



Predictors of Surgical Outcome in Acute Spinal Cord Injury Patients with Cervical Ossification of the Posterior Longitudinal Ligament

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■ **OBJECTIVE:** A retrospective study was conducted to clarify the predictors of the operation results for ossification of the posterior longitudinal ligament (OPLL) patients with acute spinal cord injury (SCI). Detailed analyses of surgical outcomes of OPLL patients with SCI have been rare because most surveys have aimed to investigate OPLL or SCI, but not both.

■ **PATIENTS AND METHODS:** A total of 36 patients who underwent operation for OPLL between January 2011 and December 2011 were included in this analysis. We investigated the patients' characteristics and surgical approaches and compared the radiographic characteristics of OPLL patients with SCI.

■ **RESULTS:** The mean modified Japanese Orthopaedic Association (mJOA) score improved dramatically after operation ($P = 0.006$). The mean preoperative mJOA score was greater in patients with Nurick 3 than in patients with Nurick 4 and 5 ($P = 0.041$). The preoperative mJOA score was dramatically lower in patients caused by traffic accident and in patients with segmental OPLL lesion ($P < 0.05$). The postoperative mJOA score was dramatically lower in patients with continuous OPLL lesion than in the segmental OPLL lesion ($P = 0.028$). Changing in mJOA score was significantly different between the patients with high-intensity zone (HIZ) and without HIZ on magnetic resonance imaging.

■ **CONCLUSIONS:** HIZ on magnetic resonance imaging was significantly related to the surgical outcomes, which should be highlighted in the preoperative communication

with patients. Patients with lower Nirick grade and segmental OPLL would show better symptom before the operation. In addition, SCI caused by slipping or falling showed better symptoms before the operation. Patients with segmental OPLL should show better resolution of symptoms after the operation.

Ossification of the posterior longitudinal ligament (OPLL) is a hyperostotic condition of the spine that presents with severe neurologic deficit.^{1,2} This disease was first reported approximately 160 years ago³ and has been recognized as a common cause of cervical myelopathy, especially in Asia. It is reported that 30% of patients with spinal cord injury (SCI) are the result of OPLL,^{4,5} indicating that patients with cervical OPLL are more likely to have acute cervical SCI. Several factors for predicting the surgical outcome of OPLL have been discussed, such as preoperative neurologic status, cord compression ratio, history of trauma, intramedullary signal intensity grade, age, and so forth, even though the exact predictors of the surgical outcome are still unclear.⁶⁻⁹ By contrast, few articles have studied the predictors of the surgical outcomes in OPLL patients with acute SCI.

Surgical strategies for OPLL patients with SCI can be divided into 2 approaches: anterior and posterior. Cervical laminoplasty is a procedure designed to decompress the spinal cord by enlarging the spinal canal while preserving the lamina. Since the invention of cervical laminoplasty in Japan, its use had spread throughout the world and had gained increased use among spine surgeons. Anterior decompression and resection of OPLL also is a surgical option, because the spinal cord is compressed from the anterior direction. We aimed to evaluate that whether these factors, some preoperative symptoms, and severity of OPLL, as graded according

Key words

- Acute spinal cord injury
- Ossification of the posterior longitudinal ligament
- Predictors

Abbreviations and Acronyms

- ACDF:** Anterior cervical discectomy and fusion
- ASIA:** American Spinal Injury Association
- CSF:** Cerebrospinal fluid
- HIZ:** High-intensity zone
- mJOA:** modified Japanese Orthopaedic Association
- MRI:** Magnetic resonance imaging
- OPLL:** Ossification of the posterior longitudinal ligament

SCI: Spinal cord injury

TA: Transverse area

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to the Nurick classification¹⁰ and American Spinal Injury Association (ASIA) scale score, would be correlated with the surgical outcomes. We conducted a retrospective study of those patients who underwent anterior decompression and resection and/or cervical laminoplasty for the treatment of OPLL with a 3-year follow-up.

MATERIALS AND METHODS

This study was approved by the Institutional Review Board of Harbin Medical University, Heilongjiang, China. Between January 2011 and December 2011, a total of 130 patients with OPLL who were admitted to the 1st affiliated Hospital of Harbin Medical University underwent operation by 2 senior surgeons (Z.G.Y. and G.F.G.) in our department, and 36 suffered from cervical cord injury. The diagnosis of cervical OPLL was confirmed by radiographs and computer tomography, which showed significant ossification behind posterior border of vertebral body.

