

# A Comparison of Clinical and Functional Outcomes Following Anterior, Posterior, and Combined Approaches for the Management of Cervical Spondylotic Myelopathy

## Abstract

**Background:** The key determinants when planning surgery in patients with CSM are the direction of compression, number of levels, sagittal alignment and instability. However there is no literature that compares the clinical and functional outcomes following different approaches in patients selected for surgery. **Aims:** Prospective non-randomized study that aims to compare the clinical and functional outcomes following surgical approaches with the goal of planning the optimal surgical strategy. **Material and Methods:** 75 patients- 61 males and 14 females (mean age: 64.2 years) with CSM underwent spinal decompression using an anterior (30), posterior (35) or combined approach (10). The surgical approach was selected based on the above mentioned key determinants. Functional disability was measured using the modified Japanese Orthopaedic Association score for myelopathy. Based on this the recovery rate was calculated. The mean followup duration was 21 months (range 6-72 months). **Results:** The preoperative mJOA score was 11.01 and the functional disability was graded as mild in 15, moderate in 50 and severe in 10. Postoperatively, the mJOA score improved to 16.41. The overall recovery rate was 77.25%. Patients with mild deficits/disability preoperatively had a significantly better recovery (<0.01) than those with more severe disability. There was comparable improvement in the functional status within the groups with the recovery rates were 83.37%, 76.6% and 64.13%. The blood loss, operative time and peri-operative complication rate were significantly higher with a combined surgery (33%) as compared to anterior (13.3%) or posterior approaches 14.8%. **Conclusions:** Outcomes are excellent following surgery for CSM. The best recovery is seen in patients with mild to moderate functional disability at the time of surgery.

**Keywords:** Cervical spondylotic myelopathy, functional outcomes, surgical approach

## Introduction

Cervical spondylotic myelopathy (CSM) is a progressive, degenerative disease that results in compression of the cervical spinal cord, leading to neurological dysfunction.<sup>1,2</sup> CSM is the most common cause of spinal cord impairment in elderly patients worldwide.<sup>1,2</sup> The natural history of cervical myelopathy is one of progressive deterioration leading to increasing disability and progressive limitation in function. Clark and Robinson<sup>3</sup> suggested that 75% of patients deteriorate in a stepwise fashion, 20% deteriorate slowly and steadily, and 5% have a rapid onset of symptoms with a stable plateau of dysfunction. Most patients will eventually require surgical intervention as a result of significant neurologic impairment.

Surgical treatment of CSM can be broadly divided into the anterior or

posterior approach. The anterior approach includes anterior cervical discectomy and fusion (ACDF) or corpectomy and fusion whereas laminectomy with or without instrumentation and laminoplasty represent the posterior approach. The key determinants of the surgical approach include the direction of spinal cord compression, the number of levels involved, the sagittal alignment of the spine, the presence or absence of instability, the presence or absence of significant axial neck pain, and the approach during any previous cervical spine surgery.

The timing of surgery and the surgical approach are still hotly debated. Although a number of studies have shown improved neurological outcomes in patients with severe neurological deficits following surgery,<sup>4,5</sup> the effects of surgery on the full spectrum of clinical presentations, ranging from mild to severe, remain in question.

**How to cite this article:** Zaveri GR, Jaiswal NP. A comparison of clinical and functional outcomes following anterior, posterior, and combined approaches for the management of cervical spondylotic myelopathy. Indian J Ortho 2019;53:493-501.

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DOI:  
10.4103/ortho.IJOrtho\_8\_16

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Several studies have addressed the problem of deciding between an anterior and posterior spinal decompression in CSM. However, none of the studies has preselected the surgical approach based on the above-mentioned key determinants and then prospectively compared the various approaches in terms of clinical and functional outcomes using validated outcome measures and with an adequate followup.<sup>6,7</sup> Our study aims to perform a prospective comparison of the anterior, posterior, and combined surgery for CSM by comparing the clinical and functional outcomes in patients preselected for a particular approach based on the above-mentioned key determinants.

