Comparison between anterior and posterior decompression with instrumentation for cervical spondylotic myelopathy: sagittal alignment and clinical outcome

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Object. A variety of anterior, posterior, and combined approaches exist to decompress the spinal cord, restore sagittal alignment, and avoid kyphosis, but the optimal surgical strategy remains controversial. The authors compared the anterior and posterior approach used to treat multilevel cervical spondylotic myelopathy (CSM), focusing on sagittal alignment and clinical outcome.

Methods. The authors studied 48 patients with CSM who underwent multilevel decompressive surgery using an anterior or posterior approach with instrumentation (24 patients in each group), depending on preoperative sagittal alignment and direction of spinal cord compression. In the anterior group, a 1–2-level corpectomy was followed by placement of an expandable titanium cage. In the posterior group, a multilevel laminectomy and posterior instrumentation using lateral mass screws was performed. Postoperative radiography and clinical examinations were performed after 1 week, 12 months, and at last follow-up (range 15–112 months, mean 33 months). The radiological outcome was evaluated using measurement of the cervical and segmental lordosis.

Results. Both the posterior multilevel laminectomy (with instrumentation) and the anterior cervical corpectomy (with instrumentation) improved clinical outcome. The anterior group had a significantly lower preoperative cervical and segmental lordosis than the posterior group. The cervical and segmental lordosis improved in the anterior group by 8.8 and 6.2°, respectively, and declined in the posterior group by 6.5 and 3.8°, respectively. The loss of correction was higher in the anterior than in the posterior group (−2.0 vs −0.7°, respectively) at last follow-up.

Conclusions. These results demonstrate that both anterior and posterior decompression (with instrumentation) are effective procedures to improve the neurological outcome of patients with CSM. However, sagittal alignment may be better restored using the anterior approach, but harbors a higher rate of loss of correction. In cases involving a preexisting cervical kyphosis, an anterior or combined approach might be necessary to restore the lordotic cervical alignment. (DOI: 10.3171/2010.1.FOCUS09253)

Key Words • instrumentation • decompression • kyphosis • lordosis • cervical spondylotic myelopathy • alignment

Cervical spondylotic myelopathy is a common cause of neurological morbidity. Although decompression is an accepted procedure for CSM, the optimal surgical strategy for this condition remains controversial. Patients with cervical deformities and kyphosis are associated with a higher risk of developing neurological deficits or pain. Therefore, the loss of lordosis and postoperative development of kyphosis should be prevented if possible. Thus, a variety of anterior, posterior, and combined approaches, with and without instrumentation, have been advocated to achieve an adequate decompression of the spinal cord, restore or maintain sagittal alignment, and avoid kyphosis.

Although isolated anterior pathologies can be treated adequately using an anterior approach, the extension of the pathology over many vertebral levels can require a posterior approach. The development of postlaminectomy kyphotic deformities lead to different modifications of posterior decompressive techniques, such as laminoplasty or laminectomy in combination with posterior screw-rod fixation. Extensive anterior decompression and instrumentation includes the danger of pseudarthrosis, stress to adjacent levels, induction of an accelerated degeneration, development of swallowing difficulty, and construct failure. Therefore, many surgeons restrict anterior approaches to diseases that involve only 1 or 2 vertebral body levels and advocate posterior approaches in these other cases. However, precise data concerning changes of the cervical alignment before and after these operations are rare. The aim of the present study was to compare the efficacy of multi-
level anterior or posterior decompressive surgery of the cervical spine with instrumentation, focusing especially on sagittal alignment.

Methods

Between 1998 and 2008, 67 patients underwent multilevel decompressive surgery for CSM. Thirty-nine patients underwent a corpectomy followed by placement of an expandable titanium cage to reconstruct the anterior column, and 28 patients underwent a laminectomy followed by posterior instrumentation with lateral mass screws. Based on our past experience, patients who underwent a corpectomy with implantation of an “all-in-one” device (AddPlus, Ulrich GmbH & Co. KG) were excluded from this study due to a higher loss of lordotic correction. For a more accurate comparison with the anterior group, patients who underwent a laminectomy greater than 4 levels were excluded from the posterior group. Thus, 48 patients were included in the study: 24 in the anterior group, and 24 in the posterior group. These patients suffered from degenerative cervical spinal canal stenosis, and underwent decompressive surgery of the cervical spine sometime between 1998 and 2008. The primary symptom in all patients was myelopathy (CSM). In total, there were 29 men (12 anterior group, 17 posterior group) and 19 women (12 anterior group, 7 posterior group) who underwent operations. The patients’ ages at operation ranged from 43 to 84 years old, with a mean of 64 years. The posterior group (66.2 ± 8.8 years) was significantly older than the anterior group (60.4 ± 9.9 years; p = 0.045).

