Acta Med. Okayama, 2022
Vol. 76, No. 6, pp. 743-748

Acta Medica Okayama
http://escholarship.lib.okayama-u.ac.jp/amo/

Case Report

Posterolateral Floating Technique for the Thoracic Ossification of the Posterior Longitudinal Ligament with Navigation: A Technical Note

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We describe a floating technique via a posterolateral approach with intraoperative O-arm navigation to facilitate decompression of the spinal cord in thoracic myelopathy due to severe ossification of the posterior longitudinal ligament (OPLL). A 62-year-old man with myelopathy due to thoracic OPLL had left-leg muscle weakness, urinary disturbance, and spastic gait. Bilateral leg pain and gait disturbance had persisted for 2 years. He was successfully treated by the posterolateral OPLL floating procedure and posterior pedicle fixation under O-arm navigation. At a 2-year follow-up, manual muscle testing results and sensory function of the left leg had recovered fully. His cervical Japanese Orthopedic Association score had improved from 5/12 to 11/12. The novel intraoperative O-arm navigation-guided posterolateral floating procedure for thoracic OPLL is effective for achieving precise decompression and strong fixation with a posterior approach only and can provide an excellent result for severe thoracic OPLL without the risk of adverse events from intraoperative radiation.

Key words: ossification of the posterior longitudinal ligament, floating method, navigation surgery, C-arm free

One of the major etiologies for thoracic myelopathy is thoracic ossification of the posterior longitudinal ligament (OPLL), which is characterized by ectopic calcification of the posterior longitudinal ligament. The incidence of thoracic OPLL in the Japanese population is approx. 0.8% [1,2]. Conservative treatment is ineffective for thoracic myelopathy due to OPLL, and surgical intervention has been established as the most effective treatment [3]. Surgical procedures for thoracic OPLL are divided into anterior, posterior, and posterolateral approaches [4-8].

Anterior approach surgery is ideal because this procedure can directly decrease the ventral compression to the spinal cord for patients with large OPLL. However, in a patient with thoracic OPLL the removal of the OPLL from the anterior direction is technically demanding and is associated with a high rate of complications [4,5]. There are several reports of posterior fixation or dekyphosis fixation for this condition [9-12]. The clinical outcomes of posterior fixation are generally satisfactory if the OPLL is small and the spinal compression is not very severe [6,7]. Poor improvement that is due to insufficient decompression or a severe complication such as paraplegia has been noted [13].

An excellent procedure to decompress OPLL from the posterolateral approach was described by Kato *et al.* [14]. We introduce herein a novel technique for decompressing the spinal cord safely and precisely: intraoperative O-arm navigation to assist a posterolateral

Received April 11, 2022; accepted June 16, 2022.
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Conflict of Interest Disclosures: No potential conflict of interest relevant to this article was reported.

OPLL floating procedure for the treatment of severe thoracic OPLL.

Case presentation

A 62-year-old man with myelopathy due to thoracic OPLL was referred to our hospital. He had muscle weakness in his left leg, urinary disturbance, and spastic gait. His activities of daily living had been restricted by bilateral leg pain and gait disturbance for 2 years. On examination, the patient was able to walk using a T-cane, showing brachybasia and spasticity of the legs. He needed some support to use stairs and reported back pain on movement and hyperesthesia in the bilateral lower limbs. His manual muscle test (MMT) scores were grade 4 for bilateral lower limbs, and hyperreflexia was detected in both lower limbs. His Japanese Orthopedic Association (JOA) score was 5/12.

Institutional Review Board Statement. The study was conducted in accord with the guidelines of the Declaration of Helsinki and approved by Okayama Rosai Hospital (approval no. 345).

Preoperative imaging. Magnetic resonance imaging (MRI) indicated severe spinal cord compression in both the cervical and thoracic regions (Fig. 1A). A lateral radiogram demonstrated severe OPLL at the C4, 5 and C7, T1, T2 levels. Preoperative computed tomography (CT) revealed a huge ossification mass occupying the posterior wall of the cervical and thoracic areas (Fig. 1B-E).

