Surgical Management of 4-level Cervical Spondylotic Myelopathy

YU SHUNZHI, MD; LI ZHONGHAI, MD; LI FENGNING, MD; CHEN ZHI, MD; HOU TIESHENG, MD

abstract

The optimal surgical approach for 4-level cervical spondylotic myelopathy is controversial. The authors compared the clinical outcomes, radiographic changes, and complications of 53 patients who underwent either discontinuous corpectomy and fusion (DCF) with reservation of the middle vertebra (n=29) or laminectomy and fusion (n=24). Neurological function was measured using Nurick's grade and modified Japanese Orthopedic Association scores. The Neck Disability Index was recorded for neck-shoulder pain level evaluation. Patients’ satisfaction with the surgery was evaluated using the Short Form 36. Segmental lordosis was measured. Both groups demonstrated significantly improved Nurick’s grades and Japanese Orthopedic Association scores (P<.001), and the recovery rate was similar between the groups (59.86%±17.63% and 60.18%±12.01%, respectively). In terms of Neck Disability Index scores, Short Form 36 scores, and cervical lordosis measurements, no significant intergroup differences were found preoperatively. Mean postoperative Neck Disability Index scores were significantly lower in the DCF group (12.31±1.91) than in the laminectomy group (15.04±3.09; P=.000). Mean postoperative segmental lordosis was significantly higher in the DCF group (14.24±2.29) than in the laminectomy group (9.96±2.14; P=.001). The Short Form 36 scores significantly improved in both groups postoperatively (P<.01). Relative to the DCF group, the laminectomy group had a significantly longer operative time (192.25±33.47 vs 192.25±33.47 minutes, respectively; P<.01) and significantly more operative blood loss (455.41±140.46 vs 253.79±77.94 mL, respectively; P<.01). Discontinuous corpectomy and fusion with reservation of the middle vertebra is a safe and effective surgical treatment for 4-level cervical spondylotic myelopathy that results in significant functional improvement in most patients.

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The authors have no relevant financial relationships to disclose.

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Cervical spondylotic myelopathy is a common spinal cord disorder that develops in elderly individuals. Surgeries from the anterior and posterior approaches have been developed with the goal of restoring the spinal canal and decompressing the spinal cord.1 Anterior cervical corpectomy and fusion (ACCF) is an effective and reliable procedure for the treatment of cervical degenerative disorders involving 1 or 2 motion segments.2,3 However, the optimal surgical approach for multilevel cervical spondylotic myelopathy remains controversial. Although laminectomy and laminoplasty have been effective for the treatment of multilevel cervical spondylotic myelopathy,4 progressive cervical kyphosis, C5 nerve root palsy, and axial neck pain are major disadvantages of these techniques.5,7 The ventral aspect of the spinal cord and nerve roots is most often compressed.8 Anterior cervical corpectomy and fusion better restores cervical lordosis and directly decompresses the spinal cord by removing the offending soft or hard disks.9 Nevertheless, when multilevel corpectomy is performed, the potential exists for significant plate failure and graft extrusion.10,11 In addition, little data exist regarding procedures involving 4-level segments. To reduce the load on the plate and graft, discontinuous corpectomy and fusion (DCF) with reservation of the middle vertebra may be an appropriated surgical procedure for the treatment of 4-level cervical spondylotic myelopathy according to clinical and radiological parameters.

**Materials and Methods**

**Patients**

Fifty-eight patients who underwent surgery for multilevel cervical spondylotic myelopathy in the authors’ institution between July 2006 and June 2011 were included in the study. Five patients were excluded because they did not complete 1-year follow-up. Seventeen women and 36 men with a median age of 59.6 years (range, 41-76 years) were included. All patients had 4-level involvement. Radiological diagnoses were established in each patient via routine preoperative cervical anteroposterior, lateral, and flexion-extension radiographs and cervical magnetic resonance imaging (MRI) or computed tomography (CT) scans. Twenty-nine patients underwent discontinuous corpectomy and fusion with reservation of middle vertebra (DCF group); lesions were in C2-C6 in 8 patients and in C3-C7 in 21. The other 24 patients underwent laminectomy and fusion (laminectomy group). All operations were performed by a single surgeon (H.T.) with more than 30 years of clinical experience in cervical spine surgery.

