

## Surgical treatment of cervical spondylotic myelopathy with anterior compression: a review of 67 cases

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**Object.** In patients with cervical spondylotic myelopathy (CSM), ventral disease and loss of cervical lordosis are considered to be relative indications for anterior surgery. However, anterior decompression and fusion operations may be associated with an increased risk of swallowing difficulty and an increased risk of nonunion when extensive decompression is performed. The authors reviewed cases involving patients with CSM treated via an anterior approach, paying special attention to neurological outcome, fusion rates, and complications.

**Methods.** Retrospectively, 67 cases involving consecutive patients with CSM requiring an anterior decompression were reviewed: 46 patients underwent anterior surgery only (1- to 3-level anterior cervical discectomy and fusion [ACDF] or 1-level corpectomy), and 21 patients who required > 3-level ACDF or  $\geq$  2-level corpectomy underwent anterior surgery supplemented by a posterior instrumented fusion procedure.

**Results.** Postoperative improvement in Nurick grade was seen in 43 (93%) of 46 patients undergoing anterior decompression and fusion alone ( $p < 0.001$ ) and in 17 (81%) of 21 patients undergoing anterior decompression and fusion with supplemental posterior fusion ( $p = 0.0015$ ). The overall complication rate for this series was 25.4%. Interestingly, the overall complication rate was similar for both the lone anterior surgery and combined anterior-posterior groups, but the incidence of adjacent-segment disease was greater in the lone anterior surgery group.

**Conclusions.** Significant improvement in Nurick grade can be achieved in patients who undergo anterior surgery for cervical myelopathy for primarily ventral disease or loss of cervical lordosis. In selected high-risk patients who undergo multilevel ventral decompression, supplemental posterior fixation and arthrodesis allows for low rates of construct failure with acceptable added morbidity. (DOI: 10.3171/SPI/2008/9/8/152)

**KEY WORDS** • anterior compression • cervical myelopathy • outcome • surgical approach

CERVICAL spondylosis is the most common acquired cause of myelopathy in the cervical spine.<sup>1,3,6,8,23,29</sup> Surgical decompression is generally indicated for patients with significant neurological deficits.<sup>4,9,15</sup> The goal of surgery is to decompress the spinal cord while maintaining the stability and sagittal alignment of the cervical spine. A variety of surgical approaches are used to treat CSM, depending on the primary site of compression, sagittal alignment, number of levels of compression, and the patient's age and comorbidities. Surgical approaches include anterior, posterior, or combined decompression with or without fusion.

In general, patients with primarily ventral disease and loss of cervical lordosis are considered to be good candidates for anterior surgery. However, in patients who have multilevel ventral disease, when significant anterior decompression is accomplished, such as with multiple cor-

pectomies, there may be an increased potential for swallowing difficulty and construct failure.<sup>10,16,21,24,30</sup> In such cases, posterior fusion procedures have been associated with improved fusion rates,<sup>7,10,12,14,16</sup> but defining which patients are likely to require a posterior fusion is controversial. The purpose of our study was to review the results of the patients who underwent anterior surgery for cervical myelopathy with or without posterior stabilization. Special emphasis was placed on neurological outcome, rates of hardware failure or nonunion, and complication rates.

### Methods

Approval was obtained from our university institutional review board prior to initiation of this study. We retrospectively evaluated 162 consecutive cases involving patients presenting with CSM at our institution between 2002 and 2006. At our institution, selecting the procedure that will adequately decompress and stabilize the spine depends on the extent of stenosis and on the sagittal alignment of the spine. Patients with cervical stenosis limited to < 3 verte-

Abbreviations used in this paper: ACDF = anterior cervical discectomy and fusion; CSM = cervical spondylotic myelopathy.

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bral levels require a 1- or 2-level ACDF or single-level corpectomy. Patients with stenosis > 3 levels and preserved cervical lordosis undergo a laminectomy with an instrumented fusion, even if cervical alignment is normal (straight or lordotic). Finally, patients with a cervical kyphosis and/or both anterior and posterior compression often require a combined anterior and posterior decompression and fusion. Theoretically, such front-back surgery is done to prevent further iatrogenic instability while performing substantial canal decompression and deformity correction. The anterior procedure includes a single- or multilevel ACDF or corpectomy depending on the extent of decompression required. The posterior procedure consists of a posterior instrumented fusion, with or without a laminectomy. At our institution, laminoplasty is not offered to such patients with CSM due to concern about untreated instability following surgical decompression.

