Anterior decompression through a posterior approach for thoracic myelopathy caused by ossification of the posterior longitudinal ligament: a novel concept in anterior decompression and technical notes with the preliminary outcomes

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OBJECTIVE Various surgical procedures are used to manage thoracic myelopathy due to ossification of the posterior longitudinal ligament (OPLL). However, the outcomes of surgery for thoracic OPLL are generally unfavorable in comparison to surgery for cervical OPLL. Previous studies have shown a significant risk of perioperative complications in surgery for thoracic OPLL. Thus, a safe and secure surgical method to ensure better neurological recovery with less perioperative complications is needed. The authors report a novel concept of anterior decompression through a posterior approach aimed at anterior shift of the OPLL during surgery rather than extirpation or size reduction of the OPLL. This surgical technique can securely achieve anterior shift of the OPLL using a curved drill, threadwire saw, and curved rongeur. The preliminary outcomes were investigated to evaluate the safety and efficacy of this technique.

METHODS This study included 10 consecutive patients who underwent surgery for thoracic OPLL. Surgical outcomes, including the ambulatory status, Japanese Orthopaedic Association (JOA) score, and perioperative complications, were investigated retrospectively. In this surgery, pedicle screws are introduced at least three levels above and below the corresponding levels. The laminae, facet joints, transverse processes, and pedicles are then removed bilaterally at levels wherein subsequent anterior decompression is performed. For anterior decompression, the OPLL and posterior portion of the vertebral bodies are partially resected using a high-speed drill with a curved burr, enabling the removal of osseous tissues just ventral to the spinal cord without retracting the dural sac. To securely shift the OPLL anteriorly, the intact PLL and posterior portion of the vertebral bodies cranial and caudal to the lesion are completely resected using a threadwire saw and/or curved rongeur. Rods are connected to the screws, and bone grafting is performed for posterolateral fusion.

RESULTS Five patients were nonambulatory before surgery, but all were able to walk at the final follow-up. The average JOA score before surgery and at the final follow-up was 3.2 and 8.8 points, respectively. Notably, the mean recovery rate of JOA score was 72%. Furthermore, no patients showed neurological deterioration postoperatively.

CONCLUSIONS The surgical technique is a useful alternative for safely achieving sufficient anterior decompression through a posterior approach and may consequently reduce the risk of postoperative neurological deterioration and improve surgical outcomes in patients with thoracic OPLL.

KEYWORDS ossification of the posterior longitudinal ligament; thoracic spine; myelopathy; anterior decompression; surgical technique

Various surgical procedures have been applied to treat thoracic myelopathy due to ossification of the posterior longitudinal ligament (OPLL). Many different methods, including posterior decompressive laminectomy with or without instrumented fusion,1–4 anterior decompression via a posterior/anterior approach,5–7 and circumferential decompression via a combined posterior-anterior approach,8,9 have been developed for the surgical treatment of thoracic OPLL. However, surgical outcomes of myelopathy caused by OPLL in the thoracic spine are...
removing the ossified PLL. However, the thoracic spine spondylosis due to a backward shift of the spinal cord without the anterior side of the spinal cord. Therefore, posterior decompresive laminectomy is less effective at inducing a backward shift of the dural sac to relieve spinal cord compression.

In theory, anterior decompression should be more effective at relieving spinal cord compression due to thoracic OPLL. However, anterior decompression via an anterior approach for thoracic OPLL is technically demanding, and significant risks of surgical complications have been reported. Anterior decompression through a posterior approach was first reported by Ohtsuka et al. in 1983. Although several modified surgical procedures have been reported, anterior decompression via a posterior approach also carries a certain risk of surgical complications, including CSF leakage and postoperative neurological deterioration. The ossified PLL strongly adheres to the posterior ribs obstruct surgical devices. Thus, in the treatment of thoracic OPLL, a safe and secure surgical method of anterior decompression should be developed to ensure better neurological recovery and prevent perioperative complications.