The following data were recorded for each patient: history; symptoms at admission; duration of symptoms; physical and neurological findings at presentation; intraoperative spinal observations; preoperative and 3-, 6-, and 12-month postoperative neurological function; preoperative and 3-, 6-, and 12-month postoperative radiological findings, intra- and postoperative complications; and follow-up time.

**Surgical Indications**

The presence of cervical spinal cord compression was confirmed on MRI or CT (Figure 1). Segmental instability was evaluated on dynamic lateral radiographs. All patients received conservative treatment (an analgesic and a muscle relaxant, cervical collar protection, bed rest, and appropriate physical therapy) preoperatively. The most common indication for surgery was cervical myelopathy followed by a loss of cervical lordosis, long-term incapacitating pain, radiculopathy, segmental instability, radiculomyelopathy, and central cord syndrome.

**Surgical Technique**

**Discontinuous Corpectomy and Fusion With Reservation of the Middle Vertebra**

Under general anesthesia, patients were placed in the supine position with their necks slightly extended. After confirmation and exposure of the appropriate vertebral levels, the middle vertebra of the segment with lesions was preserved with corpectomy of the 2 superior and inferior adjacent vertebrae. Cartilaginous end plates were removed from the adjoining vertebral bodies. The corpectomized...
bone was harvested, morsellized, and packed into 2 appropriately sized titanium meshes (DePuy Spine, New Brunswick, New Jersey). The titanium meshes had a lordotic curvature that was contoured intraoperatively. For complete decompression, the posterior longitudinal ligament was also completely removed from all patients. Anterior fusion was performed using titanium mesh. An appropriately sized anterior dynamic cervical titanium plate was then firmly fixed into the upper, lower, and middle vertebrae with screws (Slim-Loc; DePuy Spine). The platysma muscle and muscular fascia were closed with sutures.

Laminectomy and Fusion

Decompression was performed via a midline approach. The midline fascia was incised. Subperiosteal dissection was used to reflect the soft tissue structures of the spinous processes, lamina, and lateral mass. The laminae were removed with a combination of rongeurs, curettes, and a high-speed drill. Decompression of 6 patients extended from C3-C7. The 2 other patients had lesions in C2-C6, whereas the caudal third of the C2 lamina was removed. The decompressed levels were then instrumented with lateral mass (cervical) and pedicle screw fixation (Samiter; DePuy Spine). Operative time and blood loss were recorded for both groups. All patients wore rigid cervical collars for an average of 10 weeks postoperatively.

Outcome Measures

All patients underwent radiography, MRI, and CT preoperatively. Follow-ups occurred at 3, 6, and 12 months postoperatively. Cervical anteroposterior, lateral, and flexion-extension radiographs were obtained 3, 6, and 12 months postoperatively to assess graft fusion and calculate the fusion rate. Each patient was also evaluated using at least 1 MRI or CT scan with sagittal reconstruction 12 months postoperatively. Neurological function was assessed using the Nurick’s grade and Japanese Orthopedic Association (JOA) scores. An improvement rate was calculated as follows: \[
\frac{\text{postoperative JOA score} - \text{preoperative JOA score}}{\text{preoperative JOA score}} \times 100\%
\] Surgical outcome was defined according to the improvement rate as follows: excellent (improvement rate greater than 75%), good (75%–50%), fair (50%–25%), and poor (improvement rate less than 25%). The Neck Disability Index (NDI) was also recorded for the evaluation of neck-shoulder pain levels. Patients’ satisfaction with the surgery was evaluated during the early and late postoperative periods using the Short Form 36 (SF-36) (General Health Survey). The degrees of preoperative and final follow-up fusion segmental lordosis were measured using the Cobb method (Figure 2).

