Combined Anterior-Posterior Decompression and Fusion for Cervical Spondylotic Myelopathy

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Abstract

We conducted a study to evaluate the operative details, perioperative complications, and short-term outcomes associated with combined anterior-posterior decompression and fusion (CAPDF) for treating cervical spondylotic myelopathy (CSM).

We retrospectively reviewed the charts of 21 patients who underwent CAPDF at our institution. Pertinent information, including demographics, surgery indication, perioperative complications, operative time, levels fused (and number of levels fused) anteriorly and posteriorly, estimated blood loss, and length of stay, was gathered. Outpatient follow-up data were available for 20 of the 21 patients, and postoperative neurologic status was evaluated with Nurick grades as well as by subjective means.

Mean age was 62.1 years (range, 44-79 years). Of the 21 patients, 9 were female, and 12 were male. Before surgery, all patients had a diagnosis of CSM of varying degree. Mean number of levels fused was 2 (range, 1-3) anteriorly and 3 (range, 1-4) posteriorly. Mean operative time, which included patient repositioning, was 4 hours 55 minutes (range, 3:04-6:22). Mean estimated blood loss was 131 mL (range, 55-278 mL), and mean length of stay was 5 days (range, 2-10 days). The most commonly encountered complication was dysphagia (28.6%, 6/21). Neither neurologic instability nor mortality was observed after surgery. Neurologic status was subjectively improved for 19 patients and unimproved for 1 patient; no patient's neurologic status was worse. Mean Nurick grade was 1.9 before surgery and 1.1 after surgery (mean difference, 0.80; $P < .001$), at a mean follow-up of 96 days (range, 51-149 days).

When indicated, CAPDF is an efficient and effective treatment for CSM. This study found the procedure to be associated with minor complications, no new neurologic deficits, and high levels of neurologic improvement. The positive short-term outcomes and low rate of long-term complications in our study, combined with data from previous comparative studies, suggest that same-day surgery is superior to staged surgery.

Cervical spondylotic myelopathy (CSM) is a degenerative disease characterized by progressive compression of the spinal cord. CSM has been found to be the most common cause of spinal impairment as well as the most frequently acquired cause of spinal dysfunction in people over 55 years of age.[1,2] If left untreated, this condition can reduce manual dexterity and cause gait disturbances, dysesthesias, and weakness in the extremities. When conservative treatments fail, surgical intervention often becomes the preferred course of action for CSM and/or myeloradiculopathy.

The surgical approach for CSM and other advanced cervical spine (CS) deformities varies and is often a source of debate. Being a relatively safe and effective procedure, anterior decompression with fusion is optimal in treating discogenic lesions causing myelopathy but is less effective in multilevel disease.[3,4] When pseudarthrosis, adjacent

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Take-Home Points

- Surgical intervention for cervical spondylosis and radiculopathy classically involves either an anterior or posterior approach for adequate decompression of the spinal cord and associated nerve roots.
- Combined anterior-posterior surgery for cervical spondylotic myelopathy is a relatively new technique that has previously been used for disorders of the thoracolumbar spine.
- Combined anterior-posterior cervical decompression and fusion for the treatment of cervical spondylotic myelopathy is associated with minor complications and excellent neurologic outcomes.
- Combined surgery can either be performed in a single day or in a staged manner, with current literature showing that same-day surgery is superior with respect to estimated blood loss and length of stay.

segment degeneration (ASD), and hardware failure are of concern, posterior decompressive laminectomy with instrumentation is a promising option.[5] However, this method is less effective in restoring lordosis and can increase the risk for later clinical deterioration.[6] There is a select subset of patients for whom a combined anterior-posterior approach is ideal.[7-9]

In cases in which a combined anterior-posterior approach is identified as the best treatment option, whether to perform the operation in a sequential or staged manner must be decided, and this question is another source of debate. Single-day surgery is sometimes anecdotally criticized as posing a greater risk to the patient. On the other hand, some comparative studies have shown no statistically significant difference in major complication rates between the 2 options.[10,11] More descriptive studies of combined anterior-posterior decompression and fusion (CAPDF) are needed to explore the efficacy of the procedure. In this article, we describe a study we conducted to characterize the operative data, perioperative complications, and short-term outcomes associated with CAPDF for the treatment of CSM in a select group of patients.

