Circumspinal Decompression with Dekyphosis Stabilization for Thoracic Myelopathy due to Ossification of the Posterior Longitudinal Ligament

Norio Kawahara, Katsuro Tomita, Hideki Murakami, Satoru Demura, Yoichi Sekino, Wataru Nasu, and Yoshiyasu Fujimaki

Introduction

Ossification of the posterior longitudinal ligament (OPLL) in the thoracic spine is likely to be multiple or extensive. In patients with thoracic myelopathy resulting from OPLL, removing the OPLL is the most effective method for relieving pressure on the spinal cord [1–6], but the anterior approach for removing OPLL plaque is technically demanding. Postoperative neurological degradation has been reported in several articles [1,7]. Especially when the OPLL plaque is large and the spinal cord is pinched between the plaque and the inner cortex of the posterior arch or there is ossification of the ligamentum flavum (OLF), anterior removal of the OPLL plaque is extremely dangerous for the already debilitated spinal cord [3,8].

Many authors have reported that extensive posterior decompression provided posterior shift of the spinal cord, which was indirect decompression of the spinal cord [9–12]. Some authors have tried to prevent postoperative kyphosis by laminoplasty or fusion with bone grafting supported by instrumentation [9,11,12]. These procedures have not always provided satisfactory results, however, because the OPLL plaque is left in place and may still compress the spinal cord owing to the posterior shift of the spinal cord [3–5].

Thus, anterior decompression is the best approach for spinal cord recovery when treating thoracic myelopathy caused by OPLL [1–6]. We reported our original technique of circumspinal decompression for thoracic OPLL and OLF, including safe removal of the OPLL plaque, in 1990 [3,4]. We have since improved this surgical procedure by introducing the concept of dekyphosis stabilization [8].

Materials and Methods

Patients

Circumspinal decompression with dekyphosis stabilization was performed on 10 patients with thoracic OPLL at Kanazawa University Hospital from 1995 to 2002. There were seven women and three men with ages ranging from 40 to 70 years (average 56.6 years). Patients were followed up for an average of 59.2 months (24–120 months).

Evaluation System for Thoracic Myelopathy

The evaluation system for cervical myelopathy, established by the Japanese Orthopaedic Association (JOA in 1975), was used. To evaluate thoracic myelopathy, we utilized the JOA evaluation system for cervical myelopathy but modified it by excluding the category “upper extremity.” Thus, 11 points became the highest score possible for patients who have no thoracic myelopathy, meaning no neurological defects.

Surgical Technique for Circumspinal Decompression

The surgical procedure consists of two steps.

Step 1: Posterior decompression, gutter creation, and dekyphosis stabilization

Step 2: Anterior decompression

Step 1: Posterior Decompression, Gutter Creation, and Dekyphosis Stabilization

With the patient in a prone position, the posterior elements are exposed through a midline incision. The extent of the laminectomy includes at least one vertebra above and below the area affected by OPLL so the spinal cord cannot be pinched by the laminar edge as the
spinal cord, which is still compressed by OPLL, shifts backward after posterior decompression. The laminectomy also includes all levels at which the laminae are causing symptoms or signs of OLF. A diamond burr is used to thin the deep cortex of the laminae and the OLF plaque, so they can be grasped and put aside. This decompression should be done not only on the posterior side of the dura but also on the lateral side (Fig. 1A).

The next procedure is undertaken as a pretreatment for safe removal of the OPLL anteriorly. Corresponding to the area of OPLL to be removed, the inner portions of the facets and pedicles (the lateral sides of the dural tube) are drilled using a 3 mm diameter diamond burr, reaching approximately 1 cm into the vertebral body. Parallel deep gutters are then made on both sides of the dura. The lateral edge of the OPLL should be meticulously separated from the dura (Figs. 1A, 2B). Careful
bipolar coagulation is performed to stop any vertebral plexus bleeding. Oxycel cotton and Aviten are used to cover the gutters [3,4].

The last procedure of step 1 is dekyphosis stabilization. The posterior instrumentation of the pedicle screw system is placed at least two vertebrae above and below the decompression area. Underbent rods are placed in the heads of the pedicle screws to reduce the thoracic kyphosis by 5°–10° (Fig. 2A,B) [8]. Dekyphosis stabilization may provide spinal cord decompression indirectly [8,9,11]. Local bone chips of the resected laminae are grafted posterolaterally.