Recently, we developed a surgical technique using an extended curved drill, threadwire saw, and curved rongeur to achieve anterior decompression through a posterior approach. This technique is based on a novel concept that is completely different from the conventional anterior decompression procedures. The aim of our surgical technique is to achieve the anterior shift of the OPLL (as opposed to extirpation or size reduction of the OPLL) during surgery, which enables us to complete anterior decompression safely and securely. Because the OPLL is anatomically connected to the PLL at the cranial and caudal sides, and is frequently attached to the vertebral bodies, the continuity between the OPLL and the surrounding structures needs to be broken to obtain the anterior shift of the OPLL during surgery. Importantly, in our surgery, complete resection of the surrounding structures on all four sides of the OPLL is performed to obtain the anterior shift of the OPLL without the extirpation or size reduction of the ossified lesion. To our knowledge, no previous studies have clearly described a surgical maneuver to break the continuity between the OPLL and the surrounding tissues. We herein report our surgical technique to achieve the anterior shift of the OPLL and the preliminary outcomes in order to assess the safety and efficacy of our surgical procedure.

### Methods

#### Patient Population

This study involved 10 consecutive patients (4 men and 6 women, mean age 53 years) with thoracic myelopathy caused by OPLL who underwent anterior decompression with instrumentation through a posterior approach at Tohoku University Hospital between January 2017 and June 2019. The IRB of our institution approved this study. Informed consent was obtained from all patients to participate in this study. Baseline characteristics such as the age, gender, BMI, and medical history for each patient are summarized in Table 1. The average postoperative follow-up period was 27 months (range 17–40 months). The radiological findings and surgical outcomes were retrospectively reviewed in all participants.

### Assessing the Radiological Findings and Clinical Outcomes

The morphology of thoracic OPLL was evaluated on multiplanar reconstruction CT and classified as the linear, beaked, continuous waveform, continuous cylindrical, or mixed type, according to the classification established by

#### TABLE 1. Demographic data and radiological findings in all patients

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>BMI (kg/m²)</th>
<th>Past Medical History</th>
<th>Type of OPLL</th>
<th>Level of OPLL</th>
<th>Occupying Ratio (%)</th>
<th>Coexisting OLF</th>
<th>FU (mos)</th>
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<tbody>
<tr>
<td>1</td>
<td>43, F</td>
<td>50</td>
<td>HT</td>
<td>b + c + d</td>
<td>T3–8</td>
<td>71</td>
<td>Yes</td>
<td>40</td>
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<tr>
<td>2</td>
<td>69, F</td>
<td>19</td>
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<td>d</td>
<td>T3–7</td>
<td>78</td>
<td>Yes</td>
<td>36</td>
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<td>b + d</td>
<td>T6–8</td>
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<td>30</td>
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<tr>
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<td>b + d</td>
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<td>30</td>
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<td>b + d</td>
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<td>24</td>
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<td>27</td>
<td>HT</td>
<td>b + d</td>
<td>T2–4</td>
<td>82</td>
<td>Yes</td>
<td>26</td>
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<td>8</td>
<td>45, M</td>
<td>32</td>
<td>HT, DM</td>
<td>d</td>
<td>T7–8</td>
<td>76</td>
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<tr>
<td>9</td>
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<td>28</td>
<td>HT, DM</td>
<td>b</td>
<td>T11–12</td>
<td>74</td>
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<td>DM</td>
<td>b + c</td>
<td>T4–7</td>
<td>66</td>
<td>Yes</td>
<td>17</td>
</tr>
</tbody>
</table>

DM = diabetes mellitus; FU = follow-up; HT = hypertension.

The type of OPLL was classified as the linear (a), beaked (b), continuous waveform (c), continuous cylindrical (d), or mixed type.

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The Research Group for Ossification of the Spinal Ligament sponsored by the Japanese Ministry of Health, Labour and Welfare. The vertebral levels with OPLL and the OPLL-occupying ratio in the canal diameter were measured on multiplanar reconstructed CT. Concomitant ossification of the ligamentum flavum (OLF) at the corresponding levels was also evaluated. Levels of anterior decompression, levels of spinal fusion, operative duration, intraoperative blood loss, and perioperative complications were reviewed from the medical records.

