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Effect of microscopically assisted decompression with micro-hook scalpel in the surgical treatment of ossification of the posterior longitudinal ligament

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Abstract

Objective: This study was performed to investigate the effect of microscopically assisted decompression using a micro-hook scalpel on ossification of the posterior longitudinal ligament (OPLL).

Methods: Sixty-one patients with OPLL were divided into Group A (posterior surgery with laminectomy of the responsible segment and lateral mass screw fixation) and Group B (anterior cervical corpectomy with intervertebral titanium cage fusion). Neurological function was assessed by the Japanese Orthopaedic Association (JOA) score, visual analog scale (VAS) score, and recovery rate. The fixation status and the result of spinal canal decompression were radiographically assessed.

Results: In Groups A and B, the JOA score was significantly higher and the VAS score was significantly lower at 1 week postoperatively and at the final follow-up than during the preoperative period. The mean recovery rate in Group A and B was 59.92% ± 13.46% and 62.28% ± 14.00%, respectively. Postoperative radiographs showed good positioning and no damage to the internal fixation materials. The spinal canal was also fully decompressed.

Conclusions: Microscopically assisted decompression with a micro-hook scalpel in both anterior and posterior surgeries achieved good clinical effects in patients with OPLL.

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Introduction

Multilevel cervical compressive myelopathy due to multisegment cervical spondylotic myelopathy or ossification of the posterior longitudinal ligament (OPLL) is frequently encountered in clinical practice and leads to a declining quality of life. Cervical spondylotic myelopathy is one of the most common diseases in orthopedics[1,2] and often occurs among patients of advanced age, especially those aged >55 years. It can cause symptomatic compression of the spinal cord and nerve roots. The disorders associated with cervical spondylotic myelopathy usually manifest as gait disorders, clumsy hands and feet, sensory disturbance in the hands and feet, and urinary or rectal sphincter dysfunction.[3] OPLL refers to the gradual thickening of the cervical ligament structure and the replacement of ligament tissue with bony components.[4] It causes compression of the spinal cord via static or dynamic factors, leading to progressive radiculomyelopathy, the major symptom of OPLL.[5] Although still controversial, the basic principle of the surgical treatment of cervical OPLL is to achieve decompression of the spinal cord.[6,7] The natural course of OPLL without surgical treatment is generally poor with respect to neurological deficits. In contrast, stabilization or even recovery of neurological deficits may be obtained through surgical decompression in most patients.

Two main surgical strategies for spinal cord decompression are currently used: an anterior operation (cervical corpectomy with intervertebral titanium cage fusion) and a posterior operation (laminectomy of the responsible segment and lateral mass screw fixation).[8–10] However, there is considerable controversy regarding which surgical approach provides the best clinical outcome at the lowest cost. Anterior cervical decompression and fusion can directly resolve spinal cord compression.[11] Surgery for cervical myelopathy involving one or two motion segments may be successfully performed with a low incidence of complications, and the current consensus favors anterior cervical decompression with fusion and instrumentation for such patients. However, reconstruction of the cervical spine after multisegment corpectomy is technically demanding for the surgeon and more bone grafts are needed for fusion, resulting in an increased rate of graft-, instrumentation-, and surgery-related complications.[12] Posterior laminoplasty is less technically demanding than the anterior approach. Decompression via posterior laminoplasty and cervical lordosis alignment allow the spinal cord to float away from ventral compression, thus providing indirect decompression of the whole cervical cord. Again, however, this method is also inadequate. If the posterior shift of the cord is not sufficient, ventral constriction of the cord may persist, leading to decreased recovery from myelopathy.[12]

Minimally invasive decompression of the cervical spine under the guidance of microscopy has been carried out for many years, and the risk of decompression of the spinal cord under severe pressure is still very high. The success of a surgery requires not only appropriate surgical procedures but also effective surgical tools. The neurosurgical micro-hook scalpel has been used in neurosurgery for many years. The micro-hook scalpel is small and has little contact with adjacent tissues; this minimal interference with the spinal cord and dural sac reduces the possibility of nerve injury. Few reports of micro-hook scalpel-assisted decompression have been published to date. Therefore, we performed the present study to examine the role of the micro-hook scalpel in the process of spinal cord decompression and determine whether use of this tool can reduce the stimulation of spinal cord compression during surgery. To our knowledge, this study is the first to explore the effect of the micro-hook scalpel in microscopically assisted decompression.