## Materials and Methods

This is a prospective nonrandomized study conducted between March 2002 and December 2011. Approval for the study was obtained from the institute's ethics and research committee. The inclusion criteria were (1) clinical and radiological diagnosis of CSM, (2) C3 to C7 levels, and (3) age >20 years and <80 years. The exclusion criteria were (1) myelopathy secondary to medical causes (e.g. vascular, connective tissue disorder, and infection), (2) traumatic myelopathy, (3) congenital myelopathy, and (4) myelopathy secondary to ossification of the posterior longitudinal ligament (OPLL)/fluorosis.

Once the patient fulfilled the inclusion and exclusion criteria, they were selected for the study and briefed about the nature of the study, the interventions used, and written informed consent was obtained. The consented patients were enrolled in the present study. Further descriptive data of the participant, such as name, age, sex, detailed history, findings on clinical examination, and Nurick grades, were recorded. The modified Japanese Orthopedic Association (mJOA) score [Table 1] which is a validated measure of the amount of disability and functional limitation caused due to the disease was also calculated. Anteroposterior and lateral X-rays of the cervical spine, dynamic views, computed tomography (CT) scan, and magnetic resonance imaging scans were assessed, and the direction and type of compression, the sagittal alignment of the spine, the number of levels involved, and the presence or absence of instability were recorded.

Seventy five patients (61 males and 14 females) with a mean age of 64.2 (range 42 years–79 years) underwent surgery for symptoms and functional limitation due to CSM. None of the patients had been previously operated for cervical myelopathy. All patients were operated by a single surgeon at a single institute and evaluated independently.

Patients were operated by one of the three surgical approaches – anterior, posterior, and combined.

1. Anterior surgery (30 patients) consisted of either anterior discectomy and decompression with fusion or anterior corpectomy and fusion. Graft used was either an iliac crest strut or local graft packed into a cage.

**Table 1: Benzel' modification of the Japanese orthopaedic association score:**

1. Motor dysfunction score of the upper extremities	Points
Inability to move hands	0
Inability to eat with a spoon but able to move hands	1
Inability to button shirt but able to eat with a spoon	2
Able to button shirt with great difficulty	3
Able to button shirt with slight difficulty	4
No dysfunction	5
2. Motor dysfunction score of the lower extremities	Points
Complete loss of motor and sensory function	0
Sensory preservation without ability to move the legs	1
Able to move legs but unable to walk	2
Able to walk on flat surface with walking aid	3
Able to walk up and/or down stairs with a hand rail	4
Moderate to severe lack of stability but able to walk up or down with handrail	5
Mild lack of stability but able to walk up or down with smooth reciprocation	6
No dysfunction	7
3. Sensations	Points
Complete loss of hand sensation	0
Severe sensory loss or pain	1
Mild sensory loss	2
No sensory loss	3
4. Sphincter dysfunction score	Points
Inability to micturate voluntarily	0
Marked difficulty in micturition	1
Mild to moderate difficulty with micturition	2
No difficulty in micturition	3

Anterior plating was added to buttress the vertebral body-graft construct

2. Posterior surgery (35 patients) consisted of either laminectomy alone or laminectomy with interfacial fusion and lateral mass fixation
3. Combined approach (10 patients) involved either a multilevel laminectomy with lateral mass fixation and a focal decompression and fusion anteriorly at a single level or simply a posterior instrumented fusion following a multilevel anterior corpectomy and fusion.

The surgical approach was chosen based on the following key determinants [Table 2].

1. Direction of compression
2. Number of levels involved
3. Sagittal alignment of the spine
4. Presence or absence of significant instability.

In general, anterior compression due to soft or hard disc at one or two levels was dealt with by an anterior approach. Anterior decompression and fusion were also preferred when there was a multilevel anterior compression in a cervical spine with fixed kyphosis. Here, the anterior release was necessary to help restore the normal sagittal alignment.

Posterior compression due to ligamentum flavum hypertrophy or a circumferential narrowing due to congenital cervical stenosis was operated with a posterior decompression. Patients with multilevel (≥3 levels) anterior hard disc compression with neutral or lordotic spinal alignment underwent indirect decompression with a posterior laminectomy alone. If instead of lordosis, the patient had a correctible cervical kyphosis, then posterior instrumentation with fusion of the lateral pillars was performed in addition to the laminectomy.

