Ossification of the posterior longitudinal ligament in the cervical spine is a common cause of myelopathy and radiculopathy that often requires surgery to achieve decompression of the neural elements. With the evolution of surgical technique and a greater understanding of the biomechanics of cervical deformity, the criteria for selecting one approach over the other has been the subject of increased study and remains controversial. Ventral approaches typically consist of variations of the cervical corpectomy, whereas dorsal approaches include a wide range of techniques including laminoplasty, laminectomy, and laminectomy with instrumented fusion. Herein, the features and limitations of these approaches are reviewed with an emphasis on complications and outcomes. (DOI: 10.3171/2010.12.FOCUS10270)

**Key Words**  
ossification of the posterior longitudinal ligament  
corpectomy  
laminoplasty  
cervical myelopathy  
outcome

Biomechanical Considerations

Determining which surgical approach will best achieve the goals of decompression while preserving regional sagittal balance requires an understanding of biomechanics and a consideration of the preexisting deformity. Although there are insufficient clinical data to suggest that correction of any preexisting deformity improves outcomes associated with OPLL, there are retrospective data indicating that patients who undergo dorsal procedures without instrumentation may worsen neurologically as a result of progressive kyphosis. With regard to OPLL, the presence of a compressive lesion ventral to the spinal cord increases the risk of neurological deterioration during any attempt at deformity correction, particularly if a dorsal procedure is planned. For this reason, careful assessment of the presurgical sagittal alignment and the occupying volume of the ossified mass are critical to selecting the best approach as correction of deformity may not always be feasible without significant morbidity.
Cervical kyphosis may be the result of iatrogenic destabilization, trauma, degeneration, and systemic inflammatory diseases. However, it is most commonly observed after multilevel dorsal decompression, with rates of clinically significant kyphosis as high as 21%.6,12,23 If a kyphotic deformity is present, a flexion moment is created with the head pitched forward relative to the normal alignment of the cervical spine.2,3 This abnormal posture shifts the normally neutral axial force of the head ventral to the instantaneous axis of rotation, thus creating a flexion bending moment. This leads to further kyphosis.2,3 If kyphosis becomes severe, the spinal cord may stretch over the apex of the deformity and lead to further neurological decline.5

Radiographic Criteria for Approach Selection

The criteria used to select either a dorsal or ventral approach should be based on a number of factors including patient age, comorbidities, severity of symptoms, previous surgery, type of OPLL, extent of OPLL, degree of stenosis, surgeon preference, and assessment of cervical deformity. Various radiographic schemes have been proposed to help select the best approach for patients with cervical myelopathy. Gwinn et al.14 proposed a simple straight-line method to measure effective spinal canal lordosis in patients with cervical myelopathy. In this scheme, a straight line is drawn from the dorsal-caudal aspect of the C-2 VB to the dorsal-caudal aspect of the C-7 VB (Fig. 1). Effective lordosis is maintained if no ventral bone structure such as VBs, disc-osteophyte complexes, or hypertrophic calcifications project dorsal to this line. Otherwise, effective lordosis is considered lost (Fig. 2). This straight-line method of assessing cervical lordosis was compared with traditional methods of measuring cervical alignment including the Cobb and dorsal tangent methods. It was found to be a reliable indicator of overall alignment of the cervical spine as well as compression ventral to the spinal cord. It is proposed that this loss of effective lordosis due to the presence of a compressive mass may have a role in determining the best surgical approach as ventral surgery may better achieve decompression in these patients.

In 2008, Fujiyoshi et al.11 proposed a new concept for decision making regarding the surgical approach for cervical OPLL. They introduced a new index called the K-line to help determine the effectiveness of a dorsal approach. This line was defined as a line on a lateral radiograph drawn between the midpoints of the spinal canal at C-2 and C-7. According to this line, 2 groups of patients with OPLL were identified. In the K-line (+) group, the OPLL lies ventral to the K-line. In the K-line (−) group, the OPLL passes the line and lies dorsal to the line. In their series, 27 patients with myelopathy as a result of OPLL underwent either laminoplasty or laminectomy with instrumented fusion. Intraoperative ultrasonography was also used to evaluate the dorsal shift of the spinal cord from the OPLL. The relationship between the dorsal shift of the spinal cord and the K-line classification was made. Clinical outcomes were assessed using the JOA scores before surgery and at 1 year after surgery.