Patients and methods

General information

Patients with OPLL who underwent cervical decompression surgery (anterior or posterior) in our hospital from May 2010 to October 2013 were included in this retrospective study. All patients had cervical spondylotic myelopathy involving three or more segments. In addition, all patients had symptoms of spinal cord compression that had progressively worsened.

Group A comprised patients who underwent posterior surgery with laminectomy of the responsible segment and lateral mass screw fixation. Group B comprised patients who underwent anterior cervical corpectomy with intervertebral titanium cage fusion. The exclusion criteria were cervical spondylosis combined with trauma or a tumor, cervical spondylosis of simple nerve root type, and a cervical lesion such as thoracic outlet syndrome. The ethics committee of our hospital approved this study. Written informed consent was obtained from all individual participants included in the study.

Micro-hook scalpel

Specialized microscopes for spinal surgery that can provide good light and three-dimensional views were used in this study. During cervical decompression surgery, the anterior and posterior longitudinal ligaments, adhesive bands, and other soft tissues were separated and cut off with a micro-hook scalpel, which is commonly used in neurosurgery. The micro-hook scalpel is small, has minimal contact with adjacent tissues, and has minimal interference with the spinal cord and dural sac. Therefore, its use in spinal cord decompression can reduce nerve damage and spinal cord stimulation induced by blunt dissection. The micro-hook scalpel is shown in Figure 1.

Surgical technique

Patients in Group A underwent posterior surgery with laminectomy of the responsible segment and lateral mass screw fixation. After induction of anesthesia, the patients were placed in the prone position. The cervical vertebrae were kept in the neutral position with slight anterior flexion. Taking laminectomy of C4 to C7 as an

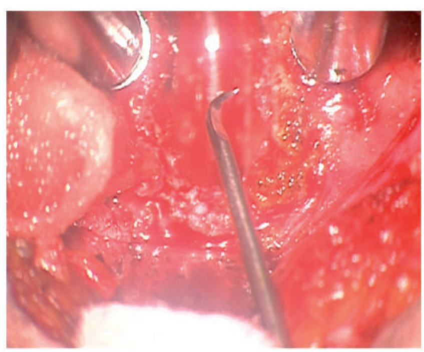

Figure 1. The micro-hook scalpel.

example, a posterior midline incision was made in the neck to expose the spinous processes, the bilateral laminae, and the lateral mass of the articular process. The entry point was set 1 mm medial to the midpoint of the lateral masses. The optimal angle of the drill was placed at 15° to the sagittal plane and 30° to the horizontal plane. Under G-arm X-ray guidance, the polyaxial lateral mass screw was implanted and confirmed to be well positioned. The rod was then pre-bent and connected according to the physiological curve of the cervical spine.

The following procedures were performed under microscopy. First, the spinous processes of C5 and C6 were completely removed. The lateral bone of the lamina was polished with a microdrill along the posterolateral side of the vertebral canal from C7 to C3 until its surface was eggshell-like. The polished vertebral plate was then penetrated by a nerve dissector (Aesculap, Tuttlingen, Germany), and the residual vertebral plate was removed with a Kerrison rongeur (Aesculap), leaving the central part of the entire lamina of C4 to C7 in an overall suspended state. Finally, the micro-hook scalpel was used to assist in separating the adhesion band on the dural sac, and the C4 to C7 segments of the lamina were removed together.

Patients in Group B underwent anterior cervical corpectomy with intervertebral titanium cage fusion. After induction of anesthesia, the patients were placed in the supine position. The cervical vertebrae were kept in the neutral position with slight posterior flexion. Taking corpectomy of C5 as an example, a right lateral transverse incision was performed in the neck. First, blunt separation was performed along the internal cervical visceral and vascular sheath, and a Caspar distractor (Aesculap) was then installed after the C5 vertebral body was confirmed under G-arm X-ray guidance.

The following procedures were performed under microscopy. The C4/5 and C5/6 intervertebral discs were carefully removed with a nucleus pulposus clamp, and the C5 vertebral body was grooved for bone cutting. The endplate cartilage was scraped with high-speed electric drill in preparation for bone grafting. To ensure adequate dural and neural decompression, the unossified posterior longitudinal ligament or adhesive band was gradually cut with the micro-hook scalpel, and the ossified ligament was then removed with a gun-type forceps. The operation under microscope ended upon completion of this step. The intervertebral height and width of C4 to C6 were measured and fitted into matching titanium cages that had been filled with autologous bone. Self-tapping screws were used cranially and caudally to fix the implant and plate. Figure 2 shows the micro-hook scalpel during the operation.