A combined approach is rarely required in patients with CSM. It is usually required when there is a multilevel anterior or circumferential compression that entails a posterior decompression, but a focal soft disc compression or severe anterior compression at one or two levels needs to be dealt with by an additional anterior decompression. Occasionally, posterior instrumented fusion is added to provide additional stability in patients who have undergone multilevel anterior corpectomy.

The intraoperative and postoperative data regarding surgical time, blood loss, complications, and hospital stay were recorded. All patients were followed at regular intervals with clinical and radiographic evaluation. The outcomes were assessed using the modified Japanese Orthopedic Association score at followup.<sup>7</sup> Participants were classified as having mild disability (mJOA ≥14), moderate disability (mJOA, 10–13), or severe disability (mJOA ≤9) based on the mJOA scores [Table 3]. Using the imputed datasets, a Chi-square test and a McNemar-like approach were used, to compare patient outcomes at 1 year postoperatively, with patient status preoperatively.

The recovery rate is calculated according to Hirabayashi<sup>8</sup> as follows:

$$\text{Recovery rate} = \frac{\text{postoperative mJOA score} - \text{preoperative mJOA score} \times 100}{18 (\text{total score}) - \text{preoperative mJOA score}}$$

## Results

Of the 75 patients included in the study, 30 patients were treated using an anterior approach alone (19 discectomy and decompression and 11 corpectomy), 35 patients underwent posterior surgery (22 laminectomies and 13 laminectomies with instrumentation fusion), and 10 underwent combined anterior plus posterior surgery performed on the same day sequentially. One patient died 8-month postsurgery due to an acute myocardial infarct. Another patient from out of station who was seen at 6 months did not return for subsequent followup. All the remaining 73 patients were followed up for a minimum of 24 months following the surgery. The average followup duration was 21 months (range 6 months–72 months).

In this study, 80% of the patients had moderate-to-severe functional disability with significant gait difficulties,

**Table 2: Patient selection criteria for various approaches**

Anterior cervical discectomy & fusion (ACDF)	
Anterior compression at level of disc at 1, 2 or 3 levels	
Compression was mild to moderate. No congenital stenosis	
Cervical alignment was neutral, lordotic or focal kyphosis	
Anterior cervical corpectomy & fusion (ACCF)	
More severe anterior compression at 1, 2 or 3 levels	
Retrovertebral compression/congenital stenosis	
Cervical alignment was kyphotic, neutral or lordotic	
Laminectomy alone	
Posterior compression, multilevel anterior compression ≥3 levels	
Congenital stenosis	
Cervical alignment neutral or lordotic & no instability	
Laminectomy + posterior stabilization	
Multilevel spinal cord compression	
Flexible kyphosis or neutral alignment in a young patient	
Evidence of instability	
Combined approach	
Multilevel stenosis with focal anterior compression or kyphosis	
Multilevel stenosis with fixed kyphosis	
Severe anterior compression	

**Table 3: Demographic data based on approach used**

	Anterior	Posterior	Combined
No of patients	30	35	10
Av age (yrs)	62.2 (Range: 48 to 75)	65.3 (Range: 42 to 79)	66.1 (Range: 62 to 69)
Sex : M:F	25: 5	28: 7	8: 2
Av mJOA score	11.6	11.4	8.8
mJOA grade	Mild- 6 Moderate- 24 Severe- 0	Mild- 9 Moderate- 24 Severe- 2	Mild- 0 Moderate- 2 Severe- 8

clumsiness, and even bladder problems. All 75 patients showed improvement over their preoperative neurology and functional disability but to a variable extent [Table 4]. The followup average mJOA score of 16.41 (range 12–18) reflects that the residual neurological and functional disability was minimum. Preoperatively, 48% of the patients were either unable to walk or used a walker to ambulate whereas only 5.3% of patients required a walker at followup evaluation. Even in the patients older than 70 years, the results were uniformly good. The primary determinant for good result seemed to be patients with mild-to-moderate disability, i.e., a preoperative mJOA score of >10 at the time of surgery. The overall recovery rate was 77.25% [Table 5]