The severity of thoracic myelopathy was evaluated using the Japanese Orthopaedic Association (JOA) score before surgery and at the final follow-up. To evaluate neurological deficits due to thoracic myelopathy, the JOA score for cervical myelopathy was modified to exclude the assessment of upper extremity functions (maximum 11 points). In addition, the recovery rate (%) was calculated using the following formula: 

\[
\text{Recovery rate} = \left( \frac{\text{postoperative JOA score} - \text{preoperative JOA score}}{11 - \text{preoperative JOA score}} \right) \times 100.
\]

According to the recovery rate, we classified the surgical outcomes as excellent (100%–75%), good (74%–50%), fair (49%–25%), unchanged (24%–0%), and deteriorated (< 0% decrease in score). The modified Frankel grade was evaluated to assess the neurological function and ambulatory status before surgery, at 3 weeks after surgery, and at the final follow-up. In this grading system, grade A was defined as “complete motor and sensory loss,” grade B was defined as “preserved sensory only,” grade C was defined as “preserved motor loss less than fair grade (nonfunctional for any useful purpose),” and grade E was defined as “normal.” Grade D was divided into three subgrades as follows: D1, preserved motor ability at the lowest functional grade (the patient can walk with support less than 100 meters and generally uses a wheelchair); D2, preserved motor ability at a midfunctional grade and able to walk stably with a cane, handrail and/or lower leg braces; and D3, preserved motor ability at a high functional grade and able to walk without any support.

### Surgical Procedure

Intraoperative spinal cord monitoring is used during surgery. The patient is placed prone. A midline skin incision is made, and the posterior elements of the spine are exposed. Pedicle screws are introduced at least three levels below and above the corresponding levels. A bent rod is connected to the screws unilaterally to stabilize the affected levels in the thoracic spine (Fig. 1A). The rod, which is bent into an upward-protruding shape (ohm-sign rod), is used to obtain a sufficient working space under the rod. Decompressive laminectomy is performed at the corresponding levels (Fig. 1B). The posterior elements, including the facet joints, transverse processes, and pedicles, are then resected bilaterally at the levels where subsequent anterior decompression is performed (Fig. 1C).

For anterior decompression, the OPLL and a posterior portion of the vertebral bodies are partially resected using a high-speed drill with a curved burr (Midas Rex,
Medtronic Sofamor Danek; Fig. 2A and 3A). The use of a curved burr facilitates the removal of the osseous tissues just anterior to the spinal cord without retracting the thecal sac. The removal of the rib heads or the costovertebral joints is usually not necessary, while the posterior cortex of the rib is partially resected only when the posterior rib is in the way of the drill. The rotating shaft of the curved burr is completely covered with a long burr guard (an outer sleeve; Fig. 2A and 3A). Partial resection of the OPLL and vertebral bodies is performed on the bilateral sides.
to make a bone tunnel under the targeted OPLL. The use of intraoperative navigation is not necessary, but it can be helpful to monitor the location of the bur during vertebral body resection.

The OPLL is anatomically connected to the PLL, which is attached to the posterior surface of the vertebral bodies cranially and caudally. To securely disengage the OPLL from the surrounding tissues, the PLL and posterior part of the vertebral bodies are completely resected using a commercially available threadwire saw (0.36-mm diameter, 700-mm length; Stryker Japan KK) and/or a curved rongeur (Tanaka Medical Instruments Co., Ltd.; Fig. 2B, 3B, and 3C). These resections are performed at the unaffected levels (Fig. 2B), where OPLL is not present and the PLL is not severely adhered to the dura mater. The cranial and caudal edges of the OPLL should be carefully evaluated on preoperative CT to confirm the unaffected levels. If PLL resection is performed at the unaffected levels, the risk of CSF leakage due to dural tear and spinal cord injury during anterior decompression can be minimized. Prior to resection of the PLL, a small and curved spatula is carefully inserted between the dural sac and the PLL to release and protect the dura mater (Fig. 3B and C).

For the placement of the threadwire saw, a dedicated and commercially available polyethylene catheter (1.2-mm diameter, 200-mm length; Stryker Japan KK), which is a flexible thin tube, is introduced into the narrow epidural space under the dural sac. Then, the threadwire saw is inserted into the catheter. After the removal of the catheter, the threadwire saw is passed through the bone tunnel under the PLL (Fig. 2B). During resection, the threadwire saw is placed under the curved spatula and is pushed ventrally using a knot-pusher to prevent the compression of the spinal cord and dural tear. In our surgical procedure, the nerve roots are not ligated or sacrificed to perform anterior decompression (Video 1).