Overall, statistically significant improvement in JOA scores was found in the K-line (+) group. Complications and neurological worsening were not reported. Based on these findings, Fujiyoshi et al.11 proposed that patients with cervical OPLL that extend dorsal to the K-line have a better chance for neurological improvement with a ventral approach, but no patients were studied to support this recommendation. Based on their outcomes and correlation with intraoperative ultrasound, it is their assertion that K-line (−) patients have kyphosis that prohibits a dorsal approach as the spinal cord has less potential to shift following decompression.

Ventral Approaches

In general, there are 2 surgical procedures for the treatment of OPLL: direct removal of the ossified ligamentum through a ventral approach, or decompression through a dorsal approach.1,5

The ventral approach with direct resection of OPLL and decompression of the spinal canal is well described and is an effective option with excellent results (Table 1).28 Ventral decompression becomes more technically demanding, however, with significant narrowing of the spinal canal and ventral displacement of the spinal cord due to large ossified lesions. The risk of complications including CSF leakage and iatrogenic neurological deterioration significantly increases with the extent of OPLL as dural ossification often prohibits identifying an adequate plane of dissection.9,10 Residual OPLL behind the VB also
requires extensive undercutting and drilling under high-power magnification to ensure adequate decompression of the spinal cord.

Several variations of the corpectomy have been reported with favorable results.\(^1\) However, these ossified lesions often extend beyond the level of the endplate and behind the VB, corpectomy is essential to allow complete visualization of the compressive mass and achieve adequate decompression of the spinal cord. Reconstruction of the ventral vertebral column can then be performed using a number of different grafts including iliac crest, fibular strut, and titanium.\(^1?\) A number of studies have reported that 16 (12%) of 129 patients required a second operation for pseudarthrosis. Epstein\(^10\) reviewed a series of 76 patients who had previously been immobilized in halos and found that 3 (4.7%) of 76 patients who had previously been immobilized in halos postoperatively. Some of these issues may be mitigated by the use of intermediate points of fixation and by the introduction of dynamic implants, although their true effectiveness in this regard has yet to be proven.\(^4\) With increased use of ventral cervical plates and a greater appreciation for the biomechanical implications of long multilevel vertebral grafts with flexion, extension, and load bearing, fusion rates have improved. Supplemental dorsal fixation following multilevel corpectomy has also decreased the rate of bone graft subsidence and graft dislocation in patients who had previously been immobilized in halos postoperatively.

A variation to the standard corpectomy is the technique of square-shaped corpectomy and use of autologous VB as graft for reconstruction of the ventral column as described by Williams and modified by Isu and colleagues.\(^1?\) This technique has been shown to be highly effective for patients with short segment compression and kyphosis, historically high rates of pseudarthrosis, bone graft subsidence, and graft dislocation have been seen with long or multilevel constructs.\(^3,22\) These complications are largely a result of suboptimal bony points of fixation, poor biomechanical constructs, and the reliance on screw fixation as the only available method of bony fixation afforded by the ventral approach.\(^4\)

Pseudarthrosis has historically been a major concern following corpectomy. The rate of pseudarthrosis ranges from 4% to 6% for 1-level fusions and increases to 17% to 30% when 3 levels are fused.\(^5,10,34\) Shinomiya et al.\(^34\) found that 16 (12%) of 129 patients required a second operation for pseudarthrosis. Epstein\(^46\) reported that 3 (4.7%) of 76 patients required supplemental dorsal fixation for pseudarthrosis. In this series, corpectomy was performed on average over 3 levels without anterior plate instrumentation, using iliac crest or fibular strut autografts. At 3 months, dynamic radiographs in 20 patients demonstrated radiographic instability consistent with pseudarthrosis. At 6 months, 10 of these patients underwent fusion and another 7 were clinically stable despite persistent evidence of lucency around the grafts. Mizuno and Nakagawa\(^29\) found 3 cases of postoperative kyphotic deformity (6.7%) due to pseudarthrosis in patients receiving iliac crest grafts and 9 cases (24%) in patients receiving VB grafts. There were no cases of pseudarthrosis when anterior plates were used in this series.

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3-level, 4 underwent 4-level, and 5 underwent 5-level procedures via the ventral approach. Ventral cervical plates were only used in 4 patients with 3-level VB grafts and 1 with a 2-level VB graft. No other patient received plating. Surgery-related outcomes were excellent or good in 89% and fair in 11%. Patients underwent follow-up for 6 months, and the overall fusion rate was 97%, with 3 patients requiring additional surgery for pseudarthrosis. Of the graft materials used in this series, VB grafts were most susceptible to pseudarthrosis. Cerebrospinal fluid leakage was the most common complication, occurring in 21 cases. Although a significant number of patients improved after surgery, it is unclear from this study how the surgical approach was selected and how these techniques affected long-term fusion rates and outcomes.