Thirty patients underwent anterior surgery. Based on their pathology, they underwent one of the three procedures – ACDF-19 pts, anterior cervical corpectomy and fusion (ACCF)-9 pts, and a combination of ACDF

**Table 4: Change in symptoms after surgery**

	Overall Patients			Anterior Approach			Posterior Approach			Combined Approach		
	Pre-op (no of patients)	At FU (no of patients)	P	Pre-op (no of patients)	At FU (no of patients)	P	Pre-op (no of patients)	At FU (no of patients)	P	Pre-op (no of patients)	At FU (no of patients)	P
Axial neck pain	72%	21.33%	<0.001	30	2	0.480*	14	10	0.72*	10	4	0.002*
Radicular arm pain	16%	4%	<0.001	12	1	<0.001*	0	2	<0.001*	0	0	
Gait difficulties	98.6%	25.33%	<0.001	30	4	0.134*	34	8	0.046	10	7	0.021*
Clumsiness	84%	36%	<0.001	26	6	0.752*	28	15	0.136*	10	6	0.011*
Bladder problems	32%	5.33%	<0.001	6	0	<0.001*	8	1	<0.001*	10	3	<0.001*
mJOA score	11.01 (7 to 15)	16.41 (12 to 18)	2.7e-014	11.6	16.96	0.000	11.4	16.42	0.000	8.8	14.7	0.000
Functional disability	Mild 15 Moderate Severe	None 23 Moderate		Mild 6 Moderate Severe	None 11 Mild 19 Moderate		Mild 9 Moderate 24 Severe	None 12 Mild 21 Moderate		Moderate Severe	Mild 8 Moderate Severe	
	50 10	Mild 48 Moderate Severe		24 Severe	0 0		2 2	2 2		8	2	

with ACCF-2 pts. An intervertebral cage packed with local bone graft was used in half the patients in this group. The average blood loss was 358cc (range 100cc–1000cc). The blood loss was higher in the corpectomy group where often the nutrient artery to the vertebral may be troublesome. The average anesthesia time was 190 min (range 125 min–230 min).

As shown in Table 4, the average preoperative mJOA score was 11.6. This showed significant improvement to 16.96 at followup. About 80% of the patients in the anterior group were found to have moderate functional disability preoperatively. This improved significantly so that 36.6% had no disability and 63.3% had mild disability at the final followup. Most patients with residual disability had numbness in the fingers or some loss of dexterity in the hand.

All patients in the anterior group had some degree of axial neck pain and hence were not ideal candidates for a posterior procedure. Excision of osteophytes, decompression, with restoration of disc height and sagittal cervical spinal alignment provided excellent relief in axial neck pain in this group. Again all patients with radicular arm pain underwent an anterior surgery to enable foraminal decompression without destabilizing the spine. All but one patient reported excellent relief in the radicular arm pain. The one patient who had residual arm pain had undergone an uneventful two-level ACDF. However, he reported only a marginal reduction in pain. Followup CT scans showed adequate foraminal decompression. The patient was subsequently treated at the pain clinic.

Thirty five patients underwent surgery through the posterior approach. The average blood loss was 351cc (range 150 cc–700 cc). The average anesthesia time was 188 min (range 140 min–250 min). The average preoperative mJOA score improved from 11.4 preoperative to 16.42 postoperative. About 74.2% of patients had moderate-to-severe functional disability before surgery. At followup, 34% of patients had no significant functional disability while 60% had mild functional limitations. Two patients with moderate disability presented for surgery 18 and 20 months after surgery. These patients showed only marginal improvement and continued to have some gait difficulties and difficulty with fine motor function at followup.