Inclusion criteria were cervical cord injury and admission through the outpatient or emergency department. Patients with spinal cord compression caused by OPLL were included. Those with the specific incomplete neurologic syndrome called central cord syndrome, which is characterized by greater muscle weakness and/or sensory loss in the upper limbs than the lower limbs and others caused by hyperextension hyperflexion, or axial loading injuries also were included. The exclusion criteria in this study included patients with any bony fractures, neoplasm, infection, congenital deformations, and chronic system illness such as rheumatoid arthritis and neurodegenerative diseases. Cases with only intervertebral disc ossification were not included in this study.

Segmental OPLL is located behind the vertebral bodies and not at the disc spaces, whereas continuous OPLL extends from body to body. The cases that were difficult to distinguish from osteophytes also were excluded. The 2 senior surgeons decided on an anterior and/or posterior approach for the treatment of OPLL patients with SCI. International standards for neurologic and functional classification of SCI, developed by the ASIA, were used as a neurologic examination tool to evaluate sensory, motor function, and neurologic level.¹¹

Patient age and sex were investigated, and particular attention was paid to information regarding the preoperative severity of OPLL, as graded according to the Nurick classification, type of surgery, surgically addressed levels, and ASIA scale. Preoperative and postoperative Nurick grades were recorded for each patient. Preoperative Nurick grades were defined as a grade before surgery but not specifically at initial presentation. Postoperative Nurick grades were recorded clinically at the last follow-up. All preoperative, immediate postoperative, and postoperative modified Japanese Orthopedic Association (mJOA) scores were determined by both the treating spinal surgeons and an attending neurologist. There were 2 patients with preoperative Nurick grade 0, because no patient without evidence of myelopathy was included. ASIA impairment scale was documented before the operation for each patient and after 36 months of the surgery. We used the ASIA impairment scale to evaluate sensory and motor function and neurologic level. We excluded data on sensory function and used only data on motor function in

the data analysis because it has been shown that motor evaluation is the best predictor of impairment in patients with SCI.¹²

In general, anterior decompressive surgery was performed more frequently in patients with focal pathology (1, 2, or 3 levels) and transverse area (TA) <45 mm². By contrast, posterior cervical decompression and fusion was performed more frequently in patients with multilevel pathology and TA >45 mm². If the OPLL involved 1 level, we conducted anterior cervical discectomy and fusion (ACDF) with plate fixation. If the OPLL involved 2 levels, we conducted corpectomy with plate fixation. If the OPLL involved 3 levels, we combined ACDF and corpectomy with plate fixation. If the OPLL involved 4 levels, we conducted subtotal multivertebrectomy in general.

All patients were evaluated clinically and radiographically before surgery. Clinical evaluation consisted of a medical history and physical examination. The clinical results were assessed with the mJOA scoring system and ASIA scale for OPLL patients with acute SCI. Standard anteroposterior and lateral radiographs with the patient in a standing position, computed tomography, and magnetic resonance imaging (MRI) of the cervical spine were conducted in a preoperative radiologic evaluation. A radiologist (Z.Y.C.) blinded to the patients' clinical and neurologic status analyzed all MRIs by using TA of the spinal cord at the site of maximal compression. Double-layer sign characterized by anterior and posterior rims of hyperdense ossification separated by a central hypodense was investigated to determine dural ossification. MRI showed compression and the presence of a high-intensity zone (HIZ) in the spinal cord.

RESULTS

There were 130 patients with OPLL who underwent surgery, and 36 had acute SCI. Of these 36, 17 were men and 19 were women; mean age was 53.47 years (range: 33–75 years). The major cause of SCI in patients with OPLL was slipping or falling (58.3%), followed by traffic accidents (41.7%). **Table 1** presents demographic and diagnostic characteristics of patients. By contrast, when we compared preoperative mJOA, immediate postoperative mJOA, postoperative mJOA after 3 years, there were no significant differences ($P = 0.425$). The mean mJOA score improved from 7.67 ± 5.545 points preoperatively to 11.44 ± 6.784 points at 36 months after operation ($P < 0.01$). The anterior approach (ACDF/corpectomy with instrumented fusion) for decompressive spinal surgery was performed in 20 patients, the posterior approach (either laminectomy and fusion or laminoplasty) was performed in 8 patients, and the combination of both anterior and posterior approaches was performed in 8 patients. The patients whose symptoms were not relieved well or even deteriorated also received adequate cord decompression as confirmed by MRI. None of them required revision surgery for inadequate cord decompression. The type of surgical procedure was not associated with mJOA scores ($P = 0.130$).

Mean ASIA motor score at admission was 29.7 ± 19.6 (range, 0–69) and improved to 57.7 ± 19.5 at last follow-up (range, 0–94) ($P < 0.001$). Overall, the mean recovery rate of the motor score was $47.1 \pm 19.7\%$ (range 0.0%–89.3%), and the recovery ratio improved in most patients except the patients who died within 24 hours.

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