For this study, 67 cases (41% of the total number of cases reviewed) of isolated ventral compression of the spinal cord as documented by MR imaging and/or CT myelography were included. Cases requiring posterior decompression alone were excluded from this analysis. Management of such cases was determined by extent of anterior compression. In patients undergoing a 1- to 3-level ACDF or a single-level corpectomy with titanium cage reconstruction with plating, no supplemental posterior arthrodesis was performed. In patients undergoing an ACDF of  $\geq 4$  levels or a  $\geq 2$ -level corpectomy, a supplemental posterior instrumented fusion was performed.

### Surgical Management

Anterior cervical discectomy and corpectomy procedures have been well described.<sup>5,13,16,19,28</sup> In this case series, removal of the posterior longitudinal ligament was performed in all patients. During ACDF procedures, precur-

fibular strut allograft and demineralized bone matrix (DBX, Synthes) were used. For corpectomy procedures, reconstruction and arthrodesis was performed using titanium cages (SynMesh, Synthes or Xpand cage, Globus Medical Inc.) filled with local autograft, allograft, and DBX. Anterior plating (CSLP small stature and variable angle, Synthes) was used in all discectomy and corpectomy cases (Fig. 1). Variable angle screws were used with all anterior plate constructs.

For patients undergoing posterior instrumented fusion, polyaxial screws (Axon OC-Fusion System, Synthes Inc., or Mountaineer OCT Spine Systems, Depuy) were placed in the lateral masses of C-1, the pedicles or lamina of C-2, the lateral masses of C3-6, or the lateral masses or pedicles of C-7 and the upper thoracic pedicles or laminae. The extent of instrumentation required varied according to each case. Titanium rods were contoured and secured to the screw heads. Intervening facet joints were decorticated and local bone autograft and allograft were mixed with DBX for arthrodesis (Fig. 2).

All anteroposterior fusion procedures were scheduled to be completed in a single day. A staged posterior fusion procedure was reserved for patients with significant medical comorbidities to limit stress on such patients. For these cases, the posterior fusion was scheduled within several days following the anterior decompression.

### Evaluation of Patients' Condition

An independent neurosurgeon reviewer retrospectively assigned patients a Nurick myelopathy scale score<sup>18</sup> (Table 1) for their preoperative condition as well as for their condition at scheduled follow-up assessments 3, 6, 12, and 24 months postoperatively. Cervical spine radiographs were also evaluated at such intervals and the presence of fusion

