Anterior Decompression via a Single Posterior Approach Using the Ultrasonic Bone Scalpel for the Treatment of the Thoracic Segmental Ossification of Posterior Longitudinal Ligament: A Report of Three Cases

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Abstract:
Introduction: Thoracic myelopathy due to ossification of the posterior longitudinal ligament (T-OPLL) is an indication for surgical treatment because the symptom is usually progressive. The surgery for T-OPLL is technically challenging for several reasons. Various operational procedures were developed for dealing with T-OPLL. The anterior decompression through a single posterior approach is a procedure to achieve the complete decompression via the direct resection of the ossified lesion, especially for the beak-type OPLL. Previous reports showed better postoperative outcomes using this method than using other procedures. However, the difficulty and risk of complications are also reported because of the blinded resection of the lesion positioning ventrally to the dura mater.

Technical Note: We describe a novel method using an anterior decompression through a single posterior approach using an ultrasonic bone scalpel. The following procedure is for a case of beak-type OPLL at the T5-6 level. The posterior elements at T2-9 were exposed after a median skin incision was created above a spinous process. First, pedicle screws were inserted bilaterally at T3-5 and T7-9. After the laminectomies and dekyphosis maneuver at T3-9, the spinal cord compression by OPLL was evaluated using intraoperative ultrasonography. After the slight medial facetectomy and pediclotomy at T5-6, the ultrasonic bone scalpel was inserted through the bilateral side of the spinal cord. The tip of the handpiece was angled to reach OPLL. The resection of OPLL was performed under intraoperative spinal cord monitoring. The intraoperative ultrasonography revealed the normal pulsation of the spinal cord and the space between the vertebral body and dura mater after completing the resection of OPLL. Posterolateral fusion was completed with local bone and harvested iliac crest.

Conclusions: The anterior decompression through a single posterior approach using an ultrasonic bone scalpel is a safe and effective treatment of thoracic OPLL.

Keywords:
Thoracic OPLL, Anterior decompression, Posterior approach, Ultrasonic bone scalpel

Introduction
Thoracic myelopathy due to ossification of the posterior longitudinal ligament (T-OPLL) is rare, and the incidence rate is reported to be approximately 0.8\(^\circ\). It is an indication for surgical treatment because the symptom is usually progressive.

The surgery for T-OPLL is technically challenging for several reasons: 1) a posterior decompression alone is not sufficient because of the kyphotic alignment of the thoracic spine, 2) anterior decompression via an anterior approach is very invasive and requires deep visualization, and 3) thoracic spinal cord is fragile. Thus, various operational procedures were developed for dealing with T-OPLL\(^2\). We focused on the anterior decompression through a single posterior approach, the so-called “Ohtsuka’s method”\(^6\). It is a procedure to achieve complete decompression via the direct resection of the ossified lesion, especially for the beak-type...
OPLL. Previous reports showed better postoperative outcomes using this method than using other procedures\(^7,8\). However, the difficulty and risk of complications are also reported because of the blinded resection of the lesion positioning ventrally to the dura mater\(^9\).

We developed a novel method using an anterior decompression through a single posterior approach using an ultrasonic bone scalpel. Here we describe the procedure and the surgical results for three cases of T-OPLL.