Methods

After receiving Institutional Review Board approval for this study (formal consent was not required), we retrospectively reviewed the charts of 21 patients who underwent CAPDF for CSM at our institution. All patients underwent surgery between February 2010 and March 2015. Criteria for inclusion in the study included same-day CAPDF for CSM. Staged procedures were excluded, as were combined procedures for the treatment of other diseases (eg, malignancies). All patients were operated on by the same primary surgeon (Dr. Davis) and co-surgeon (Dr. Labiak). The 1 patient who was lost to follow-up was excluded from the postoperative outcome analysis.

We reviewed the patients' medical records for surgical consultations, operative reports, intraoperative reports, progress notes, and postoperative office visit reports. Demographic information included age, sex, body mass index, and preoperative risk factors, such as diabetes and tobacco use. All patients had been diagnosed with myelopathy. Clinical data included previous history of CS surgery, levels fused (and number of levels fused) anteriorly and posteriorly, operative time, estimated blood loss (EBL), length of stay (LOS), and perioperative complications. Short-term (3-month follow-up) neurologic improvement was determined both objectively, with the Nurick grading system,[12] and subjectively, with determination of patient quality of life before and after surgery and with neurologic examination.

Operative Technique: Anterior Approach

All operations were performed with continuous somatosensory evoked potential monitoring of both upper and lower extremities. Each patient, positioned supine with the head in a neutral position, underwent standard endotracheal intubation. Intubation was followed by a transverse incision and dissection down to the deep cervical fascia with maintenance of the carotid sheath laterally and tracheoesophageal complex medially. Interspaces were identified and later were confirmed with lateral radiographs. Discectomy, osteophytectomy, and removal of hypertrophied or calcified ligament were then performed until decompression was satisfactory. Corpectomies were not performed. Polyetheretherketone interbody spacers (Stryker) were used with autograft harvested from vertebral body resection. Low-profile screw-plate systems were placed. After completion of the anterior procedure, the patient was placed prone, with the head fixed in a Mayfield clamping device in neutral position and with all pressure points carefully padded.

Operative Technique: Posterior Approach

A midline incision was made through the skin and subcutaneous tissue to the level of the deep cervical fascia. Then, dissection was performed to the tips of the lateral masses. Instrumentation and fusion preceded spinal decompression. This order, chosen to preserve bony landmarks for guidance during instrumentation, did not interfere with subsequent decompression. Segmental spinal instrumentation was placed using lateral mass screw-rod fixation. After the laminae and ligamenta

Table 1. **Demographic Data**

Patient	Age, y	Sex	BMI, kg/m²	Diabetes	Smoking
1	66	M	37.31	N	Y
2	69	F	23.94	N	N
3	66	F	34.32	N	Y
4	61	M	40.17	N	Y
5	59	M	34.94	Y	Y
6	63	M	25.11	N	N
7	74	F	33.06	Y	Y
8	70	M	28.18	N	N
9	64	F	22.12	N	N
10	69	M	43.02	Y	Y
11	67	M	30.85	N	N
12	62	M	27.05	Y	Y
13	44	F	39.27	N	N
14	63	F	45.60	Y	Y
15	53	M	30.81	N	Y
16	57	F	26.64	N	Y
17	46	M	36.73	Y	N
18	69	F	23.63	N	Y
19	53	F	23.71	N	Y
20	79	M	30.17	N	N
21	50	M	37.36	N	Y
Mean	62.1	42.9% F	32.09	28.6% Y	61.9% Y
SD	9.0	—	6.867	—	—

Abbreviation: BMI, body mass index.

Table 2. **Clinical Data**

	Levels Fused, n		Surgical Time,[a]		
Patient	Anterior	Posterior	h:min	EBL, mL	LOS, d
1	2	4	4:39	113	2
2	2	3	4:45	58	3
3	1	4	3:51	113	4
4	3	4	4:41	110	6
5	3	3	6:22	148	3
6	3	4	5:37	88	8
7	1	1	3:04	58	10
8	1	2	4:50	228	5
9	2	4	4:51	128	5
10	1	4	5:56	138	4
11	2	4	5:28	278	3
12	1	4	4:18	130	4
13	2	2	5:17	183	4
14	2	4	5:43	235	3
15	3	4	5:58	105	5
16	2	4	4:51	85	5
17	2	2	5:38	130	4
18	3	4	5:20	88	3
19	2	4	4:25	55	3
20	1	2	4:19	228	8
21	1	1	3:37	63	5
Mean	2	3	4:55	131	5
SD	0.7	1	—	60	2
Range	1-3	1-4	3:04-6:22	55-278	2-10