Statistical Analysis

Data were analyzed using Microsoft Excel 2003 (Microsoft, Redmond, Washington) and SPSS version 19.0 software (SPSS, Inc, Chicago, Illinois). A paired \( t \) test was used for the paired data, and an independent \( t \) test was used for the unpaired data. Chi-square test was used for categorical data. A \( P \) value less than .01 was considered statistically significant.

RESULTS

Patients were followed for 12 to 42 months postoperatively. Most patients were men (n=36; 67.9%). The duration of symptoms at presentation ranged from 6 months to 4 years (median, 2.4 years). Major symptoms at presentation were arm numbness (n=45; 86.8%), neck and arm pain (n=37; 69.8%), gait disorder (n=29; 54.7%), and foot weakness (n=21; 39.6%). All patients showed various degrees of symptom relief postoperatively (Figures 3, 4). In the DCF group, mean operative time was 155.48±17.11 minutes (range, 130-192 minutes) and mean blood loss was 253.79±77.94 mL (range, 150-420 mL). In the laminectomy group, mean operative time was 192.25±33.47 (range, 154-260 minutes) minutes and mean blood loss was 242.3±103.7 mL (range, 145-445 mL). Patients were evaluated using the Nurick’s grade and Japanese Orthopedic Association (JOA) scores. An improvement rate was calculated as follows: \[
\frac{\text{postoperative JOA score} - \text{preoperative JOA score}}{\text{preoperative JOA score}} \times 100\%
\] Surgical outcome was defined according to the improvement rate as follows: excellent (improvement rate greater than 75%), good (75%–50%), fair (50%–25%), and poor (improvement rate less than 25%). The Neck Disability Index (NDI) was also recorded for the evaluation of neck-shoulder pain levels. Patients’ satisfaction with the surgery was evaluated during the early and late postoperative periods using the Short Form 36 (SF-36) (General Health Survey). The degrees of preoperative and final follow-up fusion segmental lordosis were measured using the Cobb method (Figure 2).

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loss was 455.41±140.46 (range, 260-900 mL) mL. The laminectomy group required a significantly longer operative time than the DCF group (P=.01) and had more operative blood loss (P=.01) (Table 1).

Table 2 shows the functional results. No significant intergroup difference was observed preoperatively. The Nurick’s grades and JOA scores significantly improved in both groups postoperatively (P<.01). No aforementioned clinical parameters were statistically significant between the 2 groups. Japanese Orthopaedic Association score improvement in the DCF group was excellent in 8 patients, good in 13, fair in 7, and poor in 1. Japanese Orthopaedic Association score improvement in the laminectomy group was excellent in 3 patients, good in 17, and fair in 4. No significant difference existed between the 2 groups (P=.05).

No significant intergroup difference was found between NDI scores, cervical lordosis measurements, and SF-36 results preoperatively (Table 3). However, the pre- and postoperative NDI scores and cervical lordosis measurements significantly differed in each group. The mean postoperative NDI scores of the DCF group were significantly lower than those of the laminectomy group (P=.000). In the DCF group, the regional Cobb’s angle was 9.52°±2.27° preoperatively and 14.24°±2.29° postoperatively, which was
statistically significant (*P*<.01). In the laminectomy group, the regional Cobb’s angle was 10.13°±2.09° preoperatively and 9.96°±2.14° postoperatively. It was not significantly changed postoperatively (*P*>.05). The mean postoperative segmental lordosis measurement (Figures 3, 4) of the DCF group was significantly higher than that of the laminectomy group (*P*<.001). The SF-36 scores significantly improved in both groups postoperatively (*P*<.01). However, no significant difference existed between the 2 groups.

A summary of the complications is shown in Table 4. No cases of infection, chronic inflammation, iatrogenic neurological deterioration, or hematoma occurred during the short- or long-term follow-up.