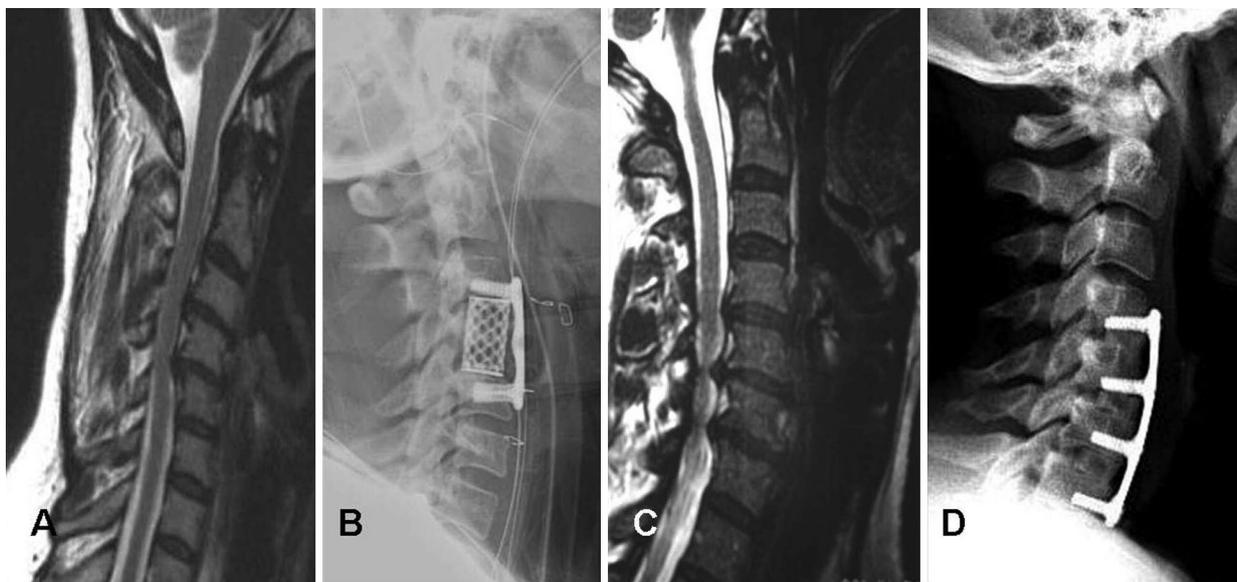


FIG. 1. A: A T2-weighted sagittal MR image revealing severe cervical stenosis at C3-4 and C4-5 with retropulsion of C-4 relative to C-5. B: Postoperative lateral radiograph (same case as in A) decompression via C-4 corpectomy and titanium cage reconstruction with plate placement. C: A T2-weighted sagittal MR image revealing severe 3-level cervical stenosis. D: Postoperative lateral radiograph (same case as in C) showing decompression via 3-level anterior cervical discectomy and fusion.

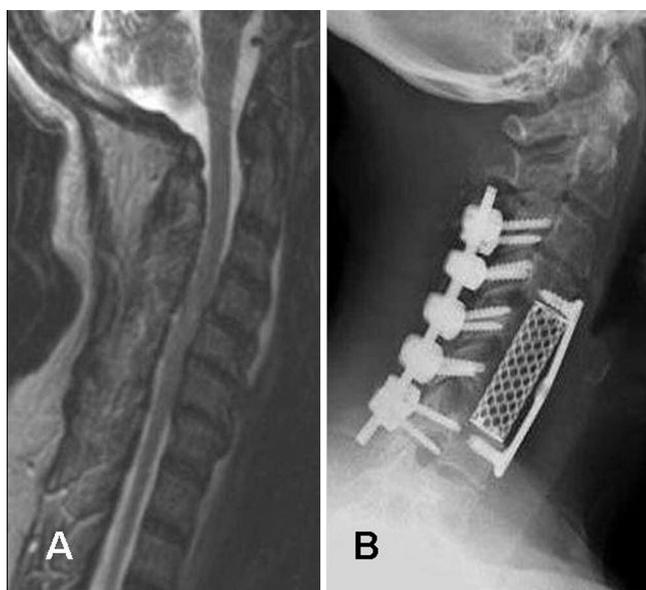


FIG. 2. A: A T2-weighted sagittal MR image showing multilevel cervical stenosis and congenital canal stenosis. B: Postoperative lateral radiograph demonstrating 2-level corpectomy with titanium cage reconstruction with plate placement, supplemented by posterior instrumentation.

was documented. Criteria for nonunion were lack of bony trabeculation across spinal segments, graft collapse, or instrumentation failure. The presence of 3 mm of horizontal motion or  $> 10^\circ$  of angular motion on dynamic radiographs was also considered evidence of nonunion.

## Results

### Neurological Outcome

Characteristics of the patient population are presented in Table 2. Of the 67 patients included in the study, 46 underwent anterior decompression and fusion (Group I) and 21 underwent anterior decompression and fusion supplemented with posterior fusion (Group II). Eleven of the 21 patients in Group II also underwent posterior decompression in addition to the supplemental fusion. Group I consisted of 21 men and 25 women, having a mean age of 53.4 years (range 31–79 years). Group II consisted of 12 men and 9 women, having a mean age of 56.7 years (range 36–67 years). The mean follow-up period for Group I was 24.9 months (range, 5–65 months), and for Group II, 27 months (range 4–59 months). Although all patients were followed up for at least 24 months after the initial procedure, 11 patients (16.4%) were lost to follow-up prior to an 18- to 24-month radiograph showing definitive fusion.