Abbreviations: EBL, estimated blood loss; LOS, length of stay after surgery.
[a]Time from incision, including repositioning.

flava were bilaterally mobilized, the entire bony ligamentous complex spanning the area of fusion was removed en masse (most commonly C3–C7) in order to decrease the number of instrument passes near the spinal cord. Next, a modest foraminotomy was performed to extend the opening laterally and ensure adequate decompression of the nerve roots. Autograft harvested from the spinous processes and laminae was used. The posterior portion of the operation contributed significantly to blood loss and postoperative pain during the perioperative period. We recommend performing a very meticulous dissection to minimize these consequences. No patient in this study required a halo orthosis.

Results

Twenty-one patients with CSM were treated with CAPDF between February 2010 and March 2015 (**Table 1**). Mean age was 62.1 years (range, 44-79 years). Nine patients were female, and 12 were male. The primary diagnosis was CSM, but several patients presented with associated conditions, including congenital cervical spinal stenosis (3 cases), cervical kyphotic deformity (3 cases), and ossification of posterior longitudinal ligament

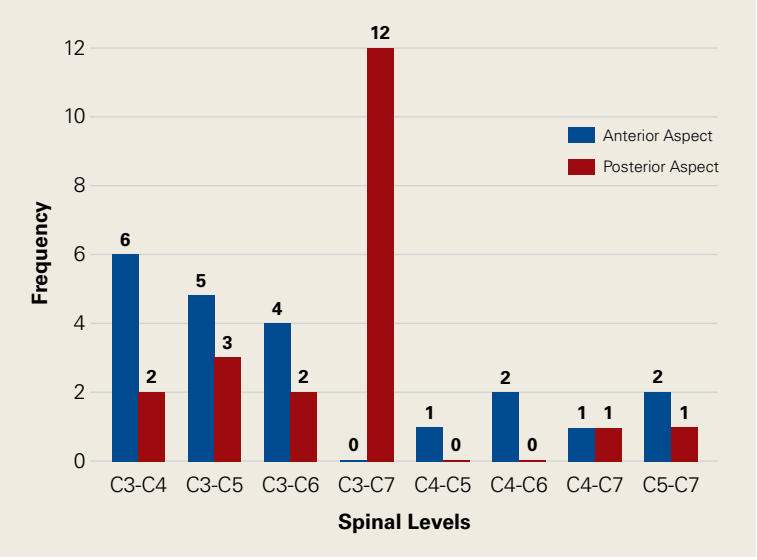

Figure 1. Bar graph. Exact range of levels fused both anteriorly and posteriorly is shown on x-axis, and frequency of each procedure performed is shown on y-axis.

Table 3. **Summary of Complications**

	Patients Affected	
Complication	**n**	**%**
Neurologic instability	0	0
Death	0	0
Adjacent segment kyphosis	1	4.8
Dysphagia	6	28.6
Dysphonia	1	4.8
Wound dehiscence	1	4.8
Seroma/excessive wound discharge	2	9.5
Urinary retention	1	4.8

Table 4. **Postoperative Neurologic Status**

Improved	19
No change	1
Worsened	0

(OPLL; 4 cases). Two patients previously underwent CS surgery: anterior fusion at C4–C6 (patient 8) and separate anterior fusions (C5–C6, C6–C7) about 11 years apart (patient 16). For these 2 patients, combined anterior-posterior surgery was performed not to revise their fusions but to extend their constructs to address ASD. The 21-patient cohort had high rates of comorbidities: Thirteen patients (61.9%) were obese or morbidly obese, 6 (28.6%) had diabetes mellitus (insulin-dependent in 2 cases), and 13 (61.9%) had a history of tobacco use (6 of these patients used tobacco the previous year).

Table 2 summarizes the operative data. Mean number of levels fused was 2 (range, 1-3) anteriorly and 3 (range, 1-4) posteriorly. C3–C4 was the most common fusion range anteriorly, and C3–C7 was the most common range posteriorly. **Figure 1** shows the frequency of type of fusion performed both anteriorly and posteriorly. Mean operative time, which included supine-to-prone repositioning at the end of the anterior operation, was 4 hours 55 minutes (range, 3:04-6:22). Mean EBL was 131 mL (range, 55-278 mL), and mean LOS was 5 days (range, 2-10 days).

