

Single-stage Anterior and Posterior Fusion Surgery for Correction of Cervical Kyphotic Deformity Using Intervertebral Cages and Cervical Lateral Mass Screws: Postoperative Changes in Total Spine Sagittal Alignment in Three Cases with a Minimum Follow-up of Five Years

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Abstract

The surgical treatment of cervical kyphotic deformity remains challenging. As a surgical method that is safer and avoids major complications, the authors present a procedure of single-stage anterior and posterior fusion to correct cervical kyphosis using anterior interbody fusion cages without plating, as illustrated by three consecutive cases. Case 1 was a 78-year-old woman who presented with a dropped head caused by degeneration of her cervical spine. Case 2 was a 54-year-old woman with athetoid cerebral palsy. She presented with cervical myelopathy and cervical kyphosis. Case 3 was a 71-year-old woman with cervical kyphotic deformity following a laminectomy. All three patients underwent anterior release and interbody fusion with cages and posterior fusion with cervical lateral mass screw (LMS) fixation. Postoperative radiographs showed that correction of kyphosis was 39° in case 1, 43° in case 2, and 39° in case 3. In all three cases, improvement of symptoms was established without major perioperative complications, solid fusion was achieved, and no loss of correction was observed at a minimum follow-up of 61 months. We also report that preoperative total spine sagittal malalignment was improved after corrective surgery for cervical kyphosis and was maintained at the latest follow-up in all three cases. The combination of anterior fusion cages and LMS is considered a safe and effective procedure in cases of severe cervical kyphotic deformity. Preoperative total spine sagittal malalignment improved, accompanied by correction of cervical kyphosis, and was maintained at last follow-up in all three cases.

Key words: cervical spine, kyphosis, alignment, correction

Introduction

Cervical kyphosis can be associated with many symptoms because of structural deformity or neural compression. This deformity, particularly in severe or progressive cases, can result in persistent neck pain, horizontal visual impairment, swallowing dysfunction, and social impairment.¹⁾ Myelopathy may arise because of spinal canal stenosis or a bowstring effect associated with structural malalignment.¹⁾

The surgical treatment of cervical kyphotic deformity remains challenging. Correction of cervical kyphotic deformity has been described using multilevel anterior decompression and fusion with plating, posterior correction

and fusion, or combined anterior-posterior approaches. These methods are technically demanding, and major complications and perioperative mortality have been reported.^{2–6)} As a surgical method that is safer and avoids major perioperative complications, the authors present a procedure consisting of single-stage anterior and posterior fusion to correct cervical kyphosis using anterior interbody fusion cages and cervical lateral mass screws (LMSs) for posterior fusion without anterior plating. Three etiologically different consecutive cases are reported. There is a paucity of literature concerning this surgical method and the change in total spine sagittal alignment following cervical kyphosis corrective surgery. We report that preoperative total spine sagittal malalignment was improved following corrective surgery for cervical kyphosis

and was maintained till the last (minimum of 5 years) follow-up in all three cases.

Case Reports

I. Case 1

A 78-year-old woman presented with a dropped head caused by cervical spine degeneration. Severe cervical kyphosis resulted in persistent neck pain, dysphagia, and difficulty with forward gaze. A plain radiograph in a neutral position revealed a 43° kyphosis of C2–C7 Cobb angle (Fig. 1a), and the kyphotic angle changed to 25° in extension and 53° in flexion. There were no symptoms of

