Original Article
Anterior corpectomy and fusion for cervical ossification of posterior longitudinal ligament associated with developmental canal stenosis

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Abstract: Objective: The aim of this study was first to evaluate the safety and efficacy of anterior corpectomy and fusion (ACF) for cervical ossification of the posterior longitudinal ligament (OPLL) associated with developmental canal stenosis. Methods: Between May 2007 and May 2010, twenty-two patients with cervical myelopathy underwent ACF and all patients showed OPLL and developmental canal stenosis. A retrospective review of clinical and radiological data before and after surgery was conducted. Results: There were 17 men and 5 women with mean age of 57.3 years and a mean follow-up period of 25.5 months. The average Japanese Orthopedic Association (JOA) score before surgery was 8.5 points which significantly increased to 14.1 points at the last follow-up (P<0.05). The improvement rate of the JOA score ranged from 20.0% to 87.5%, with a mean of 67.0%±17.1%. The excellent and good clinical results according to Hirabayashi’s criteria were obtained in 19 patients (86.4%) at the last follow-up. The average cord flattening rate improved from 25% to 51% and the average Cobb’s angle increased from 6.3 degrees to 12.5 degrees at the last follow-up (P<0.05). There were no severe surgical complications, including failure of fusion. Conclusion: Our study results demonstrate that one- or two-level anterior corpectomy and fusion is applicable as a surgical treatment of cervical OPLL even where developmental canal stenosis is present.

Keywords: Anterior cervical corpectomy and fusion, cervical spine, developmental stenosis, myelopathy, ossification of the posterior longitudinal ligament

Introduction

Cervical spondylotic myelopathy (CSM) most probably has multiple causes. Ossification of the posterior longitudinal ligament consequentially represents one of the most frequent causes of cervical myelopathy and radiculopathy in Asian population. In addition, the spinal canal size is a common predisposing factor for the occurrence of cervical myelopathy. Anterior decompression and fusion can directly remove the OPLL and has been accepted as one of the prime surgical procedures for OPLL-related cervical myelopathy [1-5]. Since 2003, anterior decompression and fusion was performed for select patients with OPLL at our institution, and have obtained good results. We surmised that favorable results might be obtained even in patients with developmental canal stenosis, if the primary cause of cervical myelopathy was OPLL. Shoda et al [6] believed that the existence of dynamic spinal canal stenosis at the level adjacent to cervical fusion is a risk factor for deterioration of myelopathy after anterior surgery. In this series, we fused the adjacent disc levels that exhibit preoperative dynamic canal stenosis when performing anterior cervical fusion. Usually one vertebra or more should be treated with corpectomy for cervical OPLL. The principal problems associated with multi-level fusion include a higher possibility of problems in the grafted bone and mechanical stress in the adjacent discs. Therefore, when the number of corpectomized vertebrae is three or more, we choose posterior approach as the main treatment. This is the first report to evaluate the safety and effectiveness of anterior corpectomy and fusion (ACF) for cervical OPLL associated with developmental canal stenosis.
**Materials and methods**

**Patient population**

Between May 2007 and May 2010, a total of 58 consecutive patients (40 men and 18 women) received ACF for cervical OPLL at our institution. Inclusion criteria were (1) patients who presented developmental canal stenosis, (2) an accountable OPLL extending less than three vertebrae, thus requiring corpectomy in one or two vertebrae, (3) the lesion below C2 and above T1. Exclusion criteria were (1) cervical myelopathy caused by disc herniation or spondylosis, (2) patients with cervical ossification of the ligamentum flavum or thoracic OPLL, (3) patients with a history of previous cervical spine surgery or injury. Based on these criteria, 22 patients were enrolled in this retrospective study. The study group comprised 17 men and 5 women with a mean age of 57.3 years, ranging from 38 to 74 years. All patients presented moderated to severe spastic limb paralysis, and the average symptom duration was 21.4 months, ranging from 6 to 36 months. All patients chose to have cervical surgery because of neurological aggravation, and the average follow-up period after surgery was 25.5 months, ranging from 12 to 36 months.