Of the 21 patients, 9 (42.3%) had at least 1 complication during the perioperative period. **Table 3** summarizes all encountered complications. Neither neurologic instability nor mortality was observed after surgery. With the exception of 1 case of adjacent segment kyphosis, all complications were transient, yielding a long-term complication rate of 4.8%. The most frequently encountered complications were dysphagia (28.6%) and excessive wound discharge (9.5%). Dysphagia is a common complication after anterior cervical surgery, with exposure above C4 being a significant risk factor.[13] Such exposure was found in 4 (66.7%) of the 6 patients with dysphagia. One patient in the study experienced kyphotic collapse below the level of fusion. Subsequent computed tomography showed no evidence of hardware failure, flexion/extension radiographs showed no progression of the kyphotic deformity, and the patient remained asymptomatic and did not undergo reoperation. The deformity was attributed to low bone quality, not to any abnormality in the surgical construct.

Patient 7 was lost to follow-up. For the other 20 patients, mean time to "3-month follow-up" was 96 days (range, 51-149 days). The most commonly noted improvements in quality of life included resolution of numbness, improvement in gait, and return to previous activities, such as walking and even exercising. The most common improvements noted on neurologic examination included decreased hyperreflexia, less reproducible beats or complete absence of ankle clonus, gait improvement, and increased motor strength. Neurologic status was subjectively improved for 19 patients

and unimproved for 1 patient; no patient's neurologic status was worse (**Table 4**). Mean Nurick grade was 1.9 before surgery and 1.1 after surgery (mean difference, 0.80; $P < .001$). **Table 5** shows the distribution of patients' Nurick grades before and after surgery.

Table 5. **Short-Term Outcome Assessed by Nurick Grade**

Nurick Grade	Before Surgery		3 Months After Surgery	
	n	%	n	%
0	1	5	8	40
1	5	25	5	25
2	10	50	4	20
3	3	15	3	15
4	1	5	0	0
5	0	0	0	0

Representative Case

Patient 15, a 53-year-old man, presented with complaints of dysesthesias of the hands. Focused neurologic evaluation at the time revealed limited CS range of motion on extension. The patient (**Figures 2A-2D**) was diffusely hyperreflexic and had pathologic spread in the upper extremities. He underwent C3–C6 anterior discectomy, instrumentation, and fusion followed by C3–C6 posterior laminectomy, medial facetectomy, instrumentation, and fusion.

Discussion

Cervical myelopathy is a common yet frequently underdiagnosed disease, owing to the fact that many patients remain asymptomatic even after experiencing degenerative changes in the spinal column.[14-16] The additive effects of spondylosis, osteophyte formation, ligamentous hypertrophy, and listhesis lead to progressive canal and intervertebral foraminal compromise, ultimately producing the clinical syndromes of myelopathy and radiculopathy.[17] The characteristic symptoms of CSM are known to have an insidious onset. In the early stages, patients note a subtle gait disturbance and later experience manual dexterity reductions and upper extremity dysesthesias.[18] As the condition progresses and conservative management fails, surgical intervention is sought.

Nevertheless, the pursuit of surgical treatment for CSM remains somewhat controversial. Some authors have found no statistically significant difference between conservative and surgical management of mild to moderate CSM,[19] whereas others have found that surgically treated patients had much better outcomes than their medically treated counterparts.[20] In 2010, Scardino and colleagues[21] reported that CSM patients who were bedridden and/or wheelchair-bound with seemingly irreversible myelopathy were capable of neurologic improvement after surgical intervention. At the very least, what remains clear is that untreated CSM is known to follow an unpredictable course, with the condition deteriorating faster for some patients than others.[22]

Traditional anterior or posterior approaches, which can be used in the majority of cases of cervical spondylosis and/or radiculopathy, have been compared extensively.[23,24] The inverse relationship concerning the integrity of an anterior construct and the number of levels fused is a well-established clinical finding.[3,4,8,25-28] Laminectomy with fusion is not without its disadvantages: Cervical instability secondary to mechanical loss of posterior cervical support, and subsequent post-laminectomy kyphosis, is a common complication.[23] In cases

