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

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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%[1)]. 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[2-5)]. 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

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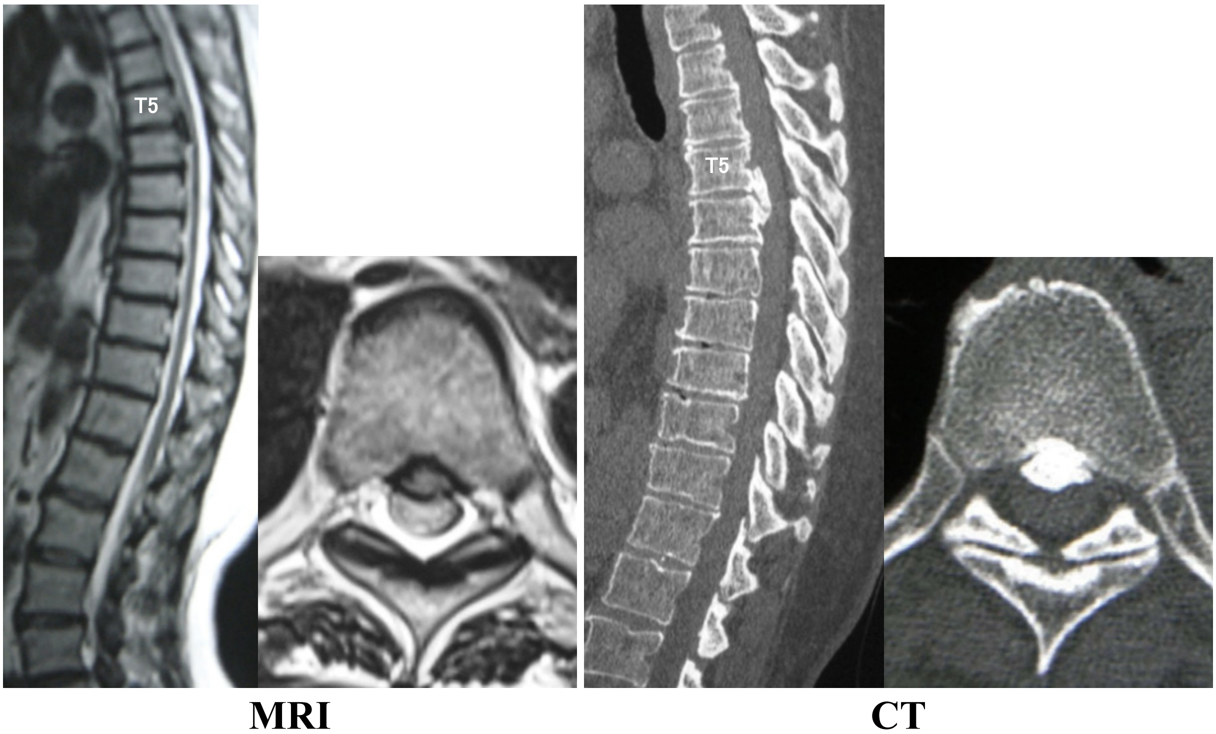

Figure 1. Preoperative MRI and CT images of beak-type OPLL at T5-6.

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 pediclotomy 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-