VIDEO 1. Clip showing the anterior decompression through a posterior approach. Copyright Haruo Kanno. Published with permission. Click here to view.

Following the completion of anterior decompression (Fig. 2C), we confirm that the remaining OPLL has shifted ventrally and that the spinal cord is floating from the ossified lesion using intraoperative ultrasonography. The remaining OPLL spontaneously shifts to the ventral side follow-
Anterior decompression through a posterior approach was performed at two levels in 4 cases, three levels in 4 cases, and four sides of the OPLL. Therefore, no specific maneuvers are usually required to deliver the remaining OPLL into the cavity created within the vertebral bodies. Rods are bent to a similar sagittal contour to the patient’s spinal alignment and then connected to the pedicle screws. Cobalt-chromium alloy rods of 5.5 mm in diameter are used. It is generally unnecessary to perform a dekphosis maneuver using posterior instrumentation to induce indirect decompression of the cord. Autograft from the local bone of resected laminae and spinous and transverse processes is performed to achieve posterolateral fusion.

In our surgical procedure, there are no technical differences between the location of the OPLL in the thoracic spine (e.g., upper and lower thoracic levels). However, we do not perform our anterior decompression procedure in patients with continuous OPLL spreading from the thoracic level to the cervical level because of the small size of the vertebral body in the cervical spine and the existence of the vertebral artery and the cervical nerve root supplying the upper limb. Our surgery can, however, be performed for thoracic OPLL spreading to the lumbar spine if anterior decompression is needed.

Results

In the classification of OPLL, 8 patients (80%) had beak-type OPLL (Table 1). The mean OPLL-occupying ratio in the canal diameter was 75% ± 9%. Concomitant OLF at the corresponding levels was observed in 9 cases (90%). Anterior decompression through a posterior approach was performed at two levels in 4 cases, three levels in 4 cases, four levels in 1 case, and five levels in 1 case (Table 2). The mean operative duration was 540 ± 106 minutes, and the average intraoperative blood loss was 940 ± 498 ml.

For ambulatory status evaluated using the modified Frankel grading system, 8 patients (80%) started to walk with support. The average intraoperative blood loss was 940 ± 498 ml. The mean operative duration was 540 ± 106 minutes, and the average intraoperative blood loss was 940 ± 498 ml. The mean JOA score before surgery and at the final follow-up was 3.2 ± 1.3 and 8.8 ± 1.0 points, respectively. Notably, the average recovery rate of the JOA score was 72% ± 13%. The surgical results were classified as excellent in 6 cases (60%) and good in 4 cases (40%). There were no cases classified as fair, unchanged, or deteriorated.

Importantly, no patient showed neurological deterioration postoperatively. The nerve root was not ligated or sacrificed during surgery in any cases. Although no clinical symptoms developed postoperatively, a CSF leak due to a small dural tear occurred in 2 patients as follows: dural tears during resection of OLF in 1 patient, and during dissection of epidural adhesion between the dura mater and the cranial edge of the OPLL in the other. Delayed postoperative paralysis due to epidural hematoma or other factors was not observed in all patients. No patients had nonunion or instrumentation failure after surgery.

Illustrative Case

History and Examination Findings

A 55-year-old woman (case 7) presented with numbness in her bilateral lower extremities and difficulty walking. Muscle weakness was detected in the left ilioptasos muscle and the bilateral tibialis anterior and extensor hallucis longus muscles. Her patella tendon reflex and Achilles tendon reflex were exaggerated bilaterally. Pinpricks and light touch sensations indicated hypoesthesia below the T8 level. MRI revealed the compressed spinal cord at the T3–4 level (Fig. 4A). CT showed beaked OPLL at the T2–4 level (Fig. 4D). The patient was diagnosed with thoracic myelopathy caused by OPLL. The JOA score was 4 of 11 points.