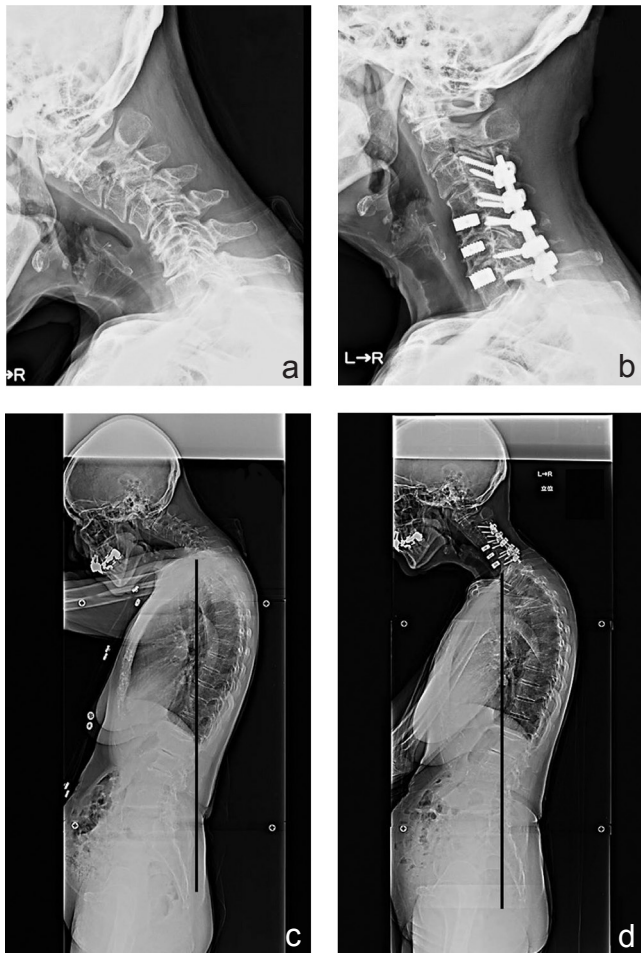


Fig. 1 a: Plain lateral radiograph of the preoperative cervical spine showing 43° kyphosis (C2–C7 Cobb angle). b: Plain lateral radiograph of the postoperative cervical spine showing 4° kyphosis at the level of C2–C7; a correction of 39° was achieved. c: Plain lateral radiograph of the preoperative total spine; C7 plumb line was displaced posteriorly, and SVA was –56 mm. d: Plain lateral radiograph of the postoperative total spine; C7 plumb line was shifted anteriorly, and sagittal alignment approached neutral balance. SVA was diminished to –4 mm. SVA: sagittal vertical axis.

neurological dysfunction in the trunk and in the upper or lower extremities. An electromyogram of her posterior paraspinal and sternocleidomastoid muscles revealed normal findings.

This patient underwent simultaneous single-stage anterior and posterior surgery with intraoperative neuromonitoring using motor-evoked potentials (MEPs) and electromyography. Anterior release, discectomies, and interbody fusion were performed using titanium cages with cancellous iliac bone graft at C4–C5, C5–C6, and C6–C7. In this case, cervical kyphosis was relatively rigid, and we considered that anterior release and discectomies at 3 levels was necessary to achieve the correction angle. After anterior surgery, posterior fusion using C3–C7 LMS fixation was performed using a cancellous bone graft from the iliac crest, and the rod system was fixed while adjusting the correction angle under intraoperative radiographic control. The operation time was 455 minutes, and the intraoperative bleeding was 620 ml. No perioperative complications occurred. All symptoms improved postoperatively. Cervical spine alignment improved to 2° kyphosis (C2–7 Cobb angle); a 40° correction was achieved immediately after surgery, and maintained (3° kyphosis: C2–7 Cobb angle) at the last (66 months) follow-up (Fig. 1b). The Neck Disability Index (NDI; a symptom-specific questionnaire for neck pain⁷⁾) improved from 42% (preoperatively) to 14% (postoperatively), and the 11-point Numerical Rating Scale ([11-point NRS]; pain intensity score from 0 = “no pain” to 10 = “pain as bad as you can imagine”⁸⁾) improved from 7 (preoperatively) to 1 (postoperatively).

The pre- and postoperative total spine sagittal alignments were assessed using lateral whole-spine standing radiographs. Her preoperative posteriorly displaced C7 plumb line (negative sagittal balance) was shifted anteriorly after surgery, and it approached neutral balance. The distance between the C7 plumb line and the superior posterior corner of S1 (sagittal vertical axis, SVA) was –56 mm preoperatively and –4 mm postoperatively (Fig. 1c, d), indicating an improvement of the total spine sagittal alignment that was maintained at the last (66 months) follow-up.