Preoperatively, 14 patients in this group had some axial neck pain. All but one of these patients underwent laminectomy with instrumentation. At followup, six patients who underwent laminectomy alone had *de novo* mild axial neck pain although X-rays did not reveal any focal instability or loss of sagittal alignment. Two patients who underwent posterior instrumentation developed radicular arm pain postoperatively. One of them had a long screw which was impinging a nerve root. The screw had to be revised before the patient got relief of pain. Another patient had foraminal osteophytes which were

**Table 5: Hirabayashi's Recovery rate of mJOA**

Preop mJOA score grading	Anterior		Posterior		Combined		Overall exclusive of approach used	
	No. of Patient	Avg recovery rate of mJOA	No. of Patient	Avg recovery rate of mJOA	No. of Patient	Avg recovery rate of mJOA	No. of Patient	Avg recovery rate of mJOA
Mild (14-18)	6	100	9	100	-	-	15	100
Moderate (10-13)	24	82.6	24	73.3	2	75	50	77.8
Severe ( $\leq 9$ )	0	-	2	69.7	8	62.2	10	63.7
Overall exclusive of mJOA grading	30	83.37	35	76.6	10	64.13	75	77.25

not decompressed as the patient did not have radicular symptoms. Intraoperatively, some compression was applied across the screws to restore the cervical lordosis. This might have resulted in further foraminal narrowing causing radiculopathy. Intravenous Solu Medrol was given for 48 h which relieved the patient's pain and it did not recur again.

Anterior plus posterior surgery was performed in ten patients. Of these, three patients had four-level and four patients had three-level posterior decompression and fusion followed by anterior decompression and fusion at one or two levels. These were patients with a kyphotic spine who had developed multilevel spinal cord compression with focal anterior compression at one or two segments. Following a posterior decompression, the instrumentation helped to realign the spine, and the focal anterior decompression and fusion were necessary to deal with the severe focal cord compression. The remaining three patients had an osteoporotic spine where posterior stabilization was performed to enhance the stability following anterior decompression and fusion. The average anesthesia time in the combined surgery group was 383 min (range 340 min–450 min), and the average blood loss was 850 cc (range 700cc–1100cc) which was significantly higher than in the other two groups.

As shown in Table 4, a combined surgery was performed in patients with more severe spinal canal narrowing resulting in severe neurologic deficit and functional disability. Even in this group, the clinical outcome was very good with the average preoperative mJOA score of 8.8 improving to 14.7 postoperative. All patients in this group had moderate-to-severe functional limitations preoperatively which improved significantly so that 80% of patients were graded with mild disability postoperatively. Mildly altered gait and residual sensory loss were frequently seen within this group.

Table 6 compares the average operating time and average blood loss, among the various approaches which shows no significant difference, except in combined approach where operating time as well as the blood loss was obviously more. Nearly 17.3% of patients had a perioperative complication. Two dural tears occurred in the anterior approach, and three patients developed postoperative radicular pain with the postapproach. Overall complication was more with the combined approach 33.3% when

**Table 6: Summarizes the average perioperative blood loss, average operating time among various approaches**

	Anterior approach	Posterior approach	Combined approach
Average blood loss (in cc)	358	351	850
Average operating time (in minutes)	190	188	383

compared with the anterior and posterior approach 13.3%, and 14.28%, respectively.

## Discussion

The management of CSM continues to be debated due to the inadequacy of information available about natural history of this disorder.<sup>9-13</sup> However, there is some agreement in the literature that a shorter duration of symptoms and milder neurological deficit before surgery yields a better postsurgical outcome.<sup>9,14,15</sup> Successful surgical treatment of CSM rests on identifying the specific pathology responsible for the clinical syndrome. The surgical approach is then tailored to deal with various static and dynamic factors causing the spinal cord compression which are often superimposed on a congenitally or developmentally narrow spinal canal.<sup>16-18</sup> The location of the compressive pathology, the number of levels involved, the sagittal cervical spine alignment and the presence or absence of instability and axial neck pain, factors in the decision as to which approach would be most appropriate for a particular patient.<sup>19</sup>