**Discussion**

Anterior cervical decompression and fusion was first reported by Robinson and Smith.12 Currently, ACCF has become one of the most widely used spinal procedures, and consensus favors this technique for cervical myelopathy involving 1 or 2 motion segments.13 However, the surgical treatment of 4-level cervical spondylotic myelopathy is associated with less predictable outcomes and a higher frequency of complications.14,15 Thus, the optimal surgical approach for 4-level cervical spondylotic myelopathy remains controversial. Anterior cervical corpectomy and fusion directly decompresses the spinal cord by removing the offending soft or hard disks and better restores cervical lordosis and reduces axial neck pain. Immediate stability of the cervical spine can be achieved with grafting. In addition, buckling of the posterior ligamentum flavum is no longer a concern with anterior stabilization. However, when multilevel corpectomies are performed, the potential exists for significant plate failure, graft extrusion, and adjacent level disease.

Posterior surgical options, such as laminectomy and laminoplasty, are widely used for the treatment of multilevel cervical spondylotic myelopathy. Posterior multilevel decompression is a convenient and quick procedure, and the surgical field of vision is wider during decompression. Posterior surgery less frequently requires instrumentation and fusion, thereby decreasing the risk of adjacent level disease. In the current study, the JOA scores significantly improved for both groups postoperatively, and the improvement rates were similar (59.86% and 60.18% for the DCF and laminectomy groups, respectively). However, major complications following laminectomy, such as C5 nerve root palsy, kyphosis, wound complications, and persistent or new axial neck pain, have not been eliminated.16 The posterior ligamentous complex and cervical spine muscles are impaired, and the incidences of axial neck pain and C5 nerve root palsy

### Table 2

<table>
<thead>
<tr>
<th>Score</th>
<th>DCF Group</th>
<th>Laminectomy Group</th>
<th><em>P</em></th>
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</thead>
<tbody>
<tr>
<td>Nurick's grade</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Preoperative</td>
<td>3.52±0.69</td>
<td>3.54±0.72</td>
<td>.9</td>
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<tr>
<td>Postoperative</td>
<td>2.24±0.83*</td>
<td>2.13±0.61*</td>
<td>.56</td>
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<tr>
<td>JOA score</td>
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<tr>
<td>Preoperative</td>
<td>7.28±1.93</td>
<td>7.21±1.77</td>
<td>.896</td>
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<tr>
<td>Postoperative</td>
<td>13.17±1.65*</td>
<td>13.13±1.45*</td>
<td>.913</td>
</tr>
<tr>
<td>JOA score improvement</td>
<td>59.86±17.63</td>
<td>60.18±12.01</td>
<td>.938</td>
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</tbody>
</table>

**Abbreviations:** DCF, discontinuous corpectomy and fusion. *Significantly different from preoperative values (*P*<.01).

### Table 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>DCF Group</th>
<th>Laminectomy Group</th>
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<tr>
<td>Neck Disability Index</td>
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<td></td>
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<tr>
<td>Preoperative</td>
<td>21.45±4.85</td>
<td>22.00±4.27</td>
<td>.725</td>
</tr>
<tr>
<td>Postoperative</td>
<td>12.31±1.91*</td>
<td>15.04±3.09*</td>
<td>.001</td>
</tr>
<tr>
<td>Segmental lordosis, deg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>9.52±2.27</td>
<td>10.13±2.09</td>
<td>.380</td>
</tr>
<tr>
<td>Postoperative</td>
<td>14.24±2.29*</td>
<td>9.96±2.14</td>
<td>.000</td>
</tr>
<tr>
<td>Short Form 36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>27.10±4.72</td>
<td>28.04±4.93</td>
<td>.484</td>
</tr>
<tr>
<td>Postoperative</td>
<td>44.17±9.65*</td>
<td>42.46±9.25*</td>
<td>.515</td>
</tr>
</tbody>
</table>

**Abbreviations:** DCF, discontinuous corpectomy and fusion; deg, degrees. *Significantly different from the preoperative values (*P*<.01).
Axial neck pain (3) 
C5 root palsy (2) 
Temporary hoarseness (2) 
C5 root palsy (2) 
Axial neck pain (3) 
CSF leakage (1) 

Abbreviations: CSF, cerebrospinal fluid; DCF, discontinuous corpectomy and fusion.