Prior to surgery, informed consent for participation in this study was obtained from each patient. The Institutional Review Board of the Third Hospital of Hebei Medical University approved the study after thorough examination and verification.

**Radiological evaluation**

All patients had pre- and postoperative plain radiographs, computed tomography (CT) scans, and magnetic resonance images (MRIs).

Plain radiographs: On the plain radiographs, we measured the sagittal diameter of the cervical canal and the sagittal diameter of the vertebral body. The sagittal diameter of cervical canal was measured from the middle portion of the posterior cortical surface of the vertebral body to the nearest point of the corresponding laminar line. The sagittal diameter of the vertebral body was measured at the midpoint from the anterior surface to the posterior surface. Pavlov’s ratio, which is unaffected by magnification error, was calculated as the sagittal diameter of the cervical canal/the sagittal diameter of the vertebral body. A value <0.82 indicates developmental cervical canal stenosis [7]. The Cobb’s angle, which was measured between intersecting lines drawn perpendicular to the bottom of the C2 vertebral body and that of the C7 or C6 body in lateral radiograph, was used to evaluate cervical lordosis prior to surgery and during follow-up period.

Computed tomography: On sagittal image, OPLL was classified into four types: local, segmental, continuous, and mixed.

Magnetic resonance imaging: The cord flattening rate was used to evaluate compression of the spinal cord on axial T1-weighted MR images. This parameter was defined as the minor axis length of the spinal cord divided by its major axis length [8].

**Surgical technique**

All surgeries were performed by a single surgeon (Y.S.). Under general anaesthesia, anterior corpectomy and fusion with plate-and-screw system was performed. The patient was placed in a supine position with the neck slightly extended, and the cervical spine was exposed through a standard right side anterior approach. After necessary discectomies, the selective corpectomy was performed in one or two vertebral bodies, using a high speed drill and an appropriate rongeur. The above and below adjacent vertebral bodies were partially removed to facilitate further decompression. Transverse decompression generally extended more than the width of OPLL base to make the ossification release from the lateral-posterior cortex of the vertebral body. A micro curette was used to lever the posterior cortex, then a micro dissector was inserted to separate the adhesion between the ossified mass and dural sac. After that, the OPLL was removed piece by piece by a 1-2 mm Kerrison rongeur. However, the OPLL sometimes adhered to the dura and the ossified mass was not able to be removed from the ossified dura mater. In this condition, the floating method was adopted. Ossified mass was gradually thinned by the drill until the thickness of ossification was less than 5 mm. Then, the ossified mass gradually floated anteriorly and did not compress the spinal cord eventually. After confirming good pulsation of the thecal...
ACF for cervical OPLL

Table 1. Clinical data before and after surgery for 22 study patients

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Male 17, Female 5</td>
</tr>
<tr>
<td>Age at operation, years</td>
<td>57.3±9.4 (38-74)</td>
</tr>
<tr>
<td>Follow-up period, months</td>
<td>25.5±8.4 (12-36)</td>
</tr>
<tr>
<td>Symptom duration, months</td>
<td>21.4±8.8 (6-36)</td>
</tr>
<tr>
<td>Type of ossification, number of patients</td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>6</td>
</tr>
<tr>
<td>Segmental</td>
<td>4</td>
</tr>
<tr>
<td>Continuous</td>
<td>2</td>
</tr>
<tr>
<td>Mixed</td>
<td>10</td>
</tr>
<tr>
<td>Number of corpectomized vertebrae</td>
<td>1.2±0.4 (1-2)</td>
</tr>
<tr>
<td>JOA score, points</td>
<td></td>
</tr>
<tr>
<td>Before surgery</td>
<td>8.5±1.2 (7-10)</td>
</tr>
<tr>
<td>Three month after surgery</td>
<td>13.6±1.9 (8-15)</td>
</tr>
<tr>
<td>At the last follow-up</td>
<td>14.1±1.8 (9-16)</td>
</tr>
<tr>
<td>IR at the last follow-up, %</td>
<td>67.0±17.1 (20.0-87.5)</td>
</tr>
<tr>
<td>Surgical outcome at last follow-up, number of patients</td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>9</td>
</tr>
<tr>
<td>Good</td>
<td>10</td>
</tr>
<tr>
<td>Fair</td>
<td>2</td>
</tr>
<tr>
<td>Poor</td>
<td>1</td>
</tr>
<tr>
<td>Surgery complications, number of patients</td>
<td></td>
</tr>
<tr>
<td>Hematoma</td>
<td>1</td>
</tr>
<tr>
<td>CSF leakage</td>
<td>4</td>
</tr>
<tr>
<td>C5 palsy</td>
<td>1</td>
</tr>
</tbody>
</table>