Smith and Robinson<sup>20</sup> popularized the anterior approach for decompression and fusion at one or two levels in the cervical spine. Others have successfully used it for patients undergoing multilevel fusion.<sup>21</sup> In our study, the anterior approach was chosen when the disease was limited to a maximum of three spinal segments. We performed a multilevel anterior discectomy with fusion when disease was at the level of the intervertebral disc, compression was milder, and there was no congenital stenosis [Figure 1]. In these patients, the overall cervical sagittal alignment was neutral or lordotic although there was often a focal kyphosis at the level of the intervertebral disc. On the other hand, a corpectomy was performed when compression was more severe or retrovertebral, there was

congenital stenosis, or the sagittal alignment was kyphotic [Figure 2]. Following surgery, there was significant neurological and functional improvement in all patients in this group. The preoperative mJOA score in the group undergoing anterior surgery was 11.6 which improved to 16.9 at the last followup. The recovery rate was 83.37%. Preoperatively, in this group, 24 patients were graded as having moderate disability and six patients were graded as having mild disability. At the last followup, 19 patients were graded as having mild residual disability and 11 were found to have no significant disability. These results were comparable to those reported by Wada *et al.*<sup>22</sup> who reported an improvement in mJOA scores from 7.9 to 13.3 at 1-year followup in 23 patients that underwent ACCF. Emery *et al.* also reported a high rate of pain relief and neurological and functional improvement in 108 patients that underwent anterior discectomy/partial or subtotal corpectomy for CSM. They correlated good outcomes with milder preoperative neurologic deficit and disability while recurrent myelopathy was correlated with a nonunion. In the current study, the recovery rate was 83.37% which was slightly better than that reported by Williams (62.35%),<sup>23</sup> Sorar (85% pts had >50% recovery rate),<sup>24</sup> and Vyas (66.9%).<sup>25</sup> This is probably because a majority of the patients that underwent anterior surgery in this study had mild-to-moderate disability preoperatively.

Although anterior surgery at one or two levels is a well-accepted procedure, when the pathology involves  $\geq 3$  levels, there are concerns regarding postoperative dysphagia, recurrent laryngeal nerve palsy, graft-related complications, and implant failure. Emery *et al.*<sup>26</sup> reported 44% nonunions among 16 patients who had three-level anterior discectomy and fusion. Vaccaro *et al.*<sup>27</sup> reported the early failure of plate fixation in 9% of two-level and 50% of three-level corpectomies and fusion. In our study, none of the patients that underwent anterior surgery alone had graft extrusion or nonunion, screw or plate breakages.

Posterior surgery, i.e., laminectomy, has for long been the treatment for multilevel CSM [Figure 3]. It allows excellent decompression of the spinal cord and is safe and quick. Hence, it is the preferred method of decompression in the elderly. Potential adverse outcomes of laminectomy include instability and epidural scar formation which may result in postoperative neck pain or headache. In the long term, loss of normal cervical lordosis or development of kyphosis along with late deterioration of neurology has been problems. Fear of instability and the need to maintain sagittal cervical spine alignment have resulted in many surgeons performing posterior lateral mass fixation with interfacetal fusion at the same time [Figure 4]. Laminoplasty was developed to decompress the spinal cord without having to remove the lamina and spinous processes. The retained posterior elements would then prevent muscle scarring to the dura and reduce the incidence of postoperative instability. Both laminectomy

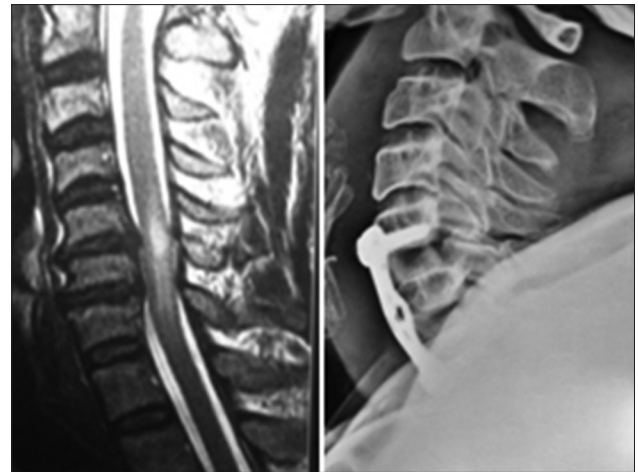


Figure 1: 65y M with myelopathy secondary to spondylosis- treated with anterior cervical discectomy and fusion at two levels



Figure 2: Multilevel spondylosis resulting in CSM in 67y male treated with corpectomy and plate fixation