### Dorsal Approaches

A number of dorsal approaches have been described including laminoplasty, laminectomy, and laminectomy with instrumented fusion.2,6 The advantages of these approaches include familiarity, ease of decompression of multiple levels, and the ability to extend the fusion rostrally to the occiput or caudally to the thoracic spine. The major disadvantage of laminectomy and laminoplasty is the obligatory disruption of the dorsal tension band, resulting in a high rate of postlaminectomy kyphosis.3,13 This complication has led some authors to caution against use of these procedures in patients with preexisting cervical kyphosis or even in the relative kyphosis of the “straightened” cervical spine.3,4,15,20 Moreover, ventral compression cannot be addressed from the dorsal approach alone, and this has therefore limited the overall effectiveness of these approaches as the ossified lesions in OPLL are known to progress over time. This limited effectiveness has been associated with greater degrees of stenosis in various series (Table 2). In some cases, the use of dorsal cervical fixation, in combination with dorsal decompression, may be used to correct a mild degenerative kyphosis.1 Although instrumented fixation may prevent and delay a loss of lordosis, it is unclear if it has any effect on the natural progression of ossification.

### Laminoplasty

Cervical laminoplasty is historically one of the most widely used surgical options for OPLL. The overall recovery rate after expansive laminoplasty for OPLL has been reported to be approximately 60%.4,13,19,32 However, several series have shown that laminoplasty in patients with OPLL may result in insufficient decompression, progression of the ossified lesion, development of kyphosis, and limited neurological improvement. Reports of paralysis following laminoplasty range from 5% to 10%. Because these dorsal approaches do not address the ossified lesion directly, these lesions may grow in length and depth over time, leading to subsequent neurological deterioration despite an early period of improvement.15,57 In 2002, Iwasaki et al.19 published their series of 92 patients who underwent laminoplasty for OPLL with more than 10 years of follow-up. After an initial interval of neurological improvement, there was a significant decrease in

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**TABLE 1: Review of surgical series: ventral approaches for OPLL***

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Total</th>
<th>Pseudarthrosis</th>
<th>Postop Kyphosis</th>
<th>Add'l Op</th>
<th>CSF Leak</th>
<th>Early (postop) Deterioration</th>
<th>Late Deterioration</th>
<th>Mean Improvement</th>
<th>Key Findings</th>
<th>FU (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abe et al., 1981</td>
<td>12</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>0</td>
<td>0</td>
<td>100.0%†</td>
<td>&gt;50% stenosis had less recovery</td>
<td>NR</td>
</tr>
<tr>
<td>Epstein, 1998</td>
<td>76</td>
<td>3 (4)</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR‡</td>
<td>no plating for mean 2.75 levels</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Isu et al., 1997</td>
<td>40</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>1: C-5 palsy</td>
<td>0</td>
<td>74.0%†</td>
<td>VB autograft w/o plating</td>
<td>3</td>
</tr>
<tr>
<td>Iwasaki et al., 2007</td>
<td>27</td>
<td>4 (15)</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>2: C-5 palsy</td>
<td>2</td>
<td>57.0%‡</td>
<td>&gt;60% stenosis had better outcomes compared w/ laminoplasty</td>
<td>6</td>
</tr>
<tr>
<td>Kim et al., 2009</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1: arm weakness</td>
<td>0</td>
<td>71.7%‡</td>
<td>VB autograft w/o plating</td>
<td>2</td>
</tr>
<tr>
<td>Masaki et al., 2007</td>
<td>19</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>0</td>
<td>0</td>
<td>68.4%‡</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Mizuno &amp; Nakagawa, 2001</td>
<td>107</td>
<td>3 (2.8)</td>
<td>12</td>
<td>10</td>
<td>21</td>
<td>3: C-5 palsy</td>
<td>0</td>
<td>89.0%†</td>
<td>kyphosis more likely when VB autograft used</td>
<td>2</td>
</tr>
<tr>
<td>Mizuno &amp; Nakagawa, 2006</td>
<td>111</td>
<td>13 (12)</td>
<td>NR</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>89.0%‡</td>
<td>no revisions required for pseudarthrosis</td>
<td>1</td>
</tr>
<tr>
<td>Shinomiya et al., 1993</td>
<td>129</td>
<td>4 (3.1)</td>
<td>NR</td>
<td>16</td>
<td>NR</td>
<td>NR</td>
<td>NR‡</td>
<td>no revisions required for pseudarthrosis</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