Factors
Clinical and Radiological Predictive Factors
Three patients had compressive pathology of the cervical disks and hypertrophic ligamentum flavum on MRI. The clinical outcomes of these patients were poorer, which might be associated with inadequate decompression of the posterior pathogenic structures. The clinical appearances of unsteady steps and zonesthesias of the chest, abdomen, and lower limbs were observed in these patients 1 year postoperatively. Two of these patients underwent laminectomy, and their symptoms improved 6 months postoperatively. Discontinuous corpectomy and fusion can directly remove all of the anterior pathogenic structures, such as a protruded disk, osteophyte, or ossification lesion, although the alleviation of posterior compression is insufficient.

Anteroposterior surgery may be another suitable option. Anterior surgery for ossification of the posterior longitudinal ligament has been reported to provide better clinical outcomes compared with posterior decompression, particularly in patients with preoperative kyphosis.9,21,22 This operation was successfully performed for 2 patients with multilevel cervical spondylotic myelopathy and ossification of the posterior longitudinal ligament, and no postoperative complications, such as cerebrospinal fluid leak or radicular deficit, occurred.

Complications
No surgeon can afford to neglect the complications of cervical procedures.23-25 In the laminectomy group, axial neck pain, a major complication related to the posterior surgical approach, was observed during follow-up after cervical surgery. Fourteen patients reported axial neck pain, which was relieved 6 months postoperatively in 12 patients. The other 2 patients required oral analgesics.

Table 4
Complications

<table>
<thead>
<tr>
<th>DCF Group</th>
<th>Laminectomy Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary odynophagia (7)</td>
<td>C5 root palsy (3)</td>
</tr>
<tr>
<td>Temporary hoarseness (2)</td>
<td>Axial neck pain (14)</td>
</tr>
<tr>
<td>C5 root palsy (2)</td>
<td>CSF leakage (1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factors</th>
<th>Clinical and Radiological Predictive Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease</td>
<td>Anterior surgery for ossification of the posterior longitudinal ligament was performed for 2 patients with multilevel cervical spondylotic myelopathy and ossification of the posterior longitudinal ligament, and no postoperative complications, such as cerebrospinal fluid leak or radicular deficit, occurred.</td>
</tr>
</tbody>
</table>

Failure rates increase with 3 or more levels of corpectomy. Vaccaro et al15 reported early failures in patients undergoing 3-level corpectomy reconstructions and fusion with a fully constrained plate. They reported that 6 (50%) of 12 patients sustained plate and graft dislodgement within 3 months postoperatively. Panjabi et al17 reported excessive screw-vertebra motion caused by fatigue at the lower end of the 3-level corpectomy model, which might explain clinically observed failures at the caudal end of long anterior cervical plate constructs. Sasso et al18 reported a 71% failure rate after 3-level fixed-plated ACCF reconstruction. These series show that bone- and plate-related complications are common after ACCF. Instead of performing ACCF in the current retrospective study, 29 patients underwent DCF with reservation of the middle vertebra. The titanium mesh used for vertebral column reconstruction was shortened, reducing the rotational movements imposed on the implant-vertebra interface.

Wang et al19 reported that graft migration or displacement was directly relevant to a long graft and lack of fixation points. Because the middle vertebra was preserved, the cervical titanium plate was firmly fixed into the upper, lower, and middle vertebrae with screws. Mechanical construct stability increases with multiple fixation points. In the current study, no patients presented with graft dislodgement and screw loosening during the short- or long-term follow-ups.