**Decision to Undergo the Second Operation**

Patients undergo extensive rehabilitation with a hard orthosis for 3 weeks after the step 1 operation. The patient then chooses whether she or he will undergo the step 2 operation (anterior decompression) based on an evaluation of the postoperative neurological recovery and imaging of the spinal cord with three-dimensional computed tomography (CT)-myelography and magnetic resonance imaging (MRI). We recommend that patients have the step 2 operation if they have incomplete neurological recovery, with the OPLL plaque still compressing the spinal cord.

**Step 2: Anterior Decompression by Thoracotomy**

For lesions at T3 or below, thoracotomy by a transthoracic approach is used. A rib is resected at the appropriate level (generally one or two levels above the OPLL to be removed). The posterior one-third of the vertebral body is drilled out using a diamond burr to visualize the two gutters marked during the step 1 protocol (Fig. 1B). These gutters show the width and extent of the OPLL to be removed (Figs. 1B, 2B). As the vertebral bodies are drilled as close as possible to the OPLL plaque, the thinly drilled OPLL, whose lateral margin has already been released during the first step, becomes mobile. Separation should be done under a surgical microscope (Fig. 1C). If the dura mater is also ossified, the thinly drilled ossified tissue is floated. As circumsinal decompression is accomplished, intradural pulsation becomes visible [3,4,8]. An iliac graft or resected rib is used for anterior interbody fusion (Figs. 1D, 2C).

For lesions at T2 or above, we choose a transsternum approach [13]. The manubrium sternum is split at the midline using a bone saw, and the junction between the manubrium sternum and the body of the sternum is cut. The two halves of the manubrium sternum are then separated. The avascular plane between the carotid sheath laterally and the trachea and esophagus medially is identified and followed down to the prevertebral fascia. The corresponding vertebral body is resected to visualize the two gutters. The OPLL is thinly drilled and excised or floated (Fig. 2C). An iliac graft is used for anterior interbody fusion.

The patient is allowed to sit and walk with a hard orthosis 2–3 days after the operation. The orthosis is worn for 8–12 weeks or until the graft appears radiographically to be incorporated.

Patients with thoracic myelopathy due to OPLL are candidates for circumspinal decompression if the spinal cord is pinched between the OPLL plaque and the inner wall of the posterior arch or OLF. Patients who have some subarachnoid space behind the spinal cord at the level of the OPLL are candidates for standard anterior decompression alone.

**Results**

Over a 12-year period we have performed circumspinal decompression with dekyphosis stabilization in 10 patients with thoracic OPLL. The first 2 patients had an one-day operation, and the other 8 patients had staged operations. The average extent of posterior decompression was 4.5 laminae (3–7 laminae), with an average posterior stabilization of 7.5 vertebrae (5–9 vertebrae). The average extent of anterior decompression was 1.5 partial vertebrectomies (1 or 3 partial vertebrectomies). Two patients had two separate levels of circumspinal decompression.

The JOA score improved from 3.5 to 7.2 points 3 months after circumspinal decompression with dekyphosis stabilization. The average JOA score at the last follow-up was 8.6 points. Most of the patients had improved neurologically within a year after the operation, and the improved neurological condition has been preserved up to the last follow-up. The average kyphosis angle in the area of stabilization was reduced from 28.4° to 22.4°. Bone fusion was seen on roentgenograms 3–4 months after operation.

For the step 1 protocol, the operating time ranged from 6.7 to 13.0 h (mean 9.7 h), and the blood loss was 680–6210 ml (mean 2140 ml). For the step 2 protocol, the operating time ranged from 6.7 to 10.7 h (mean 9.0 h), and the blood loss was 690–3320 ml (mean 1670 ml).

**Complications**

Leakage of cerebrospinal fluid lasted 2 weeks in two patients and 3 weeks in one patient. They were treated by spinal drainage. In one patient with beak-type OPLL at T6–T8, neurological deterioration appeared 2 days after the step 1 operation, and it was progressive. Three days after the operation, we reoperated using the
posterior approach. We found that the spinal cord was compressed by swelling of the paravertebral muscle. Three transverse connectors were placed to shield the posterior aspect of the spinal cord. It was suspected that the spinal cord was pinched between the beak-type OPLL and the swollen paravertebral muscle. Following the posterior procedure, anterior decompression was accomplished by floating the OPLL plaque on the same day. The patient improved neurologically from a preoperative JOA score of 3 points to a score of 7 points 3 years after the operation.