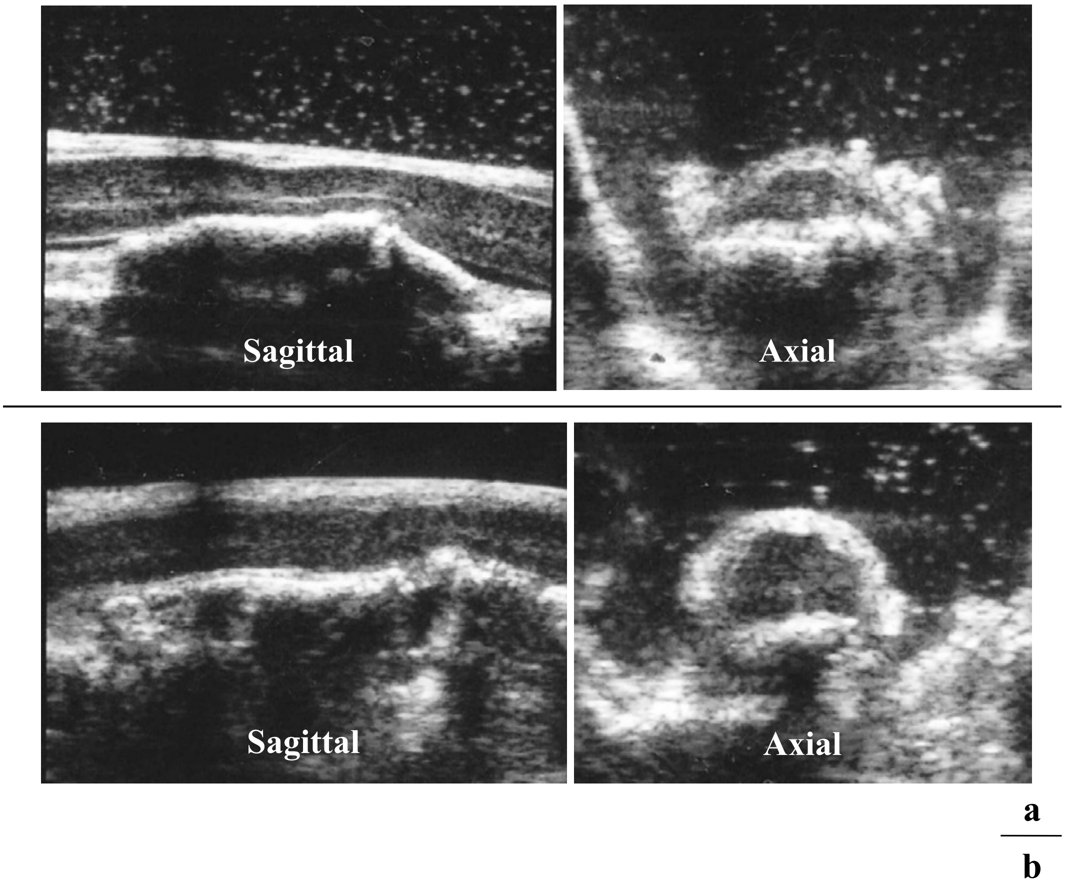

Figure 2. Intraoperative ultrasonographic findings. a: Anterior spinal cord compression evaluated by sagittal and axial ultrasonography before the removal of OPLL. b: Spinal cord evaluated via sagittal and axial ultrasonography after the removal of OPLL.