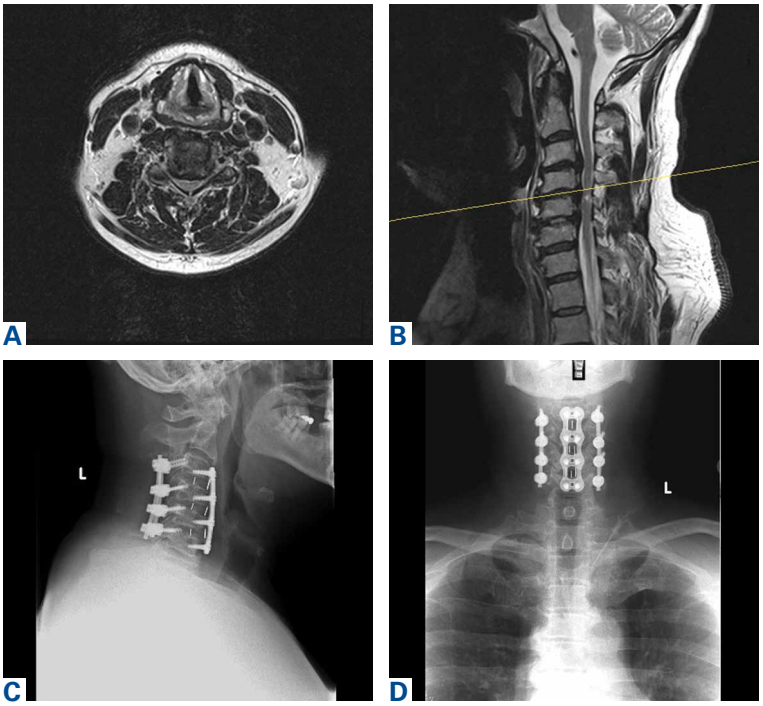

Figure 2. (A) Axial T2-weighted magnetic resonance imaging (MRI) confirms the presence of discogenic spondylotic disease and osteophyte formation. (B) Sagittal T2-weighted MRI shows evidence of congenital spinal stenosis, advanced spondylotic and discogenic disease with osteophyte complexes at C3–C6, and C4–C5 signal changes consistent with gliosis or edema. Postoperative (C) lateral and (D) anteroposterior radiographs show C3–C6 anterior fusion and C3–C6 posterior instrumentation.

in which more stability is required, the combined anterior-posterior approach is more promising than either approach alone. This technique has its roots in the treatment of several thoracolumbar spine disorders, including infections, scoliosis, trauma, and tumors.[29-31] More recently, the technique has been applied to CS disorders.

In 2008, Gok and colleagues[32] retrospectively compared the results of anterior-only fusion and CAPDF for CSM. Forty-six patients underwent anterior surgery only, and 21 underwent CAPDF. The groups' complication rates were similar: 28.6% (anterior only) and 24% (CAPDF); the incidence of ASD was lower in the combined group. Song and colleagues[33] conducted a similar study in 2010. They compared anterior fusion alone and CAPDF in treating degenerative cervical kyphosis. Results were strongly in favor of the combined technique, as it led to "greater correction of sagittal alignment, a better maintenance of correction angle, a higher rate of fusion, a lower rate of subsidence and lower complications." Both studies established that, in a select group of patients, the benefits of CAPDF outweighed the risks. These findings, combined with our study's findings of no major complications and the transience of minor complications, suggest CAPDF should not be considered too invasive or risky.

The results of our study also mirror those of 3 other studies on the use of CAPDF for CS disorders. In 1995, McAfee and colleagues[34] reported on a group of 100 patients with follow-up of 2 years or more. In most cases, the surgical indication was trauma, but neoplasm, infection, rheumatoid arthritis, and CSM were found as well. Outcomes were very favorable: improvement in a previous neurologic deficit (57/75 patients), ability to walk again (21/35 patients), no new neurologic deficits, and no hardware failures. In 2000, Schultz and colleagues[35] retrospectively reviewed the cases of 72 patients who underwent CAPDF for a variety of complex CS disorders. Two of the 72 experienced transient neurologic deficits, and, though the immediate complication rate was relatively high (32%), the long-term complication rate was down to 5%. In 2009, Konya and colleagues[36] retrospectively reviewed the cases of 40 patients who underwent CAPDF, primarily for CSM. Within 1 week after surgery, neurologic deficits were reduced in 36 patients; by 1 year after surgery, neurologic deficits were reduced in all 40 patients, and fusion was achieved in 39. These 3 studies[34-36] helped establish CAPDF of the CS as a viable and effective procedure that can be performed within a single day.