Thirty-one patients (67%) in Group I underwent ACDF over a mean of 1.60 levels, and 15 patients (33%) underwent single-level corpectomy. The mean length of hospital stay was 2.8 days (range 1–10 days). The mean preoperative Nurick grade was 2.85, which improved to a mean grade of 1.35 postoperatively ( $p < 0.0001$ , Table 3). Forty-three patients (93%) in Group I had an improvement in assigned Nurick grade following surgery and 3 patients remained the same.

TABLE 1  
Nurick myelopathy scale\*

Grade	Definition
0	patient has signs and symptoms of root involvement but no spinal cord disease
1	patient has signs of spinal cord disease w/ difficulty walking
2	patient has slight difficulty walking that does not prevent full-time employment
3	patient has difficulty walking that prevents full-time employment or completion of daily tasks, but does not require assistance w/ walking
4	patient is able to walk only w/ a walker or human assistance
5	patient is chairbound or bedridden

\* Based on Nurick, 1972.

In Group II, the number of corpectomy levels varied from 2 to 4. All patients underwent instrumented posterior fusion. The mean length of hospital stay was 9.4 days (range 2–16 days, Table 2). Seventeen (80.9%) patients demonstrated improvement of their assigned Nurick grade, and in 4 the Nurick grade remained the same. The mean preoperative Nurick grade for Group II was 2.80, which decreased to a mean score of 1.57 postoperatively ( $p = 0.0015$ , Table 3).

### Complications of Surgery

Complications from these procedures are presented in Table 4. In those patients who underwent lone anterior decompression and fusion operations (Group I), the overall complication rate was 24%. Five patients (10.9%) experienced dysphagia postoperatively. This symptom resolved within several weeks following surgery in all cases. One patient (2.2%) developed a postoperative infection that was successfully treated with a single debridement procedure.

TABLE 2  
Characteristics of 67 patients undergoing cervical decompression and fusion for spondylotic myelopathy\*

Group & Characteristic	Value
Group I: lone anterior decompression & fusion	
no. of patients	46
M/F	21:25
mean age in yrs (range)	53.4 (31–79)
no. of patients undergoing ACDF (%)	31 (67)
no. of patients undergoing corpectomy (%)	15 (33)
mean LOS in days (range)	2.8 (1–10)
mean FU in mos (range)	24.9 (5–65)
no. of patients lost to FU (%)	5 (10.9)
Group II: combined anterior-posterior decompression & fusion	
no. of patients	21
M/F	12:9
mean age in yrs (range)	56.7 (36–67)
no. of patients undergoing additional posterior decompression	11
mean LOS in days (range)	9.4 (2–16)
mean FU in mos (range)	27 (4–59)
no. of patients lost to FU (%)	6 (28.6)

\* FU = follow-up; LOS = length of hospital stay.

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TABLE 3  
Nurick scores according to procedure

Procedure	Mean Preop Nurick Grade	Mean Postop Nurick Grade	p Value
anterior decompression/fusion	2.85	1.35	<0.0001
anterior decompression/fusion & posterior fusion	2.80	1.57	0.0015

One patient (2.2%) underwent reoperation for an epidural hematoma. A total of 4 patients (8.7%) required revision surgery after the initial operation. One patient, who underwent a single-level ACDF, underwent posterior decompression and instrumentation for adjacent-level stenosis 4 years later and has remained in stable condition for 2 months since. Another patient who underwent 2-level ACDF developed adjacent-segment disease 2 years later. This patient underwent single-level adjacent-segment ACDF and had remained in stable condition for 1 month at follow-up. Another patient who underwent single-level ACDF was found to have kyphotic deformity at the adjacent level 3 years postoperatively. The patient underwent posterior fusion and has remained in stable condition for 2 months postoperatively. Hardware failure (pullout of the lower part of the plate and screws and settling of the cage into the C-6 vertebral body) occurred in a patient who underwent a C-5 corpectomy. A C-6 corpectomy and reconstruction with an expandable cage and plate was performed with supplemental posterior instrumentation. As of this writing, this patient has remained in stable condition for 3 months.