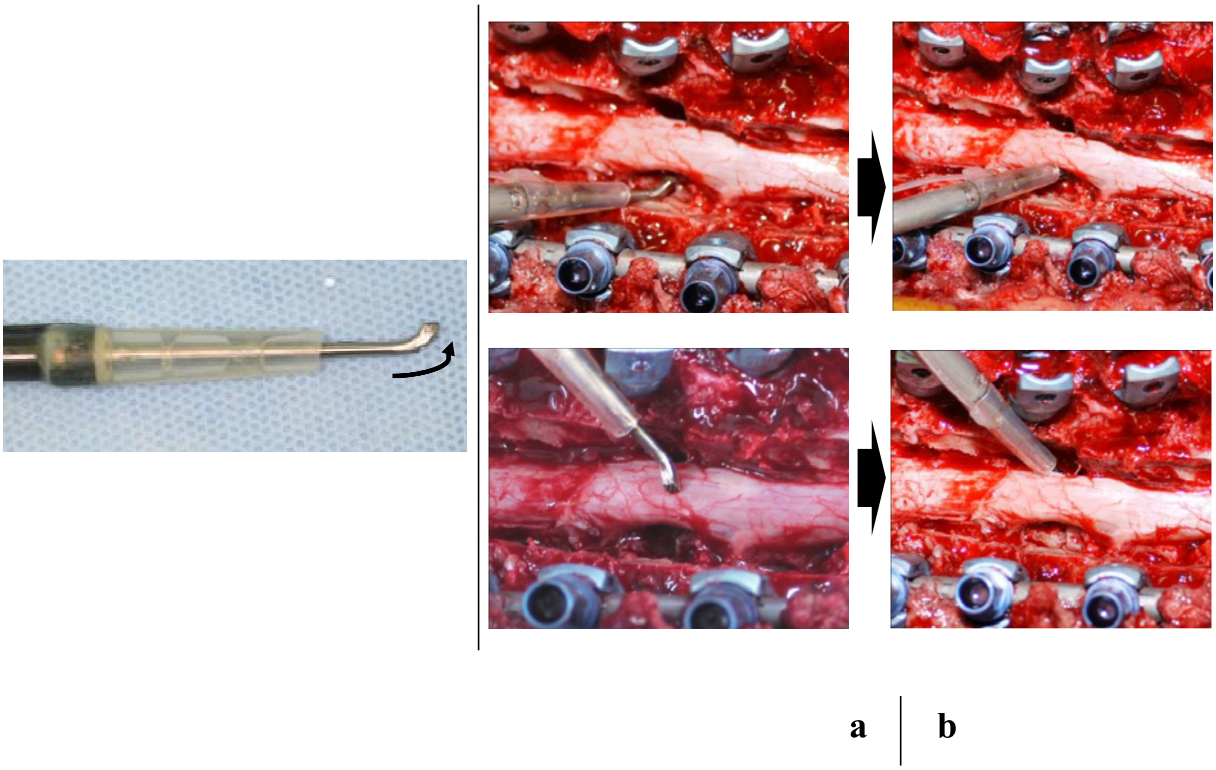

Figure 3. a: Tip of handpiece of the ultrasonic bone scalpel. b: Intraoperative view of the procedure for the removal of the anterior ossified lesion through the posterior approach.

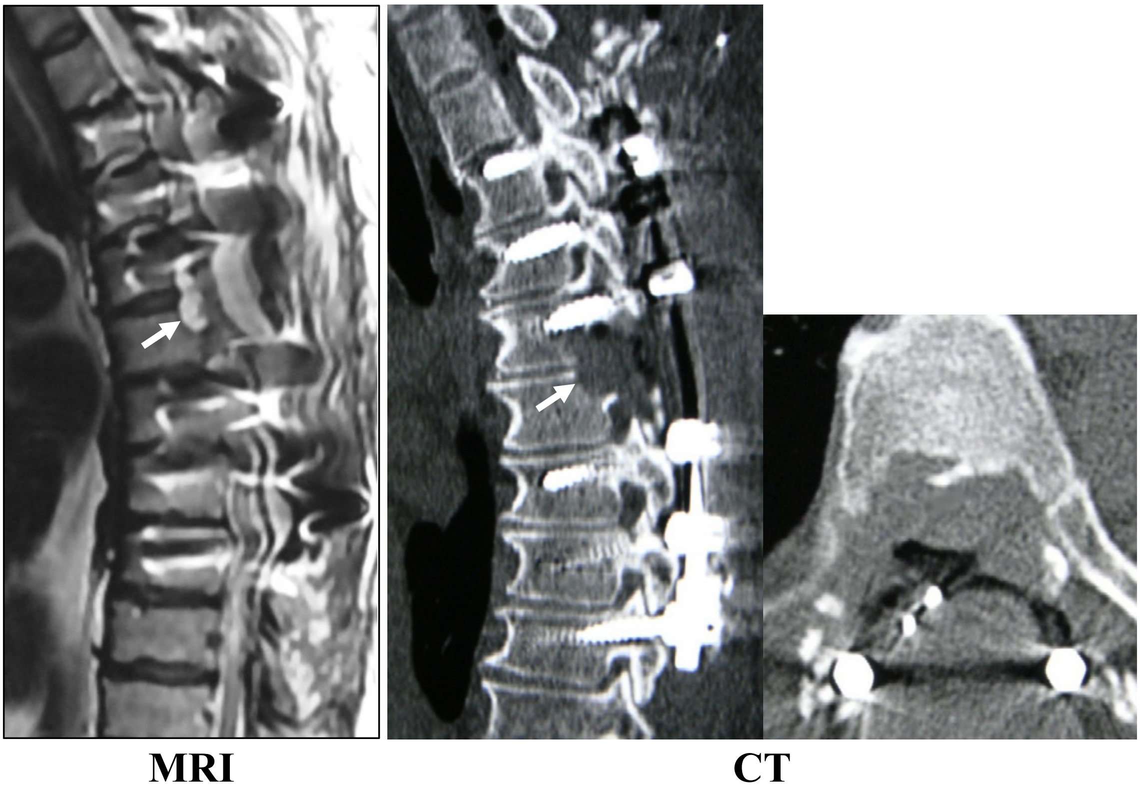

Figure 4. Postoperative MRI and CT images showing the complete removal of OPLL and circumferential decompression of the spinal cord at T5-6.

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)

racic myelopathy (Table 2) before surgery and at final follow-up. The scoring system is commonly used in Japan to indicate the severity of thoracic myelopathy. The total score for a healthy individual is 11; 2) recovery rates that were calculated at final follow-up using the Hirabayashi's method: (postoperative JOA score-preoperative JOA score)× 100/(11−preoperative JOA score); and 3) perioperative complications.