Surgery. The posterolateral OPLL floating procedure and posterior pedicle fixation were performed under the guidance of O-arm navigation (Fig. 2). Neuromonitoring is routinely used to prevent neurological complications during this procedure. With the standard posterior approach on a Jackson frame to enable O-arm CT, the appropriate levels of the posterior aspect of thoracic spine were exposed. The reference frame was attached to the most distal exposed spinous process (T5). The O-arm was subsequentially positioned, and three-dimensional (3D) reconstructed images were obtained and transmitted to the StealthStation navigation system Spine 7R (Medtronic, Memphis, TN, USA).

First, pedicle screws (C6, C7, T3, T4) were inserted under O-arm navigation guidance. A navigated high-speed burr was then used to make gutters of bilateral laminae of T1-T3, which were used to perform the floating method bilaterally in width and to the posterior cortex in depth. The laminectomy was then performed, and intercostal nerves of T2 and T3 were ligatured and cut (Fig. 3A). The dura was elevated gently to hold the nerve roots and make bilateral gutters with the navigated curved high-speed burr (Fig. 3B).

During the bone resection, a navigated ball-pointed probe was used to check the depth and position of the trough, the location of the OPLL, and the borders of the ossification mass (Fig. 4). Using real-time feedback, the surgeon was able to adjust the procedure to decompress the spinal cord and avoid injury to other important structures. This finally left the patient's OPLL adherent to the dura and floating as a small, isolated bone island. After the completion of this procedure, another O-arm scan was obtained to check the OPLL's position.

The rods were bent to reduce the thoracic kyphosis and to move the spinal cord posteriorly. The properly contoured rods were finally fixed and the wound was closed. The surgical time was 325 min, and the estimated blood loss was 480 mL. The patient experienced no postoperative complications such as cerebrospinal fluid leakage, surgical site infection, or neurological compromise.

Postoperative imaging. Postoperative radiograms showed that the patient's spinal alignment was in slight dekyphosis. Postoperative CT demonstrated that the OPLL was floating and all pedicle screws had been inserted correctly (Fig. 5).

One-year follow-up. At the 2-year follow-up, the patient's symptoms had resolved, and radiograms showed no change of spinal alignment (Fig. 6).

Discussion

As noted earlier, the incidence of thoracic OPLL in the Japanese population is ~0.8% [1]. In general, myelopathy is caused by static and/or dynamic compression mechanisms. As the thoracic spine is less mobile because of the rigid connection with the thoracic cage, myelopathy tends to occur due to static compression by an OPLL mass itself. Conservative treatment is thus usually ineffective [3]. Anterior-approach surgery can directly decrease the ventral compression to the spinal cord for patients with a large OPLL, but the removal of OPLL from the anterior direction is technically demanding and is associated

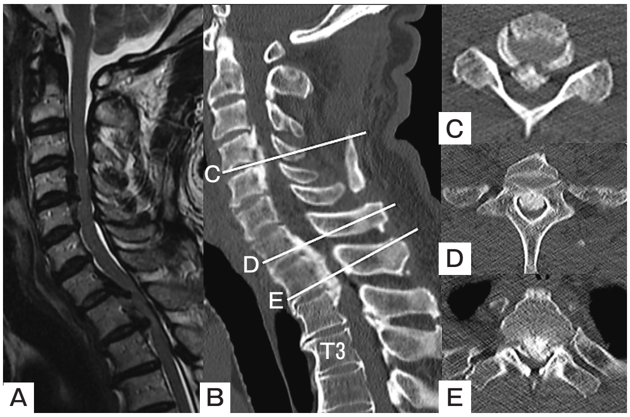

Fig. 1 The patient was a 62-year-old man with myelopathy of the thoracic OPLL. **A**, Mid-sagittal T2-weighted MRI; **B**, Mid-sagittal reconstruction CT; **C**, Axial CT at C4/5; **D**, Axial CT at C7/T1, axial CT at T1/2.

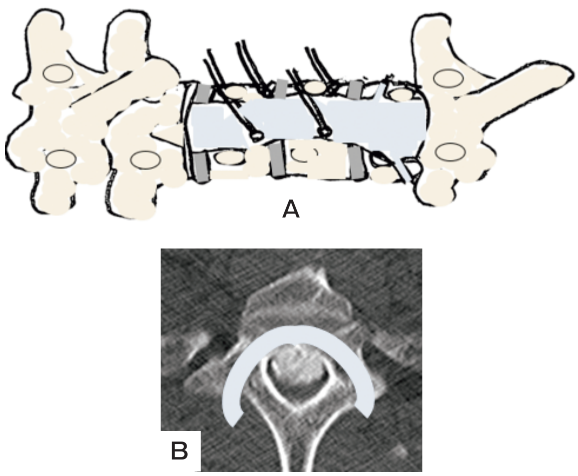

Fig. 3 Surgical technique. **A**, Surgical schema; **B**, Posterolateral tunnel.