Although many physicians have achieved favorable results with single-day surgery, the decision to operate in a sequential or staged manner remains controversial. Some anecdotally claim CAPDF poses a greater operative risk to the patient. In 1991, the continuous procedure was found to involve less blood loss and shorter LOS while providing for better correction of severe spinal deformity in patients with scoliosis and rigid kyphosis.[37] Three more recent comparative studies examining the same issue in the treatment of CS diseases found staging did not reduce the complication rate and may in fact have been associated with higher complication rates, more blood loss, and longer total operative time and LOS.[10,11,38] Our study's lower blood loss, shorter LOS, and lower major complication rate relative to the combined groups in all 3 of those studies are most likely attributable to our operating on a lower mean number of spinal levels and our restricting the surgical indication to CSM. The positive short-term outcomes and low rate of long-term complications in our study, combined with the data from these 3 comparative studies, suggest that same-day surgery is superior to staged surgery. A staged operation should be considered only if the patient cannot tolerate long periods under general anesthesia.

Many have advocated extending fusion down to T1 to prevent ASD at the C7–T1 disk space.[35,39,40] We decided against this approach for 2 reasons. First, at C7, lateral mass screws were always chosen over pedicle screws. When possible, shorter lateral mass screws were used at this level, making C7 much less rigid. Second, the C7–T1 facet capsule was maintained to preserve joint integrity. We suggest extending fusion down to T1 only if there is prior evidence of spinal disease and/or listhesis at C7–T1. Although long-term (many-year) follow-up is often desired, we specifically assessed short-term (3-month) outcomes. We have anecdotally found that degree of improvement often follows a predictable course after 3-month follow-up. If myelopathy resolves even to a small extent during the first 3 postoperative months, later improvement will likely follow an upward course. Conversely, if myelopathy does not improve during the first 3 months, further improvement is much less likely.

This trend in neurologic improvement likely is directly related to degree of myelopathy before surgery. Patients with CSM generally experi-

ence symptoms over an extended period and try conservative management before any surgical consultation. Although spinal ischemia is often resolved by decompression, permanent ischemic damage to the cord is not uncommon. In this setting, postoperative neurologic improvement is minimal or even nonexistent, and decompression is preventive rather than curative. In our study, 1 patient had no subjective improvement after surgery. At 3-month follow-up, magnetic resonance imaging showed notable myelomalacia without residual spinal cord compression. We attribute the failure of the ischemic changes to resolve to long-standing preoperative damage to the cord. Nevertheless, surgery stabilized the myelopathy and prevented further ischemic damage and clinical deterioration.

As is the case with any operation, patients must be carefully selected for CAPDF. Indications for CAPDF, as described by Kim and Alexander,[7] include acute spinal trauma, post-laminectomy kyphosis, kyphotic deformity with intact posterior tension band, multilevel spondylosis and OPLL, and preexisting risk factors for pseudarthrosis. Clearly, the severity of each varies, and the pathologies are not mutually exclusive. We emphasize that these indications provide only a guideline for performing CAPDF, and patients must be selected on a case-by-case basis. All the patients in our study were symptomatic and exhibited significant compression of the spinal cord anteriorly and posteriorly at multiple levels. Several presented with concomitant pathologies, such as cervical kyphotic deformity, congenital spinal stenosis, and OPLL. In each case, the indication for surgical intervention was undoubted. We sought both to improve the patient's baseline symptoms and to prevent further damage to the spinal cord.

This study had its limitations. First, its retrospective design predisposed it to a higher degree of bias. Second, because CAPDF is not commonly performed, the sample size was relatively small. Third, although it provided a descriptive analysis of CAPDF for CSM, the study did not use a direct comparison group to establish whether treatment within a single day or staged treatment was more beneficial for our cohort in particular. On the basis of prior experience and observation, we think performing the operation within a single day is much more beneficial for the patient. Our discussion of studies that have compared same-day and staged surgery supports this observation. Therefore, staged treatment was not recommended to our patients.

Conclusion

Few descriptive studies have explored CAPDF for CSM. Our study's results showed the procedure was associated with minor complications and provided symptomatic relief for a majority of patients as early as 3 months after surgery. In addition, CAPDF can be successfully performed sequentially within a single day. As such, it represents an excellent option for treating multilevel symptomatic CSM cases that require more extensive spinal decompression and more stability.

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