Postoperative plain CT revealed that the beak-type OPLLs were completely removed in all three cases. The JOA scores were improved at the final follow-up in all cases. The scores were 4, 7, and 6 points before surgery and 7.5, 9, and 8 points at final follow-up, respectively. Recovery rates were 50%, 50%, and 40% (Table 1). Any abnormal wave was not detected in the intraoperative spinal cord monitoring in all cases. No dural tear or CSF leakage occurred. No other perioperative complication including spinal cord injury was observed.

The surgical outcome using a high-speed drill or Kerrisons 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[11]. 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[8].

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. It

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

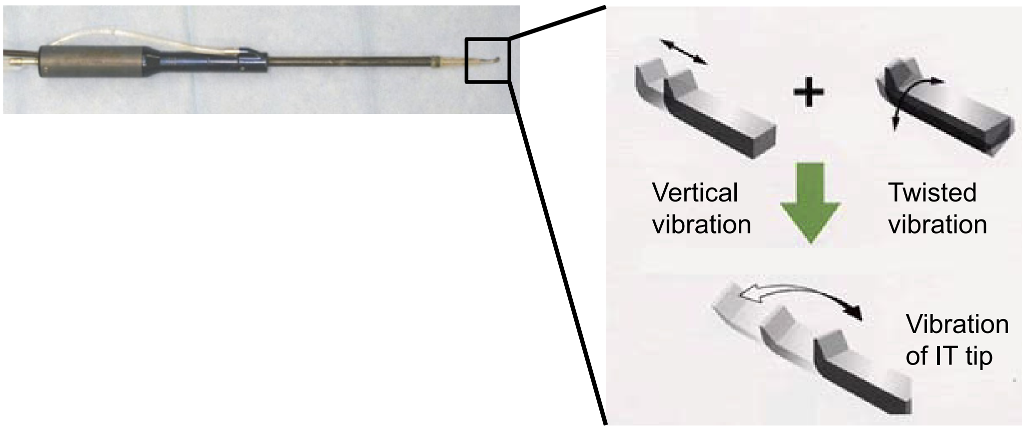

Figure 5. Vibratory tip of the handpiece.

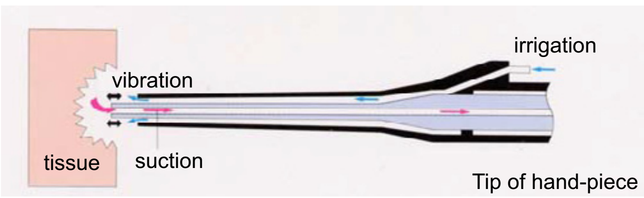

Figure 6. Self-irrigating cooling and suction system of the handpiece.

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[12]. The handpiece used in this study was developed originally in our department for microendoscopic use in s 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[13,14]. 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[15-17]. 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

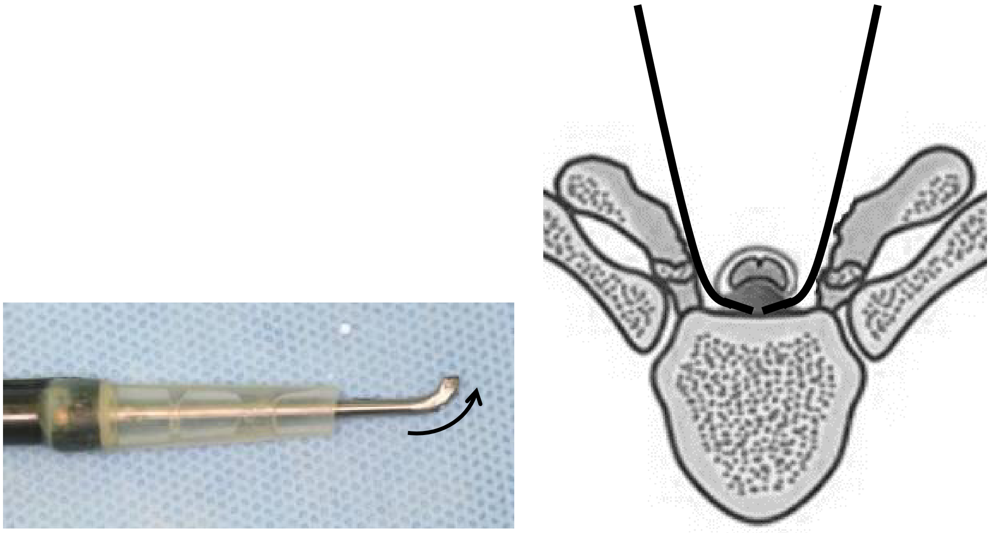

Figure 7. Schematic diagrams of anterior decompression using the angled tip of the handpiece via a single posterior approach.

spinal cord has been reported[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.