**Technical Note**

We describe the following procedure for a case of beak-type OPLL at the T5-6 level (Fig. 1). The patient was placed in the prone position on a laminectomy frame after general anesthesia. Before a skin incision, the fluoroscopic C-arm was brought into the surgical site and the targeting level was marked with an 18 G needle inserted into a spinous process under fluoroscopic AP and profile guidance. The posterior elements at T2-9 were exposed after a median skin incision was created above a spinous process. First, pedicle screws (Solera, Medtronic Sofamor Danek, Memphis, TN, USA) were inserted bilaterally at T3-5 and T7-9. After the laminectomies at T3-9 and dekyphosis maneuver according to the previous report\(^10\), the spinal cord compression by OPLL was evaluated using intraoperative ultrasonography with a 7.5 MHz linear transducer (ProSound SSD-5500, Hitachi-Aloka Medical, Ltd. Tokyo, Japan). We decided to remove the ossified lesion to decompress the spinal cord because the compression by OPLL at T5-6 was still marked and the pulsation of the dura mater was not present (Fig. 2a). After the slight medial facetectomy and pediculotomy at T5-6, the ultrasonic bone scalpel (SONOPET UST-2001, M&M, Tokyo, Japan) was inserted through the bilateral side of the spinal cord. The tip of the handpiece was angled to reach OPLL (Fig. 3). The resection of OPLL was performed under intraoperative spinal cord monitoring. The intraoperative ultrasonography revealed the normal pulsation of the spinal cord and the space between the vertebral body and the dura mater after completing the resection of OPLL (Fig. 2b). No dural tear or cerebrospinal fluid (CSF) leakage occurred. Posterolateral fusion was completed with local bone and harvested iliac crest. After the hemostasis and irrigation, a drain was placed, and the fascia and the skin were closed in layers with Vicryl (Johnson & Johnson, New Brunswick, NJ, USA) and stapler.

Plain computed tomography (CT) and magnetic resonance imaging (MRI) taken after the surgery showed that the OPLL was sufficiently removed and the spinal cord was decompressed circumferentially at the T5-6 level (Fig. 4).

**Discussion**

We performed the surgical technique for three consecutive cases (between January 2012 and December 2013) that had thoracic myelopathy due to a beak-type OPLL. The cases consisted of one male and two females (age: 52, 58, and 68 years at the time of the surgery). The levels of beak-type OPLL were T3-4, T5-6, and T8-9. The follow-up periods were 48, 60, and 24 months (Table 1). The clinical records were retrospectively analyzed. We evaluated the following: 1) the Japanese Orthopedic Association (JOA) score for tho-
**Figure 2.** Intraoperative ultrasonographic findings. 

- a: Anterior spinal cord compression evaluated by sagittal and axial ultrasonography before the removal of OPLL.
- b: Spinal cord evaluated via sagittal and axial ultrasonography after the removal of OPLL.

**Figure 3.** 

- a: Tip of handpiece of the ultrasonic bone scalpel.
- b: Intraoperative view of the procedure for the removal of the anterior ossified lesion through the posterior approach.
Figure 4. Postoperative MRI and CT images showing the complete removal of OPLL and circumferential decompression of the spinal cord at T5-6.

Table 1. Demographics and Clinical Results of the Three Patients.

| No. | 1     | 2     | 3     |
|-----|-------|-------|-------|
| Age (years) | 52    | 58    | 68    |
| Gender  | female | male  | female|
| Level of OPLL | T3-4  | T8-9  | T5-6  |
| Follow-up period | 48    | 60    | 24    |
| Preop. JOA score | 4     | 7     | 6     |
| Postop. JOA score | 7.5   | 9     | 8     |
| Recovery rate (%) | 50    | 50    | 40    |

Recovery rate (%): (postoperative JOA score − preoperative JOA score) × 100 / (11 − preoperative JOA score)

The surgical outcome using a high-speed drill or Kerrison rongeurs for thoracic OPLL can be unfavorable because of 1) the anatomy of the thoracic spine and thoracic spinal cord and 2) the “anterior” spinal cord compression by OPLL. Various surgical procedures were developed for the treatment of T-OPLL. The procedural difficulty was shown by the report of severe complications such as spinal cord injury in any surgical procedure. Matsuyama et al. analyzed 21 cases by dividing T-OPLL into flat and beak type. The report showed the following: 1) neurological deteriorations in five of 21 cases (23.8%), all of which were beak type, and 2) anterior decompression via a single posterior approach, the so-called Otsuka’s method, was performed in three of the five beak-type T-OPLL cases. Through the analysis of 154 T-OPLL cases in 34 institutes, Matsumoto et al. reported the following: 1) the recovery rate after anterior decompression was better than other surgical procedures for the treatment of T-OPLL when the anterior decompression was successfully performed, and 2) postoperative neurological deteriorations were observed in the procedure that removed ossified lesion more than in the procedures that did not remove ossified lesion.