Clinical outcome assessment

The Japanese Orthopedic Association (JOA) score was used to evaluate neurological function. The recovery rate (RR) was calculated using the preoperative and postoperative JOA scores as follows: RR = (postoperative JOA score − preoperative JOA score)/(17 − preoperative JOA score) × 100%.[13] Axial neck pain was evaluated by a visual analog scale (VAS) score. A score of 0 indicated no pain, and a score of 10 indicated extreme pain.

Radiological evaluation

Routine examinations of the cervical spine before surgery included X-ray, computed tomography, and magnetic resonance imaging. Three independent spinal surgeons assessed the imaging results. The preoperative X-ray examination showed that the cervical spine was straightened, the intervertebral space was narrow, and

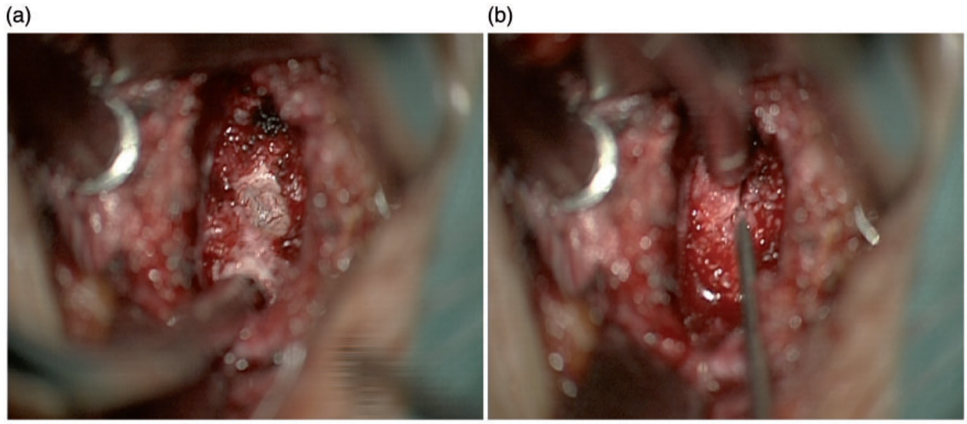

Figure 2. (a) The posterior disc protrusion was cut open by the micro-hook scalpel and (b) The ligament was cut open by the micro-hook scalpel.

OPLL was present from C4 to C6 (Figure 3(a)) and C5 to C6 (Figure 4(a)). Preoperative computed tomography showed OPLL and spinal canal stenosis from C4 to C6 and C5 to C6 (Figures 3(b) and 4(b)). In addition, preoperative magnetic resonance imaging showed spinal canal stenosis from C4 to C6 with obvious local spinal cord compression (Figure 3(c)) as well as spinal canal stenosis from C5 to C6 with obvious C6 spinal cord compression (Figure 4(c)).

Statistical analysis

All data were analyzed using SPSS 12.0 (SPSS Inc., Chicago, IL, USA). The preoperative and postoperative JOA and VAS scores were analyzed by Student's t test. Chi-squared analysis was used to calculate the RR. A P value of <0.05 was considered statistically significant.

Results

Patient characteristics

In total, 61 patients with OPLL were included in this study (Group A, $n=47$; Group B, $n=14$). Among them, 25 patients were female and 36 were male. The patients' mean age was 55.3 years (range, 47–89 years). Fifty patients had three segmental lesions involving C3 to C6 ($n=29$) or C4–C7 ($n=21$), and 11 patients had four segmental lesions involving C3 to C7. The patients exhibited the following symptoms of spinal cord compression: a "treading on cotton" gait with walking instability and lower extremity weakness ($n=45$); muscular hypertonia, tendon hyperreflexia, and patella clonus (+) ($n=12$); axial symptoms such as neck, shoulder, or back pain and limitation of activity ($n=57$); radiculopathy such as radiating pain and numbness of the upper limb ($n=13$); zonesthesia in the chest and abdomen ($n=37$); Hoffman's syndrome (+) ($n=34$); the Babinski sign (+) ($n=41$); and sphincter disturbance ($n=8$). All patients' symptoms improved to varying degrees by microscopically assisted decompression with a micro-hook scalpel. Of the 45 patients with a "treading on cotton" gait with walking instability and lower extremity weakness, 40 exhibited significant improvement and 5 exhibited partial improvement postoperatively (long disease course, partial degeneration of the spinal cord before surgery). Of the 12 patients with muscular hypertonia,