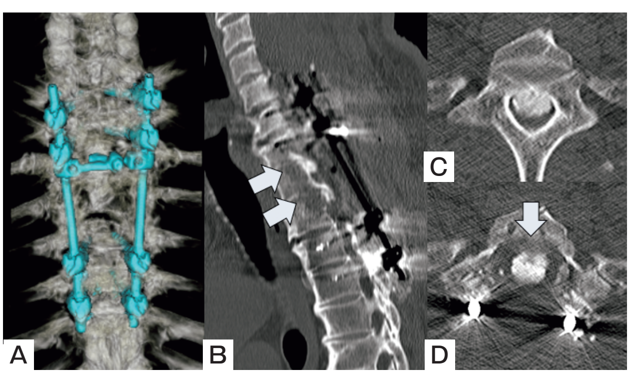

Fig. 5 Postoperative CT. **A**, 3D CT; **B**, Mid-sagittal reconstruction CT; **C**, Preoperative axial CT at T1; **D**, Postoperative axial CT at T1 showing the floating OPLL and the completely decompressed spinal cord.

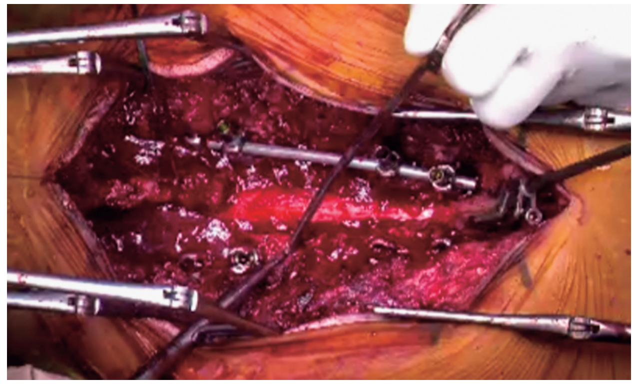

Fig. 2 Intraoperative view. A temporal rod was applied to protect against unintentional spinal cord damage.

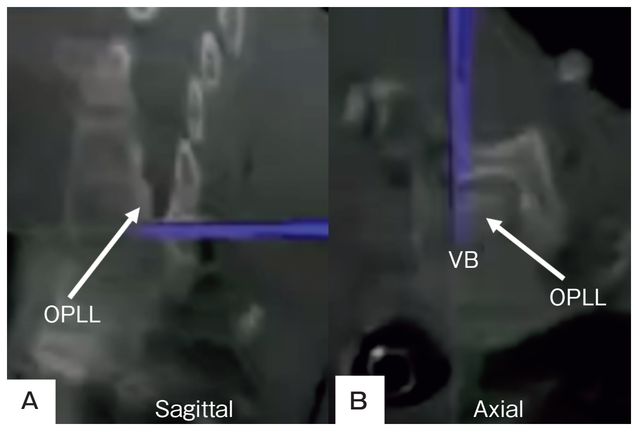

Fig. 4 Intraoperative CT. **A**, Sagittal reconstruction CT; **B**, Axial CT.

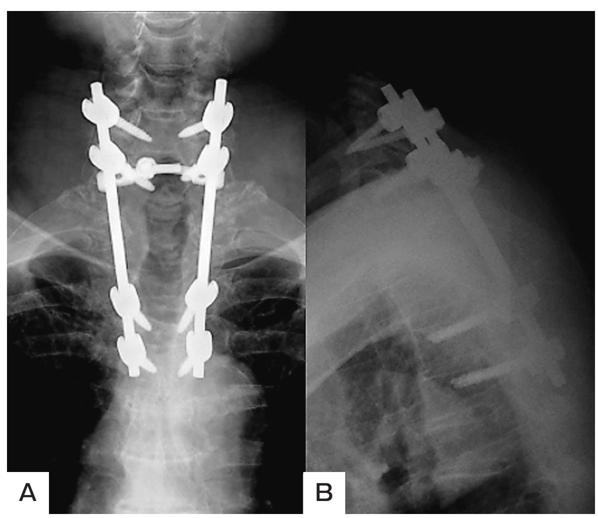

Fig. 6 Follow-up cervicothoracic radiograms. **A**, Anteroposterior radiogram; **B**, Lateral radiogram.