Surgical Treatment

Anterior decompression through a posterior approach was performed at the T2–4 level. First, the laminae and transverse processes of C5–T9 were exposed. Pedicle screws were placed bilaterally at the C5–T1 and T6–9 vertebrae. The lower half of the T1 lamina and the lami-
FIG. 4. MRI and CT findings before and after surgery and at the final follow-up. A: Sagittal and axial T2-weighted MR images obtained before the operation show the compressed spinal cord at the T3–4 level (arrow and arrowhead). B and C: MRI findings show that the spinal cord was sufficiently decompressed at the T3–4 level (arrows and arrowheads) after surgery (B) and at the final follow-up (C). D: Sagittal and axial CT findings show the beak-type OPLL (arrow) at the T3–4 level. E: The anterior shift of the remaining OPLL was observed after surgery (arrow). F: At the final follow-up, the posterior part of the vertebral bodies and the ossified lesion were fused at the T2–4 levels (arrow).
nae at T2–5 were resected for posterior decompression of the spinal cord. The facet joints, transverse processes, and pedicles were removed bilaterally at the T2–4 levels. Following posterior decompression, intraoperative ultrasonography showed that severe compression of the spinal cord due to OPLL still remained (Fig. 5A and C). Subsequently, the OPLL and a posterior part of the vertebral bodies were partially resected at the T2–4 levels using a high-speed drill with a curved burr. The PLL and posterior portion of the vertebral bodies were completely resected using a threaded saw and a curved rongeur at the T2 and T4 levels. Intraoperative ultrasonography confirmed sufficient anterior decompression and pulsation of the spinal cord (Fig. 5B and D). The nerve root was not sacrificed during surgery (Fig. 6A). Posterior instrumentation was placed from C5 to T9 (Fig. 6B and C). Autograft from the local bone was performed for posterolateral fusion.

**Postoperative Course**

Postoperative MRI clearly showed that the spinal cord was no longer compressed (Fig. 4B and C). The anterior shift of the remaining OPLL was confirmed on CT (Fig. 4E). No postoperative neurological deterioration was observed. One week after surgery, she started to move in a wheelchair. Gait training with a walker was started at 2 weeks, and she became able to walk with a cane at 3 weeks after surgery. At 24 months after surgery, the motor weakness and numbness of the bilateral lower limbs had improved to normal, and she was able to walk without any support. The JOA score improved to 10 of 11 points, resulting in a recovery rate of 86%. Bone union was achieved with no implant failure (Fig. 4F).

**Discussion**

Although a lot of surgical procedures have been performed for thoracic OPLL, various perioperative surgical complications remain a significant problem. 

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**FIG. 5.** Intraoperative ultrasonography before and after anterior decompression. **A and C:** Following laminectomy before anterior decompression, sagittal (A) and axial (C) images of ultrasonography showed severe compression of the spinal cord due to the OPLL at the T3–4 level (arrows). **B and D:** After completing anterior decompression, sufficient anterior decompression and pulsation of the spinal cord were confirmed (arrows).

**FIG. 6.** Intraoperative photograph and postoperative radiographs. **A:** Photograph after anterior decompression and instrumentation shows that the nerve roots were preserved at the lesion site. **B and C:** Anteroposterior (B) and lateral views (C) of plain radiographs after surgery. Figure is available in color online only.
Especially in surgeries for anterior decompression via an anterior/posterior approach, the risk of postoperative neurological deterioration has been reported to be high.\textsuperscript{1,2,13,17} Because the OPLL adheres strongly to the ventral aspect of the dural sac and the dura mater is frequently ossified, surgical maneuvers for removal or size reduction of the ossified PLL are technically difficult and are associated with a risk of spinal cord injury.\textsuperscript{13} However, anterior decompression is theoretically more effective for relieving spinal cord compression in comparison to posterior decompression because of the anatomical and pathological features of the thoracic OPLL. These issues related to surgical complications and the decompressive effect create a clinical dilemma in the treatment of thoracic OPLL. Therefore, a safe and secure anterior decompression technique needs to be developed to ensure better neurological recovery and prevent perioperative complications.