An ultrasonic bone scalpel is a device with a vibratory tip on a small and lightweight handpiece (Fig. 5). This device can cut hard tissues such as bone while keeping the soft tissues such as dura mater, nerves, and blood vessels intact.
Figure 5. Vibratory tip of the handpiece.

also has a self-irrigating cooling and suction system (Fig. 6). The usefulness of the device has been reported since the 1990s in the field of orthopedic surgery. The handpiece used in this study was developed originally in our department for microendoscopic use in spine surgery. The angled tip of the handpiece was specially designed (Fig. 7). The shape of the handpiece is reasonable to reach OPLL through the side of the spinal cord without sacrificing the nerve root. In this study, we successfully used the handpiece and resected the anterior ossified lesion through a single posterior approach without any perioperative complication. We believe that a floating method is also possible through this procedure in the case of dural ossification. It is confirmed by probing whether caudal and proximal edges of OPLL are cut upon a floating method.

There is a pitfall in this surgery. A few reports revealed that the continuous use of an ultrasonic bone scalpel had the potential of thermal injury to the spinal cord, nerve root, and dura mater. Intermittent use with surgical cotton inserted between the device and dura mater is recommended. We suggest the following: 1) intraoperative spinal cord monitoring to avoid spinal cord injury and 2) ultrasonographic diagnosis to detect the anterior compression of the spinal cord by OPLL upon the surgery of the thoracic spine. A benefit of intraoperative spinal cord monitoring has been reported in our study and in several others. Intraoperative spinal cord monitoring should be performed especially in the surgery of the thoracic spine because the thoracic spinal cord is fragile. The usefulness of ultrasonographic diagnosis for the anterior compression of the

Table 2. Japanese Orthopedic Association Score (JOA Score).

|          | Japanese Orthopedic Association Score |
|----------|---------------------------------------|
| A        | Motor function of lower extremity      |
|          | 0: Impossible to walk                  |
|          | 1: Need cane or aid on flat ground    |
|          | 2: Need cane or aid only on stairs    |
|          | 3: Possible to walk without cane or aid, but slow |
|          | 4: Normal                              |
| B        | Sensory deficit                       |
| a) Lower extremity | 0: Apparent sensory loss               |
|          | 1: Minimal sensory loss                |
|          | 2: Normal                              |
| b) Trunk | 0: Apparent sensory loss               |
|          | 1: Minimal sensory loss                |
|          | 2: Normal                              |
| C        | Sphincter dysfunction                  |
|          | 0: Complete urinary retention          |
|          | 1: Severe disturbance                  |
|          | 2: Mild disturbance                    |
|          | 3: Normal                              |

Figure 6. Self-irrigating cooling and suction system of the handpiece.
spinal cord has been reported\(^\text{18}\). Ultrasonography has the benefit of visualization of the decompression of the spinal cord and the pulsation of the spinal cord in real time.

In conclusion, we believe that the anterior decompression through a single posterior approach by the use of an ultrasonic bone scalpel is a safe and effective treatment of T-OPLL.

Conflicts of Interest: The authors declare that there are no relevant conflicts of interest.

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Author Contributions: Main idea: MO and YN. Initial draft: MO. Surgical treatment: MO, YN and HY. Development of the handpiece: MY. Critical revision of the manuscript: YN and HY. Review of the submitted version of manuscript: MY. All authors read and approved the final manuscript.

Ethical Approval: The case-series has been granted an exemption by our institutional review board (Wakayama Medical University).

Informed Consent: The written informed consent for this study was obtained from all participating patients and/or their family members.

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Figure 7. Schematic diagrams of anterior decompression using the angled tip of the handpiece via a single posterior approach.
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