References

1. Ohtsuka K, Terayama K, Yanagihara M, et al. A radiological population study on the ossification of the posterior longitudinal ligament in the spine. Arch Orthop Trauma Surg. 1987;106(2):89-93.
2. Min JH, Jang JS, Lee SH. Clinical results of ossification of the posterior longitudinal ligament (OPLL) of the thoracic spine treated by anterior decompression. J Spinal Disord Tech. 2008;21(2):116-9.
3. Tomita K, Kawahara N, Baba H, et al. Circumspinal decompression for thoracic myelopathy due to combined ossification of the posterior longitudinal ligament and ligamentum flavum. Spine (Phila Pa 1976). 1990;15(11):1114-20.
4. Matsuyama Y, Sakai Y, Katayama Y, et al. Indirect posterior decompression with corrective fusion for ossification of the posterior longitudinal ligament of the thoracic spine: is it possible to predict the surgical results? Eur Spine J. 2009;18(7):943-8.
5. Kato S, Murakami H, Demura S, et al. Novel surgical technique for ossification of posterior longitudinal ligament in the thoracic spine. J Neurosurg Spine. 2012;17(6):525-9.
6. Ohtsuka K, Terayama K, Tsuchiya T, et al. [A surgical procedure of the anterior decompression of the thoracic spinal cord through the posterior approach]. Orthop Surg Traumatol. 1983;26(1):1083-90. Japanese.
7. Aizawa T, Eto T, Hashimoto K, et al. Surgical results of nonambulatory patients caused by ossification of the posterior longitudinal ligaments in the thoracic spine: retrospective comparative study between posterior decompression and instrumented spinal fusion versus anterior decompression through a posterior approach. J Neurosurg Spine. 2020;34(3):492-7.
8. Matsumoto M, Chiba K, Toyama Y, et al. Surgical results and related factors for ossification of posterior longitudinal ligament of the thoracic spine: a multi-institutional retrospective study. Spine (Phila Pa 1976). 2008;33(9):1034-41.
9. Hirabayashi S, Kitagawa T, Yamamoto I, et al. Surgical treatment for ossification of the posterior longitudinal ligament (OPLL) at the thoracic spine: usefulness of the posterior approach. Spine Surg Relat Res. 2018;2(3):169-76.
10. Kawahara N, Tomita K, Murakami H, et al. Circumspinal decompression with dekyphosis stabilization for thoracic myelopathy due to ossification of the posterior longitudinal ligament. Spine (Phila Pa 1976). 2008;33(1):39-46.
11. Matsuyama Y, Yoshihara H, Tsuji T, et al. Surgical outcome of ossification of the posterior longitudinal ligament (OPLL) of the thoracic spine: implication of the type of ossification and surgical options. J Spinal Disord Tech. 2005;18(6):492-7.
12. Sawamura Y, Fukushima T, Terasaka S, et al. Development of a

handpiece and probes for a microsurgical ultrasonic aspirator: instrumentation and application. Neurosurgery. 1999;45(5):1192-6.

13. Sanborn MR, Balzer J, Gerszten PC, et al. Safety and efficacy of a novel ultrasonic osteotome device in an ovine model. J Clin Neurosci. 2011;18(11):1528-33.

14. Hu X, Ohnmeiss DD, Lieberman IH. Use of an ultrasonic osteotome device in spine surgery: experience from the first 128 patients. Eur Spine J. 2013;22(12):2845-9.

15. Iwasaki H, Tamaki T, Yoshida M, et al. Efficacy and limitations of current methods of intraoperative spinal cord monitoring. J Orthop Sci. 2003;8(5):635-42.

16. Yoshida G, Ando M, Imagama S, et al. Alert timing and corresponding intervention with intraoperative spinal cord monitoring for high-risk spinal surgery. Spine (Phila Pa 1976). 2019;44(8):E 470-9.

17. Kobayashi K, Imagama S, Matsuyama Y, et al. Efficacy of intraoperative intervention following Tc-MEP alert during posterior decompression and fusion surgery for thoracic OPLL: a prospective multicenter study of the monitoring committee of the Japanese Society for Spine Surgery and Related Research. Spine (Phila Pa 1976). 2021;46(4):268-76.

18. Tokuhashi Y, Matsuzaki H, Oda H, et al. Effectiveness of posterior decompression for patients with ossification of the posterior longitudinal ligament in the thoracic spine: usefulness of the ossification-kyphosis angle on MRI. Spine (Phila Pa 1976). 2006; 31(1):E26-30.