Despite the presence of an additional partial vertebral body in the middle of the operative field, the skip corpectomy technique can provide adequate visualization for dural sac decompression.20 Being similar to traditional ACCF, corpectomy of 2 vertebrae can clearly expose 4-level intervertebral spaces, making decompression comprehensive and convenient. In some cases, the nucleus pulposus bulges out beyond the damaged posterior longitudinal ligament and compresses the spinal cord behind the middle vertebra. It is still possible to decompress the middle vertebra from an angled approach with extirpation of the nucleus pulposus and osteophytes along with adequate visualization and direct decompression. When the posterior part of the middle vertebra contributes to compression, adequate decompression of the posterior portion of the middle vertebra can also be achieved using this method (Figure 5).

Complications

No surgeon can afford to neglect the complications of cervical procedures.23-25 In the laminectomy group, axial neck pain, a major complication related to the posterior surgical approach, was observed during follow-up after cervical surgery. Fourteen patients reported axial neck pain, which was relieved 6 months postoperatively in 12 patients. The other 2 patients required oral analgesics.
Axial neck and parascapular pain is common and has been debated among proponents and detractors of the cervical laminoplasty and laminectomy procedure. The reasons for axial neck pain remain contentious and include issues related to the extensive posterior dissection and detachment of the cervical musculature, muscular atrophy, disturbance of the facet joint, cervical alignment, radiculopathy leading to neck and shoulder girdle pain, and the duration of immobilization. Extensive posterior dissection of the muscles attached to the C2 and C7 spinous processes and postoperative muscle dystrophy are associated with the risk of axial neck pain. Preservation of the muscles attached to the C2 and C7 spinous processes and early postoperative exercise may reduce axial neck pain.

Most of the complications in the DCF group were related to the surgical approach. Postoperative voice and swallowing dysfunction are common complications of anterior cervical decompression and fusion. A higher risk for these complications was reported in patients with multilevel cervical spondylotic myelopathy. Seven patients reported some degree of odynophagia or dysphonia in the early postoperative period, which were relieved 3 months postoperatively in 5 patients. Mild swallowing discomfort was observed in the other 2 patients. Soft tissue swelling in the neck, direct surgical trauma, neuropaxia due to nerve traction, and postoperative edema might be the primary causes of swallowing discomfort.

Kahraman et al reported that the most important factor related to recurrent laryngeal nerve injury was excessive retractor pressure and sharp dissection rather than duration of pressure. Properly performed endotracheal intubation, careful blunt dissection and surgical technique, and correct retractor placement beneath the bodies of the longus colli muscles away from the tracheoesophageal groove are critical in preventing direct surgical trauma to the nerve. Chen et al reported a novel preoperative anterior cervical spine surgery treatment comprising mechanical tracheal/esophagus traction and compared the postoperative outcomes regarding dysphagia with those of untreated patients. They reported that preoperative tracheal/esophageal traction exercise affects postoperative dysphagia following multilevel anterior cervical spine surgery.

Cerebrospinal fluid leakage occurred after a dural tear intraoperatively due to tight adhesion in 1 patient. However, no significant dural defect occurred in this patient because dural adhesion was preserved by careful dissection. The dural fissure was small, and a drain was maintained. Cerebrospinal fluid leakage usually stopped after 3 to 5 days of conservative treatment with local pressure. C5 root palsy was observed in 2 patients. At the final follow-up, these complications had also resolved.

**Conclusion**

Discontinuous corpectomy and fusion with reservation of middle vertebra is a safe and effective surgical treatment for 4-level cervical spondylotic myelopathy. The procedure results in significant functional improvement in most patients.
However, patients with multilevel cervical spondylotic myelopathy require careful evaluation before a surgical approach is selected. Potential complications associated with the recommended approach should not be neglected. This study had some limitations. The investigation was retrospective, and the number of included patients was relatively small. Furthermore, the incidence of adjacent segment disease cannot be followed adequately because the follow-up period was a minimum of 1 year. Therefore, a longer follow-up study is needed.

REFERENCES