Recently, we developed a surgical procedure that is based on a novel concept of anterior decompression for thoracic OPLL. This anterior decompression technique does not require extirpation or size reduction—so-called “floating” of the OPLL—which has been an aim of conventional anterior decompression procedures.\textsuperscript{5,7,13,16,26,27} The goal of our surgical technique is to achieve the anterior shift of the bone block that includes the OPLL and the posterior part of the vertebral bodies without the removal or size reduction of the OPLL. This unique concept enables us to safely and securely achieve anterior decompression, even if the OPLL shows severe adhesion to the dura mater. To achieve sufficient anterior shift of the OPLL, in addition to the osseous tissues on the bilateral and ventral sides of the targeted OPLL, the PLL located on the cranial and caudal sides of the ossified lesion must be completely resected. In our operation, the application of unique surgical devices, including a curved drill, threadwire saw, and curved rongeur, allows us to accomplish adequate anterior decompression with minimal risk of surgical complications, as discussed below.

In previous studies, various anatomical structures, such as the nerve root, transverse process, facet joint, costal head, and rib, were resected or sacrificed to perform anterior decompression through a posterior approach.\textsuperscript{5,12,17,28} These structures around the spinal canal were removed to visualize the border between the dural sac and OPLL and to achieve anterior decompression using a high-speed drill safely within a narrow operating field.\textsuperscript{5,12} In recent years, a high-speed drill system with a diamond burr on a long, curved shaft has been widely used in various surgeries.\textsuperscript{22,23,29,30} A long, curved burr enables easy access to the lesion site and safe removal of the bone within a narrow operating field.\textsuperscript{31} However, to our knowledge, a drill with a long, curved burr has never been used in surgeries for thoracic OPLL. In our surgery, the use of a long, curved burr facilitates access to the postero medial part of the vertebral body, which is located just anterior to the OPLL and the spinal cord. Removal of the rib heads or costovertebral joints is not required for anterior decompression because the posterior rib usually does not block the curved drill. In addition, the use of a curved drill can minimize the amount of bone resection of the vertebral body, which contributes to maintaining the stability of the anterior column after surgery.\textsuperscript{32} Furthermore, the rotating shaft of the curved burr is completely covered with a narrow, nonrotating tube, so the risks of dural tear and nerve root injury caused by the drill are minimized. Thus, the use of a long, curved drill resulted in safer and easier procedures and reduced the surgical invasiveness for anterior decompression through a posterior approach in the thoracic spine.

Several studies have suggested that total resection of the ossified PLL is unnecessary during anterior decompression via a posterior approach for thoracic OPLL.\textsuperscript{10,26} The pressure of CSF can induce the gradual anterior migration of the residual thin OPLL and consequently provide an additional decompressive effect during the postoperative course.\textsuperscript{16,26} However, the OPLL is anatomically connected to the PLL and is frequently attached to the posterior cortex of the vertebral bodies at the cranial and caudal sides of the lesion site. Therefore, to obtain secure anterior shift of the OPLL during surgery, the continuity between the OPLL and the surrounding structures needs to be broken. To our knowledge, no previous studies have mentioned an actual surgical maneuver to break the continuity between the OPLL and the intact PLL or the posterior surface of the vertebral body on the cranial and caudal sides.\textsuperscript{7,16,26} In our surgery, we developed a novel technique to allow sufficient anterior shift of the OPLL using a threadwire saw and curved rongeur. This technique enables us to easily and securely resect the intact PLL and posterior cortex of the vertebral bodies at cranial and caudal sides to the OPLL. In addition, if this procedure is performed at unaffected levels where the spinal cord is not compressed or the dura matter does not adhere to the surrounding tissue, the ligament and bone can be removed more safely. Performing resection at the unaffected levels can minimize the risks of CSF leakage and spinal cord injury during anterior decompression. Consequently, our technique safely induces sufficient anterior shift of the OPLL immediately after surgery and provides secure anterior decompression without extirpation or size reduction of the OPLL.