II. Case 2

A 54-year-old woman with athetoid cerebral palsy since birth presented with cervical kyphosis associated with progressive cervical myelopathy. Severe cervical kyphosis resulted in persistent neck pain and difficulty with forward gaze. A plain radiograph in a neutral position revealed a 35° kyphosis of C2–C7 Cobb angle (Fig. 2a); there was remarkable instability and spondylolisthesis at C4–C5. The kyphotic angle changed to 18° lordosis in extension and 47° in flexion. This patient underwent simultaneous single-stage anterior and posterior surgery with intraoperative neuromonitoring using MEPs and electromyography.

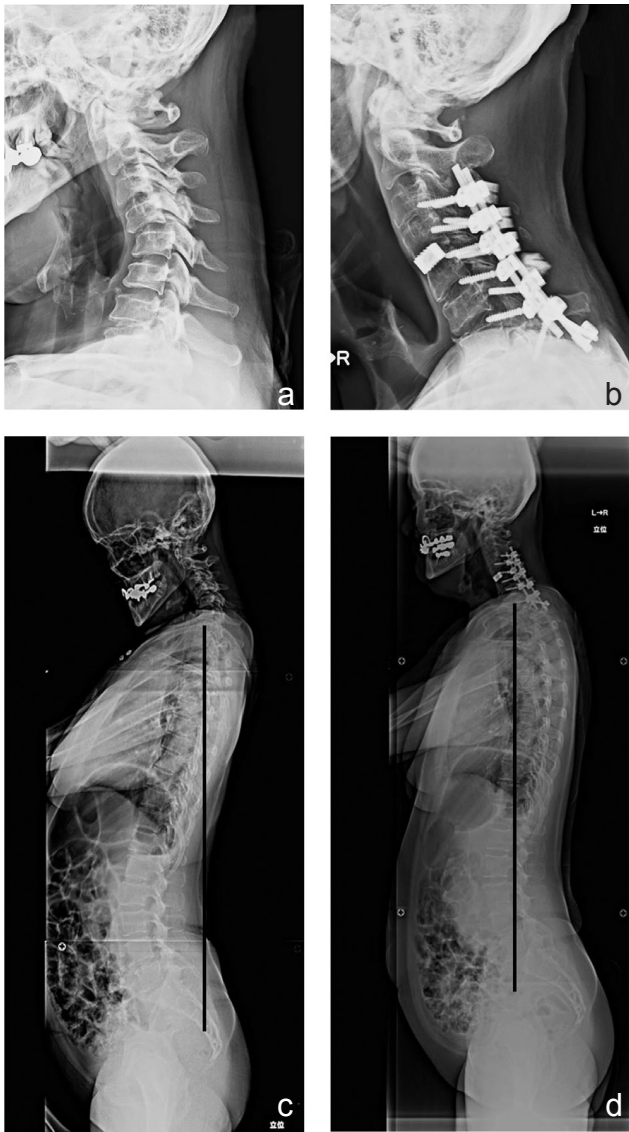


Fig. 2 a: Plain lateral radiograph of the preoperative cervical spine showing 35° kyphosis (C2–C7 Cobb angle). b: Plain lateral radiograph of the postoperative cervical spine showing 8° lordosis at the level of C2–C7; a correction of 43° was achieved. c: Plain lateral radiograph of the preoperative total spine; C7 plumb line was displaced posteriorly, and SVA was –50 mm. d: Plain lateral radiograph of the postoperative total spine; C7 plumb line was shifted anteriorly, and sagittal alignment approached neutral balance. SVA was diminished to 0 mm. SVA: sagittal vertical axis.

Anterior release and interbody fusion were performed using a titanium cage with cancellous iliac bone graft at C4–C5. In this case, cervical kyphosis was relatively flexible at C4–5 level, and we considered that the anterior release of discs at 1 level was sufficient to achieve the correction angle. After the anterior procedure, posterior decompression with double-door laminoplasty and posterior fusion was performed using LMS with cancellous

bone graft from the iliac crest at C3–C7 level, and the rod system was fixed while adjusting the correction angle under intraoperative radiographic control. The operation time was 401 minutes, and the intraoperative bleeding was 815 ml. No perioperative complications occurred, and all preoperative symptoms improved.