with a high rate of complications [4, 5]. The posterior approach is simple and more familiar in the current era. Poor improvement due to insufficient decompression or a complication such as paraplegia in cases of severe thoracic OPLL has been noted [13]. Circumferential decompression via a posterior approach alone [8, 14-20], staged decompression surgery [15, 16, 18], and circumferential decompression via combined posterior and anterior approaches [21, 22] have been described.

Kato *et al*. noted that the posterior circumferential OPLL plaque floating technique seems to be a safe and more effective mode of treatment for the thoracic beak type of OPLL [14]. In their technique, an extensive posterior space is created by removing the posterior elements and pedicle for the adequate visualization of the OPLL, and a posterior gutter is created in the vertebral body to give space for the settling of OPLL plaque. This provides adequate decompression of the spinal cord without removing the OPLL plaque. The likelihood of neurological worsening, dural tear and its complications that may occur during plaque separation, and cord decompression procedure is reduced.

In our novel technique, we used the similar principle of OPLL plaque floating, but the creation of a gutter with the help of a navigation tool enhances the real-time feedback for the bone cutting and trough creation. Bone resection is carried out with a navigation-guided angled high-speed burr, and a navigation ball-pointed probe is used to check the depth and position of the trough, the location of the OPLL, and the borders of the ossification mass. Using real-time feedback, the surgeon can adjust the procedure to decompress the spinal cord and avoid injury to other important structures. This finally leaves the OPLL adherent to the dura floating as a small, isolated bone island. The navigation guidance also contributes to the accurate placement of the pedicle screws to minimize the risk of complications related to pedicle screw placement [23, 24].

Seki *et al*. described a method for circumferential decompression with the help of micro-endoscopy for the removal of the plaque [25]. This technique poses a steep learning curve for using micro-endoscopy in the thoracic spine. Kim *et al*. described the use of an ultrasonic osteotome for the direct removal of a beak type of thoracic OPLL [26]. In our technique, we use a navigation tool which itself is a unique and safe method for the surgical management of thoracic OPLL by the posterior approach only. This O-arm navigation-guided procedure is radiation-free for the surgeons and operation room staff. We usually use a small field of view and a low-dose mode for the O-arm 3D scan in order to reduce the radiation dose to the patient per se. One O-arm scan is estimated to deliver 9 mGy of radiation, equivalent to 35 sec of fluoroscopy [27].

Intraoperative ultrasound [7, 8, 20, 28] is advocated to reconfirm the adequacy of decompression. In our technique, we perform another O-arm scan to check OPLL positions and spinal cord decompression. As a routine part of complex spinal surgery, we are also in favor of using electrophysiological neuromonitoring [13, 28, 29] to avoid intraoperative complications such as spinal cord damage by direct injury and compression.

The major limitation of this study is that it describes a single patient and is retrospective in nature. However, this was a prototype case of posterior-only circumferential decompression of the beak type of thoracic OPLL under the guidance of O-arm navigation. We advocate a further multicenter prospective study of the novel navigation-guided posterior-only circumferential-decompression floating technique for the severe variety of thoracic OPLL. Although navigation is useful for accurate and safe implant placement and bone resection for spinal decompression, it should be utilized as one of the supporting imaging technologies, and surgeons should recognize the existence of specific pitfalls in navigated surgery [30]. The cost of installing the navigation device is also a major issue in the widespread use of navigated surgery.

Conclusions

The intraoperative O-arm navigation-guided floating procedure via the posterolateral approach described herein is an effective technique, achieving precise decompression. This new navigation technique provides excellent results for severe OPLL without the risk of adverse events from intraoperative radiation.

Acknowledgments. This study was supported by Okayama Spine Group.

Funding. This study received funding from the Japan Organization of Occupational Health and Safety.

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