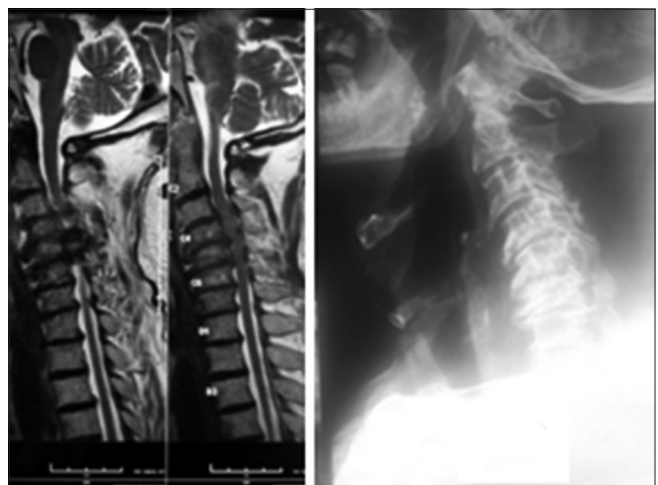
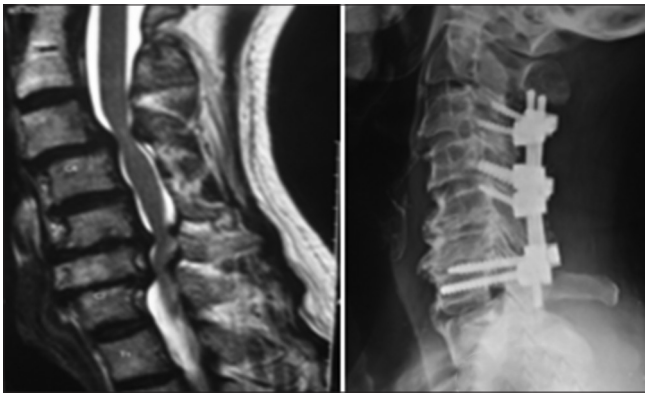


Figure 3: 64 year male with multilevel cervical spondylosis, overall straight spine and large anterior stabilizing osteophytes resulting in CSM treated with posterior laminectomy

and laminoplasty are recommended in patients with a well-maintained cervical lordosis. This allows the spinal cord to



**Figure 4: Multilevel spondylosis with instability resulting in CSM in 56 year female treated with posterior laminectomy and fixation**

translate backward resulting in an indirect decompression. Although the posterior translation of the spinal cord is not as significant in a straight spine, adequate decompression is achieved in patients with milder anterior compression. In a kyphotic spine, the posterior translation of the spinal cord does not occur, and hence, the indirect decompression of the spinal cord does not take place.

In our series, 22 patients underwent laminectomy alone and 13 patients had an additional posterior stabilization. Lateral mass fixation and interfacetal fusion were performed in younger patients with neutral sagittal spine alignment or a correctible kyphosis and absence of anterior osteophytes that would confer stability to the spine. The preoperative mJOA score among the 35 patients that underwent posterior surgery alone was 11.4. Based on the mJOA score, there were 9 patients with mild disability, 24 with moderate disability, and 2 with severe disability. Postoperative mJOA score improved to 16.4. Moreover, the disability was graded as none in 12 patients, mild in 22, and moderate in 1 patient. The recovery rate was 76.6%. This was comparable to that reported by Ratliff and Cooper who reported a recovery rate of 55%–80% following posterior laminectomy or laminoplasty. Houten and Cooper evaluated 38 patients who underwent laminectomy and lateral mass plating for CSM.<sup>28</sup> A significant improvement in neurological function occurred in 97% of patients. The mJOA score improved from 12.9 to 15.6 at a mean followup of 6 months. Complications included one patient with C5 nerve root palsy.