JOA indicates Japanese Orthopedic Association; IR indicates improvement rate; CSF indicates cerebrospinal fluid; Values are expressed as the mean ± standard deviation (range); ※P<0.01, compared with the data before surgery using the student t test.

Clinical assessment

The clinical outcomes were evaluated using the Japanese Orthopedic Association (JOA) scoring system before and after surgery. With the JOA score, an improvement rate (IR) was calculated according to Hirabayashi et al as IR= (postoperative JOA score-preoperative JOA score /17-preoperative JOA score) ×100%. Surgical results were indicated by the IR as follows: less than 25% (poor), 25% to 49% (fair), 50% to 74% (good), and 75% or more (excellent) [9].

Table 1 summarizes the clinical data for the 22 patients. All patients had signal changes in spinal cord on cervical MRIs. With respect to OPLL type, it was local-type in 6 patients, segmental-type in 4 patients, continuous-type in 2 patients, and mixed-type in 10 patients. Anterior decompression involved one-level corpectomy in 17 cases, and two-level in 5. No patient was lost to follow-up. The mean JOA score increased from 8.5 (range, 7-10) at pre-operation to 13.6 (range, 8-15) at the 3-month follow-up and 14.1 (range, 9-16) at the last follow-up (P<0.05). The improvement rate of the JOA score ranged from 20.0% to 87.5%, with a mean of 67.0%±17.1%. According to Hirabayashi’s criteria (Hirabayashi et al., 1981), nine (40.9%) patients were graded excellent, ten (45.5%) patients were good, two (9.1%) patients were fair, and one (4.5%) patient was poor at the last follow-up.

The operation-related complications involved hematoma in one patient, cerebrospinal fluid (CSF) leakage in four patients, and C5 palsy in one patient. The patient who developed dyspnea due to hematoma was cured after an emergency operation without neurological deterioration. When dural tearing occurred intraoperatively, timely treatment was performed, including covering with artificial dura and gelatin sponges, suturing platysma myoides densely, and would drainage. Four patients developed CSF leakage postoperatively. CSF leakage usu-
ally stopped after 3-to 7-day conservative treatment such as continuous pressure to the wound, bed rest and anti-infection measures. However, one patient experienced a cerebrospinal fluid pseudocyst, which gradually disappeared after three weeks of repeated puncturation and aspiration. C5 palsy developed at 8 hours postoperatively, and the strength of deltoid and biceps muscles decreased to grade 1 in manual muscle test (MMT). Neurotrophy drugs and high-pressure oxygen therapy were the main treatments for this patient. Strength of deltoid and biceps muscles increased to four in MMT after 3 months. Fortunately, aggravation of neurological symptoms by cord injury, wound infection, fusion failure, cervical instability, and adjacent segment degenerative changes were not observed during the follow-up period (Figure 1).

**Radiological outcomes**

The mean sagittal diameters of spinal canal from C3 to C7 were less than 11 mm and the values of Pavlov’s ratio were less than 0.82. With respect to radiological findings, the mean preoperative Cobb’s angle was 6.3 degrees which increased to 12.5 degrees at the last...
follow-up (P<0.05). The cord diameter significantly increased after operation, and the mean preoperative cord flattening rate was 25% which increased to 51% at the last follow-up (P<0.05) (Table 2).