Illustrative Patient Presentation

A 40-year-old woman had suffered from paresthesia and spastic palsy in both legs for 3 months. She was referred to our hospital because she had become unable to walk. The score for thoracic myelopathy on admission was 5/11 points (1, 1, 1, 2). We found that the spinal cord was compressed by OPLL at the level of T1–T2, although she had extensive OPLL from the upper to the middle thoracic spine (Figs. 3A, 4A). She also had cervical spinal stenosis due to OPLL (Fig. 3). During the step 1 phase of treatment, laminectomy of T1–T6 and cervical expansive laminoplasty of C3–C7 were performed, followed by dekyphosis stabilization from C7 to T6 (Fig. 4B). Her JOA score improved to 8 points 3 weeks after this operation. Anterior decompression and fusion of intervertebral bodies from T1 to T3 were performed through the manubrium-splitting approach 4 weeks after the step 1 operation (Figs. 4C, 5A,B). Her JOA score improved to the best possible score (11 points) 3 years after the second operation.

Discussion

Dekyphosis Stabilization

Matsuyama et al. reported postoperative neurological degradation possibly due to intraoperative instability produced by wide laminectomy for thoracic beak-type OPLL [9]. Yamazaki et al. reported that 3 of 16 patients who underwent posterior decompression had postoperative neurological degradation, and two of the three patients recovered after revision surgery using posterior instrumentation [12]. Posterior instrumentation prevents postoperative kyphosis and instability after

Fig. 3. Preoperative magnetic resonance imaging scan (T2-weighted image)
posterior decompression for thoracic OPLL, which leads to neurologic deterioration [9,11,12]. Underbent rods were placed in the pedicle screws to reduce thoracic kyphosis (dekyphosis) by 5°–10° to achieve decompression of the spinal cord indirectly in our series [8]. Using intraoperative ultrasonography, Matsuyama et al. clearly showed that reducing the thoracic kyphosis caused a posterior shift of the compressed spinal cord [9]. Dekyphosis stabilization is done not only to maintain spinal stability but also to reduce the compressive pressure of the OPLL plaque on the spinal cord [8,9,12]. Furthermore, dekyphosis

Fig. 4. Computed tomography images at the T2 level. A Before operation. B After the step 1 operation. C After the step 2 operation (circumspinal decompression)

Fig. 5. Postoperative radiographs. A Anteroposterior view. B Lateral view
stabilization changes the spinal cord alignment and slightly loosens the tension of the spinal cord. This spinal cord relaxation increases spinal cord blood flow, which may promote spinal cord recovery [14].

**Circumsplinal Decompression**

Anterior decompression is the best approach for treating thoracic myelopathy caused by OPLL that lies on the concave side of the spinal cord and achieving spinal cord recovery [1–6,8]. The major issue with this operation is how easily, safely, and completely the OPLL can be removed or floated. Anterior excision of the OPLL plaque is dangerous for the already damaged spinal cord, especially in cases in which the OPLL plaque is so large it presses the spinal cord against the inner cortex of the posterior arch or OLF. In such patients, posterior decompression (step 1 operation) may provide room posteriorly for the spinal cord to escape from being compressed during an anterior decompression maneuver, such as drilling (step 2 operation). In addition, dekyphosis stabilization causes a posterior shift of the spinal cord and reduces the compressive pressure by the OPLL plaque on the spinal cord. It is also less dangerous for the spinal cord during an anterior decompression maneuver [4,5,8].

As a definitive solution for safe removal of OPLL, we drilled a deep gutter in the vertebral body from a posterior approach after an extended laminectomy. The gutter is created for two important purposes: The extent of OPLL to be removed is indicated, and the gutter(s) helps the surgeon remove OPLL safely during the second step of the operation, as its lateral rim has already been released from the dura [4,5,8].

Our patients in the present series did not have postoperative neurological deterioration owing to the anterior decompression maneuver of the OPLL in the thoracic spine, and their average JOA score had improved from 3.5 to 8.6 at the last follow-up. For patients suffering from OPLL in the thoracic spine, this operative method brought a satisfactory recovery from neurological deficits in more cases than we had expected.

**Conclusions**

OPLL plaque in the thoracic spine is most easily, safely, and completely removed or floated by circumsplinal decompression with dekyphosis stabilization. This radical procedure demands meticulous preparation and utmost care throughout the operation, but it is a rewarding method to alleviate severe thoracic myelopathy due to OPLL.

**References**