The reasons for using the anterior approach were spondylosis in 14 patients, ossification of the posterior longitudinal ligament in 6, degenerative kyphosis in 2, and spondylolisthesis in 2. The reasons for using the posterior approach were spondylosis in 17 patients, and os-
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Radiological examinations included plain radiography, MR imaging, CT, myelography, and lateral tomography. Radiological outcome was evaluated using measurement of cervical lordosis as an angle between C-2 and C-7, according to Cobb. An angle between the adjacent vertebral bodies to the affected or removed vertebral body was measured to evaluate segmental lordosis (Fig. 1).

Stability was assessed in the anterior and posterior groups. Solid arthrodesis was evaluated using flexion-extension radiographs and defined as the absence of motion between the spinous processes in the anterior group and between the vertebral bodies of the posterior group. Additionally, in the anterior group, the operated segment was considered solid in the absence of a radiolucent gap between the cage and the endplate. Because titanium cages were used, trabeculation between the adjacent segments could not be assessed correctly in all patients; therefore, CT scans were additionally performed in some of these cases. However, the absence of motion was the main criterion used to determine solid arthrodesis, which had also been used in other analyses involving cervical fusion cages.11,18,46

In the posterior group, a 2- to 4-level laminectomy followed by posterior instrumentation with lateral mass screws was performed in 10 cases with the Spine System Evolution cervical system (Aesculap), in 13 cases with the S4 cervical system (B Braun Melsungen AG), and in 1 case with the Oasys system (Stryker). Autograft bone from the corpectomy was placed around or into the cages.

Postoperative radiographs were obtained after 1 week and after 12 months in all cases, and at last follow-up after 15–112 months (mean 33 months). Clinical outcome was assessed before and after surgery using the VAS score of neck pain and the mJOA scale score, and using the Odom criteria.31

The chi-square test, nonparametric Mann-Whitney U-test, and t-test were used for statistical analysis of data. Results were considered significant at a p value < 0.05.

Results

In the anterior group, corpectomies were performed in 5 cases at the C-4 level, in 4 cases at C-5, in 4 cases

### TABLE 1: Clinical outcomes in both groups according to the VAS, mJOA scale, and Odom criteria*

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Anterior Group</th>
<th>Posterior Group</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS score†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>preop</td>
<td>4.8 ± 1.2</td>
<td>4.4 ± 1.1</td>
<td>0.6</td>
</tr>
<tr>
<td>12 mos</td>
<td>3.3 ± 1.0</td>
<td>3.5 ± 1.0</td>
<td></td>
</tr>
<tr>
<td>last FU</td>
<td>3.3 ± 1.1</td>
<td>3.6 ± 0.9</td>
<td>0.56</td>
</tr>
<tr>
<td>p value preop/last FU</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>mJOA scale score†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>preop</td>
<td>12.5 ± 2.1</td>
<td>11.7 ± 3.2</td>
<td>0.522</td>
</tr>
<tr>
<td>12 mos</td>
<td>15.2 ± 2.1</td>
<td>14.3 ± 2.8</td>
<td></td>
</tr>
<tr>
<td>last FU</td>
<td>15.8 ± 2.8</td>
<td>14.9 ± 3.2</td>
<td>0.537</td>
</tr>
<tr>
<td>p value preop/last FU</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Odom criteria‡</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>excellent</td>
<td>11 ± 45.8</td>
<td>13 ± 54.2</td>
<td></td>
</tr>
<tr>
<td>good</td>
<td>8 ± 33.3</td>
<td>7 ± 29.2</td>
<td></td>
</tr>
<tr>
<td>fair</td>
<td>4 ± 16.7</td>
<td>4 ± 16.7</td>
<td></td>
</tr>
<tr>
<td>poor</td>
<td>1 ± 4.2</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

* FU = follow-up.
† Values given as mean ± SD.
‡ Values given as number of patients (%).