In the previous studies, ligation of the thoracic nerve roots has occasionally been applied to specific spinal surgeries, such as total spondylectomy for spinal tumor\textsuperscript{33} and anterior decompression through a posterior approach for thoracic OPLL.\textsuperscript{5,26} Several studies have suggested that sacrificing the thoracic nerve root and lifting up the ligated root can help visualize the ossified PLL under the dural sac, especially when extirpation or size reduction of the OPLL is performed during anterior decompression through a posterior approach.\textsuperscript{5,26} However, bilateral nerve root ligation at multiple levels carries a risk of ischemic spinal cord injury.\textsuperscript{5,14} According to the previous studies,\textsuperscript{4,34,35} nerve root ligation in the thoracic spine should be limited to three pairs or fewer to prevent ischemic injury of the spinal cord. Therefore, the number of spinal levels for anterior decompression through a posterior approach may be limited if nerve root ligations are performed at the affected levels.\textsuperscript{5} Indeed, the previous studies have suggested that anterior decompression with nerve root ligations should be indicated for thoracic OPLL at three consecutive vertebral levels or fewer.\textsuperscript{5,14,26} Importantly, in our surgical method for anterior decompression, the ligation of the thoracic nerve root was not required, as there was no
need to visualize the ossified PLL under the dural sac to perform extirpation or size reduction of the OPLL. Preserving the nerve roots at multiple levels can help avoid ischemic spinal cord injury.\textsuperscript{24,35} We performed anterior decompression through a posterior approach at more than three vertebral levels in two patients (cases 2 and 10) with no postoperative neurological deterioration. Therefore, our surgical technique may help expand the indication for anterior decompression through a posterior approach to treat patients with thoracic OPLL at multiple levels. In addition, several previous studies have suggested that sacrifice of the nerve root and traction at the ligated nerve root can induce a risk of minor nerve root avulsion and postoperative CSF leak.\textsuperscript{36,37} Postoperative CSF leak may result in various complications, including wound infection and neurological deficits related to the compression of neural elements.\textsuperscript{11,36,38} Therefore, the preservation of the nerve root using our surgical technique might help prevent CSF leak from worsening the postoperative clinical outcomes.

According to previous studies, the average recovery rate of neurological functions evaluated by the JOA score has been reported to range from 45.4\% to 55\%\textsuperscript{10,11} in various surgeries for thoracic OPLL. In anterior decompression through a posterior approach, the average recovery rate was reported to range from 28.8\% to 63.1\%.\textsuperscript{1,11,13,14} Notably, the average recovery rate of the JOA score in our series (72\%) was higher than that in previous reports. All 5 patients who were nonambulatory before surgery were able to walk at the final follow-up examination. A multicenter study in Japan showed that the incidence of postoperative motor strength aggravation in the lower extremities was 32.2\% and the mean period until the recovery of motor palsy to the preoperative motor status was 2.7 months.\textsuperscript{10} In contrast, our surgical procedure caused no postoperative neurological deterioration. Furthermore, 8 (80\%) of the 10 cases in our study became able to walk with support within 3 weeks after surgery. Our surgical technique may be considered to safely provide sufficient anterior decompression, and to consequently improve the rate of JOA score recovery and reduce the risk of postoperative neurological deterioration in patients with thoracic OPLL.

Notably, anterior decompression surgery for thoracic OPLL is technically demanding because of the anatomical complexity of the thoracic spine and the fragility of the thoracic spinal cord. Therefore, a careful preoperative assessment, meticulous surgical planning, and precise technique are crucial for obtaining optimal outcomes, even when our anterior decompression technique is applied in the surgical treatment of thoracic OPLL.

Conclusions

We developed an anterior decompression technique for thoracic OPLL that does not require extirpation or size reduction of the ossified PLL. Our technique enables the intact PLL to be easily and securely resected on the cranial and caudal sides of the targeted OPLL, providing sufficient anterior shift of the OPLL immediately after surgery. The application of unique surgical devices, including a curved drill, threadwire saw, and curved rongeur, allows adequate anterior decompression to be accomplished with minimal risk of surgical complications. This surgical procedure can achieve safe and sufficient anterior decompression through a posterior approach without postoperative neurological deterioration and provide favorable surgical outcomes in patients with thoracic OPLL.

References

Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Kanno, Aizawa. Acquisition of data: Kanno, Aizawa, Hashimoto. Analysis and interpretation of data: Kanno, Aizawa, Hashimoto. Drafting the article: Kanno, Aizawa. Critically revising the article: all authors. Approved the final version of the manuscript: all authors.

Supplemental Information

Videos


Previous Presentations

Portions of this work were presented in abstract form as proceedings at the 49th Annual Meeting of the Japanese Society for Spine Surgery and Related Research, in Kobe, Japan, September 7–9, 2020.

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