* Add'l = additional; FU = follow-up; NR = not reported.
† Outcome was assessed using the JOA scoring system for cervical myelopathy.
‡ Outcome was assessed based on improvement noted during neurological examination.
# Review of surgical approaches and outcomes for cervical OPLL

## TABLE 2: Review of surgical series: dorsal approaches for OPLL

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>No. of Pts</th>
<th>No. of Op</th>
<th>Postop Kyphosis</th>
<th>Revision Op</th>
<th>Postop CSF Leak</th>
<th>Postop Deterioration</th>
<th>Late Deterioration</th>
<th>FU (yrs)</th>
<th>Mean Improvement†</th>
<th>Key Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baba et al., 1995</td>
<td>47 laminoplasty</td>
<td>NR</td>
<td>NR</td>
<td>1</td>
<td>2; C-5, C-6 palsy</td>
<td>0</td>
<td>54.6%</td>
<td>&gt;50% stenosis had worse outcomes</td>
<td>7.3</td>
<td></td>
</tr>
<tr>
<td>Chen et al., 2009</td>
<td>83 laminectomy + fusion</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10; C-5, C-6, C-7 palsy</td>
<td>0</td>
<td>62.4%</td>
<td>high rate nerve root palsy</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>Cho et al., 2008</td>
<td>14 laminectomy</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3; C-5, C-6 palsy</td>
<td>0</td>
<td>43.5%</td>
<td>kyphosis not associated w/ neurological change</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>Iwasaki et al., 2002</td>
<td>92 laminoplasty</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>10; C-5, C-6 palsy</td>
<td>0</td>
<td>60.0%</td>
<td>kyphosis not associated w/ neurological change</td>
<td>12.2</td>
<td></td>
</tr>
<tr>
<td>Kato et al., 1998</td>
<td>44 laminectomy</td>
<td>14</td>
<td>1</td>
<td>3; iatrogenic spinal cord injury</td>
<td>0</td>
<td>32.8%</td>
<td>kyphosis not associated w/ worse outcomes</td>
<td>14.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Masaki et al., 2007</td>
<td>40 laminoplasty</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>52.4%</td>
<td>kyphosis not associated w/ worse outcomes</td>
<td>10.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nakano et al., 1988</td>
<td>14 laminectomy</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3; iatrogenic spinal cord injury</td>
<td>0</td>
<td>81.4%</td>
<td>kyphosis not associated w/ worse outcomes</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>Ogawa et al., 2004</td>
<td>72 laminoplasty</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>5; C-5, C-7 palsy</td>
<td>0</td>
<td>63.1%</td>
<td>kyphosis not associated w/ neurological change</td>
<td>9.5</td>
<td></td>
</tr>
<tr>
<td>Tani et al., 2002</td>
<td>12 laminoplasty</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>39.0%</td>
<td>&gt;50% stenosis had worse outcomes</td>
<td>4.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Pts = patients.
† Outcome was assessed using the JOA scoring system for cervical myelopathy.
outcome as assessed by JOA scores. Postoperative progression of the ossified lesion was noted in 70% of the patients, and additional surgery was required in 1 patient. Postoperative progression of kyphotic deformity was also observed in 8% of the patients.

Similarly, Ogawa et al. reported their series of 72 patients who underwent follow-up for more than 5 years. The mean recovery rate was 62.1% at 1 year but decreased to 41.3% after 5 years. Postoperative progression of the ossified ligament was observed in 46 patients (63.9%), and a change in the cervical alignment was observed in 28 patients (38.9%) at last follow-up. In these patients, a change from lordosis to straight was most common (12 patients), followed by a change from lordosis to kyphosis.

The severity of stenosis has also been associated with poorer outcomes following dorsal procedures. In their review of 47 cases, Baba et al. found that patients with stenosis greater than 50% had less improvement than those with stenosis less than 50%. In this group of patients with severe stenosis, the mean improvement in JOA scores was 51.8% versus 61.6% at last follow-up (p < 0.05).

**Laminectomy**

Laminectomy is also an option for decompression, although it is used less frequently than laminoplasty, as evident by the lack of long-term clinical data. Kato et al. reported the largest series of patients treated with cervical laminectomy for OPLL. In their series, 52 patients underwent cervical laminectomy with a mean follow-up of 14.1 years. The neurological recovery rate of 44.2% at 1 year after laminectomy was maintained at 5 years but worsened to 32.8% at last follow-up. Late neurological deterioration was observed in 10 (23%) of 44 patients at an average of 9.5 years. The earliest deterioration occurred at 1 year and the latest was at 17 years after surgery. Postoperative expansion of the OPLL was noted in 70%, and progression of kyphotic deformity was observed in 47% of patients. This series is consistent with other reports that have demonstrated a high incidence of postlaminectomy kyphosis, although the significance of this with regard to overall outcome is still unclear.