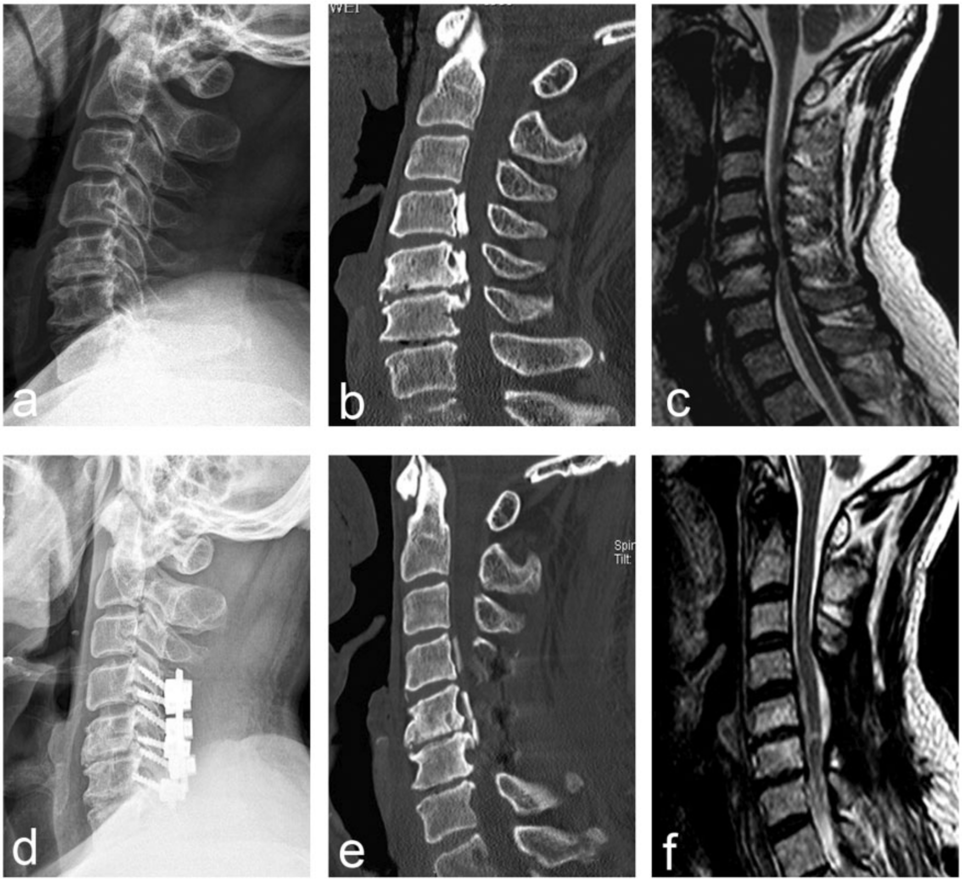

Figure 3. A 60-year-old man with a 2-year history of numbness and weakness of the limbs. (a) Preoperative X-ray examination showed that the cervical spine was straightened, the intervertebral space was narrow, and ossification of the posterior longitudinal ligament was present from C4 to C6. (b) Preoperative computed tomography showed ossification of the posterior longitudinal ligament and spinal canal stenosis from C4 to C6. (c) Preoperative magnetic resonance imaging showed local spinal canal stenosis from C4 to C6 with obvious spinal cord compression. (d) Postoperative X-ray examination showed good positioning of the internal fixation of the cervical vertebra. (e) Postoperative computed tomography showed spinal canal enlargement from C4 to C6. (f) Postoperative magnetic resonance imaging showed that the spinal canal was enlarged from C4 to C6, the local spinal cord had moved backward, and the spinal cord was not significantly stressed.

tendon hyperreflexia, and patella clonus (+), 10 showed significant improvement and 2 showed partial improvement postoperatively (long disease course, partial degeneration of the spinal cord before surgery). Of the 57 patients with axial symptoms such as neck, shoulder, or back pain and limitation of activity, 47 showed significant improvement and 10 showed partial improvement (a certain correlation with long segment fixation was observed). Of the 37 patients with zonesthesia in the chest and abdomen, 35 exhibited significant improvement and 2 exhibited partial improvement. Of the 34 patients with Hoffman's syndrome (+), 30 were negative