The sagittal balance of the cervical spine improved to 8° lordosis (C2–7 Cobb angle), and a 43° correction was achieved immediately after surgery, and maintained (8° lordosis: C2–7 Cobb angle) till the last (65 months) follow-up (Fig. 2b). NDI improved from 40% (preoperatively) to 28% (postoperatively), and the 11-point NRS improved from 8 (preoperatively) to 2 (postoperatively). Myelopathy symptoms, as assessed by the Japan Orthopedic Association (JOA) score (severity score of cervical myelopathy),⁹⁾ improved from 7.5 points (preoperatively) to 12.5 points (postoperatively).

Her preoperative posteriorly displaced C7 plumb line was shifted anteriorly, and it approached a neutral balance (C7 plumb line moved anteriorly) postoperatively, improving the total spine sagittal alignment. The SVA was shortened from –50 mm (preoperatively) to 0 mm (postoperatively) (Fig. 2c, d). The normalization of the total spine sagittal alignment was maintained at the last (65 months) follow-up.

III. Case 3

A 71-year-old woman presented with cervical kyphotic deformity (C2–C7 Cobb angle: kyphosis 23°) after a laminectomy for cervical spondylotic myelopathy (Fig. 3a). The kyphotic deformity was relatively rigid and changed from 19° in extension to 26° in flexion.

Severe cervical kyphosis resulted in persistent neck pain, dysphagia, and difficulty with forward gaze. Myelopathic symptoms were progressive, and the patient underwent surgery using a simultaneous single-stage posterior–anterior–posterior approach, taking into account the severe spinal cord compression (decompression is necessary prior to corrective procedures to avoid further deterioration of myelopathy) and rigidity of her kyphotic deformity, with intraoperative neuromonitoring using MEPs and electromyography. A posterior procedure was performed, including decompression of the dural tube with excision of the laminectomy membrane, C3–C6 LMS insertion, and T1–T5 pedicle screw insertion. After the posterior procedure, anterior release, discectomies, and interbody fusion using interbody fusion cages with cancellous iliac bone graft were performed at C3–C4, C4–C5, C5–C6, and C6–C7. In this case, cervical kyphosis was rigid, and we considered that anterior release of the discs at 4 levels was necessary to achieve the correction angle. Finally, screws were connected to a rod system at the C3–T5 level via a posterior approach, and rod system was fixed while adjusting the correction angle under intraoperative radiographic control. Operation time was 663 minutes, and intraoperative bleeding was 1,925 ml. No major



Fig. 3 a: Plain lateral radiograph of the preoperative cervical spine showing 23° kyphosis (C2–C7 Cobb angle). b: Plain lateral radiograph of the postoperative cervical spine showing 16° lordosis at the level of C2–C7; a correction of 39° was achieved. c: Plain lateral radiograph of the preoperative total spine; C7 plumb line was significantly displaced posteriorly, and SVA was –115 mm. d: Plain lateral radiograph of the postoperative total spine; C7 plumb line was shifted anteriorly, and SVA was shortened to –58 mm. SVA: sagittal vertical axis.

perioperative complications occurred, and all preoperative symptoms improved.

The sagittal balance of the cervical spine improved to 19° lordosis (C2–7 Cobb angle), a 42° correction was achieved immediately after surgery, and the alignment was maintained (16° lordosis: C2–7 Cobb angle) at the last follow-up (61 months) (Fig. 3b). NDI improved from 68% (preoperatively) to 32% (postoperatively), and the

11-point NRS improved from 8 (preoperatively) to 3.5 (postoperatively). The myelopathic symptoms in her JOA score improved from 8.5 points (preoperatively) to 10.5 points (postoperatively).

Her preoperative posteriorly displaced C7 plumb line moved anteriorly, and it approached a neutral balance postoperatively. The SVA was –115 mm preoperatively and –58 mm postoperatively (Fig. 2c, d). Although total spine sagittal balance was not corrected perfectly postoperatively, improvement in the total spine sagittal alignment (C7 plumb line anterior movement of 57 mm) was achieved and maintained at the last follow-up (61 months).

Discussion

The following three approaches are suitable for surgical correction of a cervical kyphotic deformity: anterior, posterior, and combined anterior and posterior surgery.