In those patients who underwent combined anterior-posterior decompression and fusion operations (Group II), the overall complication rate was 28.6%. Two patients (9.5%) experienced postoperative dysphagia that resolved within 12 weeks. One patient (4.8%) required re-exploration for repair of a cerebrospinal fluid fistula and pseudomeningocele after anterior surgery. One patient (4.8%) developed a postoperative infection after posterior surgery; the infection was treated with a single debridement procedure. One patient (4.8%) experienced postoperative unilateral deltoid weakness that resolved within 10 weeks of the operation. One patient (4.8%) who underwent 2-level corpectomy and posterior fusion developed progressive neck pain 5 months postoperatively. Imaging studies revealed failure of the plate with maintained position of the cage. Since the cage was in a good position, the patient underwent removal of the plate, additional arthrodesis, and subsequent fusion, and his neck pain resolved.

## Discussion

Since the introduction of anterior cervical discectomy and fusion by Smith, Robinson, and Cloward,<sup>5,26</sup> anterior decompressive procedures have evolved from single-level discectomies to multilevel corpectomies with complex deformity correction. With reports of nonunion following these procedures, the concept of increasing the stability of the anterior construct with a posterior fusion has been used more commonly.<sup>7,11,12,14,17,25,32</sup>

TABLE 4  
Postoperative complications\*

Group & Characteristic	Value (%)
Group I: lone anterior decompression and fusion	
dysphagia	5 (10.9)
revision surgery	4 (8.7)
adjacent-segment disease	3 (6.5)
hardware failure, nonunion	1 (2.2)
infection	1 (2.2)
re-exploration for epidural hematoma	1 (2.2)
total	11 (24)
Group II: combined anterior-posterior decompression and fusion	
dysphagia	2 (9.5)
revision surgery	1 (4.8)
hardware failure, nonunion	1 (4.8)
infection	1 (4.8)
CSF leak	1 (4.8)
new C-5 palsy	1 (4.8)
total	6 (28.6)

\* Values represent numbers of complications, with percentages given in parentheses. Abbreviation: CSF = cerebrospinal fluid.

Anterior cervical decompression and fusion of 1–3 levels is consistently reported to be safe and effective for decompressing ventral pathology.<sup>20,28,30–32</sup> Applying this procedure to > 3 levels, however, can result in suboptimal outcomes, including graft extrusion, subsidence, fracture, and pseudarthrosis.<sup>2,20,28,31,32</sup> These complications also apply to anterior cervical corpectomy. Single-level corpectomy has been associated with successful outcomes for CSM.<sup>13,31,32</sup> Increasing the number of corpectomies has been associated with a significant increase in pseudarthrosis rates.<sup>7,20,21,24,32</sup> Vaccaro et al.<sup>30</sup> studied the effect of corpectomy level on nonunion. Early instrumentation failure was reported to occur in 9% of 2-level corpectomies with bone graft and ventral instrumentation. In patients undergoing 3-level corpectomy with ventral instrumentation, the failure rate increased to 50%. Similarly, Sasso et al.<sup>21</sup> reported a 6% failure rate after plated 2-level corpectomies and a 71% failure rate after 3-level plated corpectomies using iliac crest autograft. Daubs<sup>7</sup> demonstrated a 67% rate of early failure for 2-level corpectomies that increased to 100% for 3-level corpectomies with titanium cage reconstruction and anterior plate placement.

For these reasons, posterior stabilization can be used to supplement more extensive anterior decompressions. Supplemental posterior fixation has been shown to effectively add to the stability of the cervical spine in flexion and extension in biomechanical studies; this effect has also translated into higher fusion rates clinically.<sup>12,14,16,21,22,25</sup> In addition, patients at risk for nonunion have been shown to benefit from a more stable anterior-posterior construct.<sup>10,12,14,22</sup>

The disadvantage of a posterior fusion is the need for a second procedure. This has been shown to contribute to a longer hospital stay.<sup>27</sup> This may partially be offset by performing the posterior fusion as part of a single-anesthesia procedure. Decreased anesthesia time, decreased blood loss, and shorter duration of hospitalization have been achieved by performing circumferential fusion in a single sitting.<sup>27</sup> However, patients with significant comorbidities

may require a 2-stage procedure to avoid a prolonged single-stage operation. In this study, patients with comorbid conditions requiring a posterior fusion had this procedure scheduled within several days of the initial decompression.