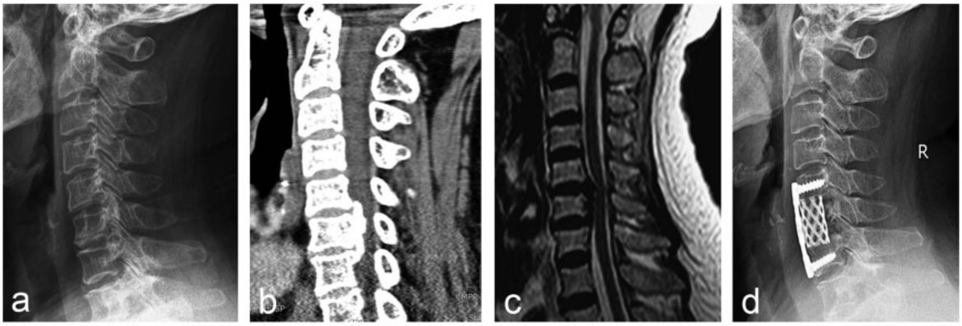

Figure 4. A 62-year-old man with a 6-year history of weakness of the limbs and pain in the neck and shoulder. (a) Preoperative X-ray examination showed ossification of the posterior longitudinal ligament from C5 to C6. (b) Preoperative computed tomography showed ossification of the posterior longitudinal ligament from C5 to C6 and spinal canal stenosis. (c) Preoperative magnetic resonance imaging showed spinal canal stenosis from C5 to C6 and obvious spinal cord compression at C6. (d) Postoperative X-ray examination showed good positioning of the internal fixation and no settlement of the titanium cage.

Table 1. Outcomes of VAS and JOA scores of 61 patients at three time points.

	JOA score				VAS score		
Group	Before surgery	One week after surgery	Last follow-up	RR (%)	Before surgery	One week after surgery	Last follow-up
A	7.2 ± 1.5	13.2 ± 2.4	13.7 ± 1.8	59.92 ± 13.46	6.8 ± 2.1	2.5 ± 1.4	2.3 ± 2.0
B	7.5 ± 1.3	13.8 ± 2.1	14.1 ± 1.6	62.28 ± 14.16	7.1 ± 2.4	2.3 ± 1.5	2.2 ± 1.8

Data are presented as mean± standard deviation. JOA, Japanese Orthopaedic Association; VAS, visual analog scale; RR, recovery rate.

and 4 were suspected to be positive postoperatively. Of the 41 patients with the Babinski sign (+), 35 were negative and 6 were suspected to be positive postoperatively. Finally, the symptoms in all eight patients with sphincter disturbance substantially improved.

JOA and VAS scores

All patients were followed up for 6 to 38 months (mean, 16 months). The mean JOA scores, VAS scores, and RRs are shown in Table 1. In Group A, the preoperative JOA and VAS scores were 7.2 ± 1.5 and 6.8 ± 2.1, respectively; the postoperative JOA and VAS scores were 13.2 ± 2.4 and 2.5 ± 1.4, respectively; and the JOA and VAS scores at the final follow-up were 13.7 ± 1.8 and 2.3 ± 2.0, respectively. The JOA score improved significantly after surgery ($P < 0.05$), while the VAS score decreased significantly ($P < 0.05$). The RR of neurological function was 59.92% ± 13.46%. In Group B, the JOA and VAS scores were 7.5 ± 1.3 and 7.1 ± 2.4 preoperatively, 13.8 ± 2.1 and 2.3 ± 1.5 postoperatively, and 14.1 ± 1.6 and 2.2 ± 1.8 at the final follow-up, respectively. The RR in Group B was 62.28% ± 14.00%. Both groups showed a significant difference in the JOA and VAS scores from the preoperative period to 1 week postoperatively and the final follow-up ($P < 0.05$).

Radiographic outcomes

Figures 3 and 4 show two patients who underwent spinal cord decompression. The patient in Figure 3 underwent the posterior approach with laminectomy of the responsible segment and lateral mass screw fixation, while the patient in Figure 4 underwent anterior cervical corpectomy with intervertebral titanium cage fusion. Postoperative radiographs indicated good positioning and no damage to the internal fixation materials at the postoperative follow-up (Figures 3(d) and 4(d)). Postoperative computed tomography and magnetic resonance imaging showed that the spinal canal was expanded from C4 to C6 and that the local spinal cord had moved backward with no obvious spinal cord compression (Figure 3(e) and (f)).