Discussion

Surgical strategies to treat varying degrees of cervical OPLL involve anterior and posterior approaches. However, evaluation of the two approaches differs between institutions [1-3, 8, 10]. An appropriate operation must maximize the chance of optimal neurological outcome and minimize surgical morbidity. In general, anterior decompression by direct resection of OPLL seems to be an ideal option, and laminoplasty attempts to provide indirect decompression by the posterior shift of the spinal cord from the anterior compressions. In addition, cases have been reported of progressive kyphosis and growth of OPLL after laminoplasty causing further neurological deterioration [11]. In osteophtectomy, several authors have noted a high incidence of iatrogenic neurological deterioration after surgery [12, 13]. Although anterior decompression is technically more demanding with increasing occupancy ratio of the OPLL, the surgical outcome is better than that for posterior decompression [8, 14].

Cervical OPLL is fundamentally a deteriorating lesion associated with age. When developmental canal stenosis is also present, even if the protrusion due to the OPLL is mild, myelopathy may be significant. Based on autopsy study, Ogino et al [15] have reported that congenital cervical canal size is an important predisposing factor for production of myelopathy and the main cause is not spondyotic protrusion. Epstein et al [16] emphasized that patients with a developmentally narrow canal and no significant evidence of spondylosis should receive posterior decompression. However, patients with developmental canal stenosis usually show clear evidence of compression on the cervical cord caused by spondyotic protrusion. Kadoya et al [17] believe that myelopathy usually results from spondyotic changes with advancing age rather than the narrow canal itself. They found that for patients with developmental cervical canal stenosis and multiple anterior cord compressions, removal of the anterior lesions associated with interbody fusion has resulted in significant improvement in neurological function and no deterioration was seen during a long-term follow-up period. Posterior surgery was consequently not required. Therefore, they concluded that spondylosis is the primary predisposing factor in the genesis of cervical spondylotic myelopathy with developmental canal stenosis.

In this series, we retrospectively analyzed 22 cases with cervical OPLL and developmental canal stenosis and this is the first report to evaluate ACF for this type of myelopathy. Anterior decompression has not been widely recommended, especially in our cases with a narrow canal and virtually no significant space between the OPLL and the cervical cord. We think that surgeons should not choose posterior approach just because it is easier, especially in patients for whom the anterior lesions are significant. Based on this consideration, a micro dissector was used to separate OPLL from dura, and resection of the OPLL should begin from a nonossified region to avoid a traumatic manipulation to the cervical cord. Dural ossification is frequent with severe OPLL and floating method seems to be favorable to avoid dural tears. The residual ossified mass gradually floated anteriorly and eventually did not compress the cervical cord. Luckily, no iatrogenic cord damage appeared postoperatively and in our 22 cases, it has been possible to resect the OPLL safely.

In our current study, the improvement of neurological function was significant. Radiological findings such as nonoccurrence of fusion failure and cervical instability, and increases of cervical lordosis and the cord diameter at the
level of maximal cord compression during follow-up period were satisfactory. The achievement of an optimal alignment is a major goal of cervical spine surgery. Anterior decompression and fusion could achieve good release and distraction, so an improvement of cervical alignment can be achieved and maintained. Our radiological outcomes support the results of existing literatures [18, 19], showing a significant improvement of cervical lordosis. Anterior surgery also provided a significant increase in the cervical cord diameter, and all patients had a significantly improved cord-flattening ratio after surgery. CSF leakage was the most common complication after anterior decompression for OPLL, with an incidence rate between 4.6% and 32% [20]. In the current study, CSF leakage resulting from dural tearing occurred in 4 patients because of the tight adherence of OPLL with dura mater or dural ossification. Various dural repair techniques, such as suture and fascial graft, seemed to be unnecessary because CSF leakage could be cured by conservative treatment. Immobilization of the neck, continuous pressure to the wound, wound drainage, and anti-infection measures are basic and important conservative treatments.

The small number of patients, the short follow-up period, the retrospective character and the absence of a control group constitute limitations of this study. Furthermore, the biomechanical effect on the cervical spine due to the stabilization of multiple interspaces may lead to spondylotic changes at nonoperated vertebral levels. Additional study is required to compare ACF to laminoplasty for these patients.

Disclosure of conflict of interest

None.

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