Based on our experience, patients with CSM from anterior cord compression who require decompression and fusion have good neurological outcomes with an acceptable rate of complications. For both groups of patients in this study, benefit was obtained following decompression as measured by Nurick grades. As might be expected, a slightly higher complication rate was associated with the more extensive combined anterior-posterior surgical procedures compared to anterior surgery alone (28.6 vs 24%, respectively), and consistent with the experience of others, the addition of a posterior fusion in this study extended the inpatient stay by approximately 1 week.<sup>27</sup> Interestingly, symptomatic adjacent-segment disease that led to revision surgery was greater in the group of patients who underwent only anterior surgery. Overall, the rate of symptomatic nonunion leading to revision surgery was 3% during follow-up, but this number might have been greater if no patients were lost to follow-up. Nonetheless, it is possible that use of supplemental posterior fixation in patients undergoing extensive anterior decompressions, as is practiced at our institution, may contribute to overall lower rates of nonunion.

The results of this study suggest that patients with CSM undergoing anterior decompression and fusion with and without additional posterior decompression and fusion may have favorable clinical outcomes with regard to neurological status and postoperative complications. There are, however, significant limitations of this study. First, analysis of this group of cases was retrospective, as was the allocation of preoperative and postoperative Nurick scores. Obviously, analysis performed in this way is prone to bias, and thus strong conclusions from such data must be tempered. Second, incidence of complications, such as dysphagia, may have been underreported. In other words, retrospective data collection may be sensitive to identify patients with clinically significant complications but may miss symptomatic patients who did not present back to the clinic or emergency department with new postoperative complaints.

A third weakness of this study is lack of long-term follow-up. Although the overall mean duration of follow-up was 25.6 months, true evidence of fusion or declaration of nonunion may not become clear until 24 months postoperatively. Thus, in patients who were lost to follow-up before an 18- to 24-month radiograph showing solid fusion had been obtained, short-term follow-up may actually underestimate the true incidence of nonunion. Along these lines, given that titanium cages were used for all corpectomy procedures, radiographic assessment prior to 12 months may represent assessment of construct stability rather than actual fusion. Although such stability may indirectly represent the potential for subsequent fusion, it is not a direct radiographic measurement of osseous integration.

A fourth potential weakness of this study is the limited evaluation of patients undergoing cervical spine surgery from the perspective of postoperative function and pain. For instance, the addition of objective measurements such as a visual analog scale for pain or the Oswestry Disability Index for functional disability might have made this analy-

sis more robust. Our data were not prospectively obtained, however, and such information cannot be retrospectively assigned. Furthermore, the scope of this manuscript was to assess initial severity of cervical myelopathy and subsequent level of postoperative myelopathy following cervical decompression procedures. Patients were selected a priori to undergo such procedures due to neurological compromise, not neck pain. So for all patients in this study, neck pain was not the primary indication for surgical decompression, and likewise improvement in neck pain was not the primary goal of surgery. However, it would be expected that new or worsening neck pain did occur after some procedures, and that such discomfort may indeed have been greater in patients who underwent additional posterior procedures.

Finally, this study does not address the additional costs incurred by performing circumferential fusions versus lone anterior fusion procedures. When circumferential fusions are performed, it would be expected that surgical costs and possibly hospital costs would increase, the latter likely affected by increased length of stay. Such analysis has not been done. In addition, it is also not clear if such additional posterior surgery in the acute phase corresponds to less construct failure and revision surgery later on. Therefore, a true cost analysis that takes into account the costs of initial surgery and subsequent revision surgeries would be beneficial to determining the best treatment algorithm for such patients.

## Conclusions

Significant improvement in Nurick grade can be achieved in patients who undergo anterior surgery for CSM for primarily ventral disease or loss of cervical lordosis. Our data suggest that patients requiring an ACDF of  $\leq 3$  levels, or a 1-level corpectomy, may not require posterior stabilization. In selected high-risk patients who undergo multilevel ventral decompression, however, supplemental posterior fixation and fusion may limit the risk of pseudounion and construct failure with acceptable added morbidity.

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