Discussion

The micro-hook scalpel is a surgical knife that has been applied in neurosurgery for many years. Clinically, the micro-hook scalpel is mainly used to cut and separate the dura mater and pia mater.[14] Specialized microscopes for spinal surgery can provide good light and clear three-dimensional views. Adhesive bands, fine veins, the posterior longitudinal ligament, and the dural sac in the spinal canal are clearly visible under microscopy. In the present study, we used an L-shaped or hook-shaped scalpel with the cutting edge on the ventral side to assist in decompression. Our study showed that the micro-hook scalpel can effectively reduce the intraoperative surgical stimulation of the cervical spine. Both groups showed a significant difference in the JOA and VAS scores from before surgery to 1 week after surgery and the final follow-up ($P < 0.05$). This may be because the micro-hook scalpel has minimal contact with adjacent tissues and minimal interference with the spinal cord and dural sac, thus reducing nerve damage. The micro-hook scalpel is a powerful supplement to a gun-type rongeur in decompression of the cervical spine, especially in patients with a small tear of the posterior longitudinal ligament, unclear exposure of deep tissue, and a high risk of separation using a gun-type rongeur. The micro-hook scalpel can not only gradually cut the posterior longitudinal ligament or adhesive band from shallow to deep, but it can also enlarge the opening of the posterior longitudinal ligament from small to large, clearly revealing the tissue in a deep and expanded view. This feature facilitates further manipulation of the gun-type rongeur and reduces the stimulation of the spinal cord caused by blunt dissection.

The surgical choice for the treatment of OPLL decompression must take into account the number of cervical segments, the position of ossified ligament stenosis, the force line of the cervical vertebra, and the proficiency level of the operator. Two primary surgical strategies are currently used for spinal cord decompression: an anterior operation and a posterior operation.[8–10] Anterior surgery can directly relieve the compression of the spinal cord, nerve roots, and blood vessels. Furthermore, when combined with an internal fixation technique involving bone graft fusion and a locked titanium plate, anterior decompression not only maintains the height of the intervertebral space but also ensures the stability of the vertebral body simultaneously. In general, anterior surgery is a good choice when OPLL of the lower cervical spine involves fewer than three segments, the thickness of the ossification site is <5 mm, and the stenosis of the spinal canal is <45%.[15]

Clinically, however, patients with OPLL usually have symptoms caused by multiple-segment lesions, spinal canal stenosis, and ligament ossification. To ensure complete decompression, the surgeon must enlarge the incision and perform multisegmental intervertebral fusion, which inevitably increases the difficulty of the surgery and incidence of anterior operative complications such as dysphagia and nerve and blood vessel damage. In addition, after multisegmental intervertebral fusion, the physiological curvature and mechanical properties of the cervical vertebrae have changed, leading to increased degeneration of adjacent segments, poor fusion of the vertebral body, and the formation of pseudarthrosis and kyphosis.[16] For patients with multisegment cervical spondylosis and OPLL, direct resection of the ossification by an anterior approach can easily lead to rupture of the dural sac and even catastrophic damage to the spinal cord.[17] Therefore, posterior surgery should be considered when anterior surgery is not suitable and the following symptoms have occurred: OPLL with ossification involving more than three segments; ossified segments involving C1, C2, C6, or C7 extending to the thoracic vertebrae; >5-mm thickness of ossification; continuous-type and mixed-type OPLL; acute spinal cord injury requiring extensive laminectomy; and OPLL with developmental spinal canal stenosis.[18] Decompression via posterior surgery allows the spinal cord to float away from vertical compression, which can indirectly achieve decompression without resection of the posterior longitudinal ligament and stimulation of nerves. Posterior surgery is relatively simple and safe and its range of decompression is unaffected, making it more suitable for patients with large segmental spinal canal stenosis and severe cervical spinal cord injury. Our study showed that both anterior and posterior surgeries can achieve significant improvement in patients' clinical conditions.

Conclusion

Micro-hook scalpel-assisted decompression achieved good clinical effects in anterior and posterior surgeries. Therefore, when selecting the optimal surgical method, an appropriate surgical tool is also indispensable because it will increase the safety and success rate of the operation. However, our study also has some limitations. The accuracy of the surgical methods used in this study must be verified by long-term follow-up. In addition, the micro-hook scalpel can only sharply cut the soft adhesion and posterior longitudinal ligament/yellow ligament. The ossified ligament and the epiphysis cannot be cut, and only the soft tissue/adhesion of the edge of the isolated ossified tissue can be revealed. The ossified part still requires a gun-type rongeur.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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