### TABLE 2: Radiological outcomes of both groups according to cervical and segmental lordosis*

<table>
<thead>
<tr>
<th>Lordosis (°)</th>
<th>Preop</th>
<th>1 wk</th>
<th>1 yr</th>
<th>Last FU</th>
<th>p Value‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>cervical</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>anterior group</td>
<td>5.3 ± 26.2</td>
<td>16.1 ± 10.7</td>
<td>13.8 ± 11.5</td>
<td>14.1 ± 12</td>
<td>0.006</td>
</tr>
<tr>
<td>posterior group</td>
<td>12.4 ± 12.9</td>
<td>6.6 ± 13.3</td>
<td>6.1 ± 13.8</td>
<td>5.9 ± 12.6</td>
<td>0.004</td>
</tr>
<tr>
<td>p value†</td>
<td>0.039</td>
<td>0.027</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>segmental</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>anterior group</td>
<td>-2.5 ± 18.0</td>
<td>4.5 ± 12.0</td>
<td>3.6 ± 13.8</td>
<td>3.7 ± 13.1</td>
<td>0.004</td>
</tr>
<tr>
<td>posterior group</td>
<td>6.1 ± 10.5</td>
<td>3.0 ± 10.3</td>
<td>2.4 ± 10.0</td>
<td>2.3 ± 8.9</td>
<td>0.004</td>
</tr>
<tr>
<td>p value†</td>
<td>0.030</td>
<td>0.870</td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>

* All values given as mean ± SD.
† Between groups.
‡ Preop/last FU in same group.
at C-6, in 2 cases at C-7, and in 9 cases at multiple levels (C4–5 in 5 cases and C5–6 in 4 cases). The follow-up period in this group ranged from 15 to 112 months (mean 35 months). The implantation of the expandable cages was performed without complications and the adjustment of the height could be performed in situ.

In the posterior group, all laminectomies and instrumentation were performed at multiple levels, involving 2 levels in 1 case (C3–4), 3 levels in 11 cases (C3–5 in 4 cases, and C4–6 in 7 cases), and 4 levels in 12 cases (C3–6 in 9 cases, C4–7 in 2 cases, and C1–4 in 1 case). The follow-up period in this group ranged from 15 to 67 months (mean 28 months).

In all patients undergoing operations, an adequate decompression was achieved, as demonstrated on postoperative MR images or myelograms that were compared with preoperative images (Figs. 1 and 2). Clinical evaluation revealed significant improvement of both groups following spinal cord decompression according to scores on the mJOA scale and VAS (p < 0.0001). The comparison between the anterior and posterior groups did not show any significant differences before or after the operations according to the VAS score, mJOA scale score, and Odom criteria (Table 1). All patients stated that they would have undergone the operation again, even the patient with a poor outcome. The flexion-extension radiographs did not show any motion of the operated segment in any cases in either group.

Cervical lordosis improved in the anterior group by 8.8° (p = 0.006) and declined in the posterior group by 6.5° (p = 0.004) at last follow-up (Table 2). Despite a significantly higher preoperative cervical and segmental kyphotic angle in the anterior group (p = 0.039), the surgical change of segmental lordosis immediately improved the overall cervical lordosis in the anterior group (7°), whereas an immediate loss of segmental lordosis was observed in the posterior group (3.1°; p = 0.004). However, the loss of correction of the overall cervical lordosis was higher in the anterior group compared with the posterior group at last follow-up (−2.0 ± 1.1° vs −0.7 ± 0.7°, respectively; p = 0.041).

Complications were noted in 7 cases, 5 requiring revision surgeries. In the anterior group, in which semiconstrained plates were used, follow-up imaging revealed 1 screw break and 1 screw loosening without the necessity of a revision operation. One case in the anterior group required additional dorsal fixation due to adjacent segment disease 1 year after surgery.

In the posterior group, epidural bleeding occurred in 1 case involving 2-level decompression and in 1 case involving 3-level decompression, requiring immediate surgical revision. A wound infection and a CSF fistula required surgery in another 2 cases.

Discussion

The optimal approach in the treatment of CSM remains a controversy in spine surgery. However, the aim of the present study was to compare the exact achievement of sagittal alignment and the possibility of sagittal maintenance and correction, rather than to test the clinical superiority of the presented operative techniques. Data of exact pre- and postoperative sagittal changes are rare in the literature.

We presented 48 patients who underwent multilevel cervical decompression for CSM. Twenty-four patients were treated with a 1–2 level corpectomy followed by placement of an expandable titanium cage (anterior group), and 24 patients underwent a multilevel laminectomy followed by posterior instrumentation with lateral mass screws (posterior group). The clinical outcome did not differ between groups; however, radiological analysis revealed a better restoration of sagittal alignment in the anterior group, but better maintenance of this alignment in the posterior group.