Combined anterior plus posterior cervical decompression and fusion was first reported by McAfee *et al.*<sup>29</sup> They reported on 100 patients who underwent a single-stage anterior cervical decompression and fusion with posterior stabilization for trauma, tumors, infection, etc., Seven patients had CSM; however, their results have not been discussed separately. Major intraoperative complications were seen in 11% of the patients. However, there were no perioperative airway-related problems. Seventy-six percent of the patients with a preoperative neurological deficit showed some improvement. There were two nonunions and two patients had loss

of anterior fixation necessitating revision surgery. They concluded that one-stage combined anterior and posterior operative reconstruction optimizes the environment for maximum neurological recovery. Epstein<sup>30</sup> reported on her experience of 22 circumferential decompression for severe myelopathy secondary to OPLL. The mean anesthesia time was 9.8 h, and approximately 3.5 U of blood was transfused. One patient had a deep vein thrombosis and another died of myocardial infarction. Three patients required a second operation and two for fracture of the vertebral body at the end of construct. At 22-month followup, patients improved approximately three grades on the Nurick scale.

A combined anterior plus posterior surgery for CSM is a major undertaking. In our series, ten patients required a combined surgery which was performed at the same sitting. The main indication was patients with multilevel stenosis with focal anterior compression at one or two segments or a focal kyphosis. Here, an anterior decompression and fusion are followed by a multilevel laminectomy and posterior stabilization. In patients with frank cervical kyphosis with multilevel cord compression, a multilevel anterior corpectomy is performed along with strut graft for decompression and restoration of sagittal alignment. In these patients, additional posterior stabilization helps to reduce the incidence of graft- and hardware-related complications, especially if there is accompanying osteoporosis. Occasionally, if there is very severe anterior compression, we prefer to perform a laminectomy first before tackling the anterior compression. The patients in this group tended to be worse neurologically and function wise with eight of them graded as severe and two as moderate with an average mJOA score of 8.8. Even in this group, there was an excellent neurological recovery and the average postoperative mJOA score was 14.7 with eight having mild dysfunction and two with moderate residual disability. The recovery rate was 64.13%.

In the current study, 75 patients with CSM underwent decompression and spinal stabilization using three different approaches. We chose the approach based on the above-mentioned criteria. In all three groups, there was significant neurological recovery, and there was no significant difference in good results or complication rate among the three groups. The only major difference was that the combined surgery group has a longer anesthesia time, more blood loss, and longer hospital stays. As a whole, the average preoperative mJOA score of 11.01 improved to 16.4 at the last followup. The recovery rate was graded as excellent at 77.25%. The functional disability which was preoperatively graded as mild in 15, moderate in 50, and severe in 10 improved to none in 23, mild in 49, and moderate in 3 after the surgery. The significant improvement ( $P = 0.001$ ) in mJOA scores reflects the excellent neurological and functional recovery in our study population. The best results were obtained in those patients that had mild neurological deficits preoperative.

Complications perioperatively were seen in 16% of patients. These patients required longer hospital stay. At the followup, adjacent level degeneration was seen in six patients of which four were asymptomatic. Implant-related complications were seen in three patients but were asymptomatic and hence were left untreated. While we did not encounter any nonunions in the anterior or combined group, it has been difficult to assess fusion in the posterior group. However, the implants were holding well in all, but one patient and the patients were largely asymptomatic.

In the recent years, there has been abundant literature that has helped us understand the various factors that determine the surgical approach in CSM. Improved surgical techniques, the use of a microscope for decompression, and excellent instrumentation have made surgery safer and a good outcome more predictable. Improved anesthesia has also gone a long way toward making surgery successful.

Our study is a single-surgeon-based consecutive cohort of patients studied prospectively and reviewed independently using valid outcome measures. The study group is large and helps us to study the role of surgery in CSM while comparing the results and complications following different surgical approaches.

However, the study also has several limitations. The decision regarding the surgical approach used is not randomized. It is based on the surgeon's experience. The only outcome measure used is the mJOA score which does not measure the patient's pain and the disability thereof. The study duration too is small. With further followup, one may find failures of the posterior fusion/instrumentation because interfacetal fusion is difficult to assess on plain X-rays. Further with longer followup, adjacent level degeneration and postlaminectomy deformity may also affect the clinical outcome.

## Conclusion

Authors want to conclude on the basis of this short to medium-term study, that the results of surgery for CSM are excellent. The best neurological and functional recovery is seen in patients with mild-to-moderate functional disability at the time of surgery. While the neurological recovery has been excellent with all the surgical approaches in our study, we feel that choosing the correct approach is the first step in reducing the incidence of postoperative complications and poor results.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

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