**Laminectomy With Instrumentation**

The addition of instrumentation to laminectomy provides rigid fixation and prevents the development of postlaminectomy kyphosis. Although the effect of stabilization on the natural history of OPLL is unknown, it has been shown to prevent kyphosis in limited series. Chen et al. reported on 83 patients who underwent laminectomy and instrumented fusion with an average follow-up of 4.8 years. The mean JOA score significantly increased, and neurological improvement was sustained in 62.4% of patients. The degree of stenosis was not associated with a difference in outcomes in this series. Lordosis was maintained postoperatively with no revision surgeries. Progression of OPLL was not measured in this series. Postoperative nerve root palsy was seen in 10 patients and was the main complication. This was thought to be related to preserved lordosis as this was not as common in published laminoplasty series.

**Strategies for Decision Making**

As discussed earlier, selection of the best surgical approach depends on many factors including the radiographic assessment of cervical lordosis, severity of ventral compression, and most importantly, consideration of anticipated complications and outcomes. With a lack of prospective, randomized, controlled clinical studies with strict selection criteria to guide clinical decision making, the best available data are represented by limited retrospective institutional experiences with one particular surgical technique. In recent years, several authors have published their results comparing dorsal and ventral approaches and have attempted to identify factors that may lead to poor surgical outcomes.

Masaki et al. compared their results of ventral decompression with fusion to laminoplasty for patients with cervical myelopathy due to OPLL. Nineteen patients underwent ventral surgery and 40 underwent dorsal surgery. At 1 year, the neurological improvement in the ventral group was 68.4% versus 52.5% in the dorsal group (p < 0.05). Elderly patients treated with laminoplasty had an especially poor surgical outcome, as did patients in the laminoplasty group who showed progressive loss of lordosis. Patients in the laminoplasty group who did poorly also showed greater evidence of segmental mobility at the operated levels on dynamic imaging.

Tani et al. compared the clinical results of 14 patients who underwent ventral decompression and fusion with 12 patients who underwent laminoplasty for cervical OPLL with an occupation ratio in the spinal canal exceeding 50%. They found that the average recovery rate was significantly higher after ventral surgery than after laminoplasty. No neurological deterioration occurred after ventral surgery, whereas postoperative neurological deterioration occurred in 4 patients after laminoplasty. The authors suggested that a decrease in the lordosis of the cervical spine and tethering of nerve roots due to insufficient decompression are factors associated with poor outcomes after laminoplasty.

In the largest reported comparative series with the longest follow-up, Iwasaki et al. compared the results of 27 patients who underwent ventral surgery with 66 who underwent laminoplasty, with a mean follow-up of 6 years. Overall, patients who underwent ventral surgery had better outcomes than those who underwent laminoplasty. This was particularly true for patients whose ossified lesions had an occupying ratio greater than 60%. Multiple regression analysis showed that the most significant predictors of poor outcome after laminoplasty were hilly-shaped ossification, occupying ratios greater than 60%, lower preoperative JOA scores, postoperative changes in cervical alignment, and older age at surgery. It is evident from these studies that each surgery has its benefits; however, it seems that laminoplasty is associated with worse outcomes, especially in patients whose ossified lesions have an occupying ratio greater than 50%.

**Conclusions**

There remains considerable debate regarding the sur-
Review of surgical approaches and outcomes for cervical OPLL

gical management of myelopathy due to cervical OPLL. Over the years, numerous innovative surgical techniques have been developed to treat these difficult lesions, from either a dorsal or ventral approach. Although there is currently little evidence to support the superiority of one technique over the other, there are data regarding the known risks, complications, and expected outcomes associated with each. Although the ventral approach offers direct decompression of the spinal cord with resection of the ossified mass, it is plagued by a high risk of CSF leakage and pseudarthrosis. Likewise, the dorsal approach provides a relatively simple and safe means to decompress the spinal cord. However, it is subject to progressive kyphosis, expansion of the ossification, and limited neurological improvement, especially in patients with preexisting kyphosis or hilly-shaped OPLL. The addition of instrumentation and fusion may help overcome some of the late complications of dorsal decompressive operations. This information, gathered from years of experience along with an understanding of the biomechanics of cervical deformity, equips the surgeon with the tools to make the best possible decision.

Disclosure

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