice to avoid these complications of posterior decompression alone. Koda et al.¹⁸⁾ compared clinical outcomes between laminoplasty, posterior decompression with instrumented fusion and anterior decompression with fusion for cervical OPLL based on the relationship between cervical OPLL and the C2-7 line, representing what we call the K-line. They demonstrated that neurological recovery was significantly better in anterior decompression with fusion than in laminoplasty or posterior decompression with

instrumented fusion. Neurological recovery in the posterior decompression with instrumented fusion was also significantly better than in laminoplasty. They concluded that laminoplasty should not be used for OPLL with a negative K-line. Anterior decompression with fusion is one of the suitable surgical treatments for K-line-negative OPLL.

Combined approach

The majority of cervical OPLL can be well treated by anterior or posterior single approach. Previous studies have mainly focused on comparisons between anterior resection of the OPLL with fusion and posterior decompression with or without fusion. There is also another concern for the selection of posterior-anterior surgery, anterior-posterior surgery presented here or posterior and anterior-posterior surgery. The surgical selection itself may be affected by the surgeon's preference, experience or skill, or the clinical condition of patient himself or herself. Few investigations have reported on the benefits and limitations of anterior and posterior combined surgery.^{25,26)} Lee et al.²⁶⁾ presented a two-stage procedure for posterior and anterior-posterior 540° for extensive cervical OPLL with kyphotic deformity. They suggested that their procedure could avoid the shortcomings of standard anterior or posterior surgery for extensive cervical OPLL, although disadvantages may exist in terms of staged surgeries, longer operation time or hospital stay. In that procedure, posterior decompression of laminectomy with segmental screw fixation without rod assembly was performed first, followed by multilevel anterior cervical discectomy with fusion at the apex of kyphotic deformity and posterior fusion. In the multilevel anterior cervical discectomy, they opted to thin the OPLL rather than perform extensive resection, to reduce the risk of surgery-related complications. The surgical concept presented in this study may be fairly close to their idea, although extensive anterior decompression at the apex of the OPLL was achieved first in our procedure. Our procedure may be more technically demanding than that described by Lee et al., but offers relatively straightforward decompression of the neural elements, correction of the spinal curvature and local stabilization. In this technical note, anterior surgery was first done, and followed by posterior surgery. Extended ACDF with partial resection of the OPLL can reduce the surgical risk or disadvantage of standard anterior corpectomy. Additional PCDF can also reduce the surgical risk of posterior decompression alone, with or without relatively long fusion. Extended ACDF followed by PCDF was strictly applied for the patients with the neurological condition of severe myelopathy caused

by severely localized OPLL with an occupying ratio more than 60% on sagittal images or crossing the imaginary line between the midpoints of C2 and C7 on sagittal images, a line that we call the “K-line” in this technical note. Although surgical indication is of particular importance, it may be safely applied for the patients with the neurological condition of moderate myelopathy or radiculopathy caused by OPLL with an occupying ratio even less than 60% on sagittal images or not crossing the K-line. Further clinical investigation needs to be done to make its surgical indication clear. In conclusion, this technical note suggested that the anterior and posterior segmental decompression and fusion for severely localized OPLL of the cervical spine can offer satisfactory decompression of the neural elements and stabilization of the cervical spine when applied appropriately, and can be considered among the surgical options.

Conflicts of Interest Disclosure

No funds were received in support of this work. No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript. All authors report no conflicts of interest concerning the materials or methods used in this study or the findings specified in this paper. All authors who are members of The Japan Neurosurgical Society (JNS) have registered online Self-reported COI Disclosure Statement Forms through the website for JNS members.

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