Decompressive Surgery of the Cervical Spine

There are different approaches to decompressive surgery of the cervical spine, including multilevel discectomy, corpectomy, laminoplasty, and laminectomy. An adequate decompression of the spinal cord to improve clinical outcome can be achieved using both approaches,12,26,28 which is also reflected in the present study. Anterior pathologies that involve only 1 or 2 vertebral body levels usually proceed using an anterior approach,9,12 while in cases of more than 2 levels the posterior approach appears to be more suitable due to swallowing difficulty and construct failure.4,9,10,12,14,17,19,26,33,34,42 However, in cases involving multilevel disease with kyphosis, where the spinal cord is stretched over anterior osteophytes, a combined approach using anterior release and reconstruction of lordosis as well as posterior decompression with instrumentation may be suitable.30

Sagittal Alignment

Effective decompression can be achieved by laminoplasty when lordosis of the cervical spine is preserved. However, the long-term success of laminoplasty depends on the preoperative and postoperative preservation of cervical spinal lordosis.25,36–40 The loss of physiological lordosis and the development of kyphosis following cervical surgery should be avoided to prevent further degeneration and late clinical deterioration.2,24,26,35,37 Therefore, prevention of the late development of kyphosis—which can be observed following anterior45 and posterior approaches—and the achievement of an optimal alignment is a major goal of spine surgery.

Our clinical and radiological data support the results of the existing literature,12,26 showing an improvement of cervical alignment in the anterior group and a significant loss of lordosis in the posterior group. The preparation and consecutive denervation of deep extensor muscles is a common cause for loss of lordosis following laminoplasty.22,44 Correction of kyphosis is more difficult or even impossible using only a posterior approach, due to anterior fixation caused by osteochondrosis and spondylosis that cannot be resolved from the posterior side and may prevent distraction and reposition.30 Both approaches can improve cervical lordosis, whereas anterior approaches demonstrate a better overall correction due to a higher possibility of achieving release and distraction.12,26,42 Fur-
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thermore, patients show better radiological results when undergoing combined procedures than when using poste­rior or anterior instrumentation alone.1 Nevertheless, pa­tients undergoing extended posterior decompression and instrumentation maintain sagittal correction for a signifi­cant period,26,28 which is also reflected in our results. The postoperative loss of lordosis in our posterior group could be partly attributed to a straightening of the cervical spine during positioning that was fixed by dor­sial instrumentation (Fig. 2C). Thus, the operative pro­cedure was modified and posterior fixation with a curved rod was performed only after intraoperative optimization of sagittal alignment. Big screw heads can come in close contact during lordotic positioning (Fig. 2); thus, smaller screw heads improve lordotic positioning further. An­other possibility for avoiding close contact of the screw heads, which might hinder adequate sagittal correction, is instrumentation of only every second vertebra.28

In the posterior group, the instrumentation involved only the vertebral bodies affected by the laminectomy, even in cases of C-7 laminectomy. We did not observe any indication to extend the instrumentation in these 2 cases, although laminectomies and instrumentation that are discontinued at C-7 rather than at T-1 might harbor the risk of cervicothoracic kyphosis.

The higher loss of correction in our anterior group can be explained by subsidence of the cages before a suc­cessful fusion was achieved to support the integrity of the construction. The high modulus of elasticity with titanium could be an important factor in cage subsidence. Ma­terials with a lower modulus of elasticity that approach normal bone, such as polyetheretherketone cages, carbon fiber cages, and autograft iliac crest or allograft fibula, show a lower rate of long-term subsidence.30 The small values of 2.0° and 0.7°, representing loss of correction in the anterior and posterior groups, respectively, lie within measurement errors, but the differences between both groups resemble similar findings in the literature.3,5,26,28,42

The screw breakage and screw loosening in the anterior group might be explained by a less effective load sharing of constrained plates compared with dynamic plates.32

Conclusions

The aims of treatment for cervical spinal canal stено­sis are decompression of the spinal cord and restoration/ maintenance of the sagittal alignment. Our results dem­onstrate better restoration of the sagittal alignment in the anterior group, but less loss of correction in the posterior group. Anterior spondylotic osteophytosis may prevent adequate restoration of the sagittal alignment using only a posterior approach. In these cases, an anterior or com­bined approach may be necessary to achieve an adequate release and restore lordotic alignment.

Disclosure

Dr. Woiciechowski has served as a consultant to Ulrich GmbH & Co. and Aesculap. Dr. Kroppenstedt has also served as a consult­ant to Aesculap.

Author contributions to the study and manuscript preparation include the following. Conception and design: C Woiciechowski, M Cabraja, S Kroppenstedt. Acquisition of data: C Woiciechowski, M Cabraja, A Abbushi, D Koeppen, S Kroppenstedt. Analysis and interpretation of data: C Woiciechowski, M Cabraja, S Kroppenstedt. Drafting the article: C Woiciechowski, M Cabraja. Critically revis­ing the article: C Woiciechowski. Reviewed final version of the manuscript and approved it for submission: C Woiciechowski.

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References