Several studies have reported the use of anterior approaches for decompression and reduction of cervical kyphotic deformity. However, the anterior-only approach is limited by high rates of complications in multisegmental constructs using plates,^{10–12} including pseudoarthrosis, graft subsidence, graft dislodgement, dysphasia, airway edema requiring extended or repeat intubation, and vocal cord paresis. Sasso et al. reported a 71% reconstruction failure rate after three-level anterior cervical fusion using plates.¹¹

In the posterior-only approach, mild degenerative kyphosis can be corrected using posterior cervical instrumentation [cervical pedicle screw (CPS) fixation];¹³ however, it is limited to flexible kyphosis. Moreover, CPS placement is technically demanding because of the potential risks of vertebral artery and neural injury.

A combined anterior and posterior fusion approach using anterior plates for cervical kyphotic deformity provides good maintenance of sagittal alignment and a high fusion rate.^{2–6} However, this surgical method is invasive and is associated with major perioperative complications and mortality. The overall complication rates were 27–69%.^{2–6} Schultz et al. reported that almost all perioperative complications were related to the anterior portion of the procedure during combined cervical fusion surgery. The authors consider that minimizing the anterior procedure prevents perioperative complications.¹⁴

In anterior cervical fusion surgery, the use of an interbody fusion cage lowers the risk of complications compared to a strut iliac bone graft.¹⁵ Interbody fusion cages offer several theoretical advantages over bone fusion with or without a plate, including maintenance of a constant height, a lower profile than plates, and diminishing donor site morbidities. An interface with the esophagus that is common to all plate devices

and may provoke dysphagia is not observed with the cervical cage, which is recessed below the vertebral surface.¹⁵⁾ The authors consider that using interbody cages is also advantageous for avoiding airway edema that may require extended or repeated intubation because of its low profile property. We harvested only cancellous iliac bone graft in this case series; however, harvesting autogenous strut-graft from the iliac crest can be associated with significant blood loss and also with postoperative pain at the graft site. Sawin et al. found a 25.3% morbidity rate that included pain, hematoma, fracture, and meralgia paresthetica.¹⁶⁾

In patients with anterior column support, the safety and efficacy of LMS have been reported.¹⁷⁾ In a cadaveric biomechanical load study,¹⁸⁾ there was no significant difference in posterior instrumentation (C3–C7 LMS) versus posterior and anterior (plating) instrumentation. This report concluded that rigidity imparted to the cervical spine by C3–C7 LMS fixation is not augmented by adding anterior plates. A combination of anterior fusion cages and LMS insertion may be a safe and effective procedure for cervical kyphotic deformity correction.

The major advantage of single-stage anterior and posterior surgery versus staged surgery is that the single-stage procedure provides immediate rigid stabilization of the cervical spine, even in severe cases needing substantive kyphotic deformity correction.^{2,3,6,14)} The disadvantages of single-stage combined surgery are greater invasiveness, longer operation time, and greater blood loss. Single-stage circumferential fusion is considered effective for severe cervical kyphotic deformity in cases that are acceptable in terms of operative invasiveness.

Few studies have reported the change in total spine sagittal alignment after surgery for cervical kyphosis correction. Sagittal balance of the thoracolumbar spine was improved by correction of the cervical kyphotic curve in this case series. In all three cases, preoperative C7 plumb lines were displaced posteriorly. The authors suggest that the sagittal malalignment of posterior displacement of the C7 plumb line exists as a compensatory sagittal curve in patients with severe cervical kyphosis before treatment, and that improvement of total spine sagittal alignment occurs postoperatively through correction of the cervical kyphotic deformity. Potter et al. reported that a normal SVA value is a distance of ± 3 cm.¹⁹⁾ In Cases 1 and 2, negative imbalance of total sagittal spinal alignment was present preoperatively and was improved postoperatively; SVA was within the normal range. In Case 3, although total spine sagittal balance was not corrected perfectly, improvement in the total spine sagittal alignment (C7 plumb line anterior movement of 57 mm) was achieved. Additionally, we report that improvement of total spine alignment can be maintained throughout a minimum 5-year follow-up.

Conflicts of Interest Disclosure

The authors have no potential conflict of interest to report relevant to this article. The authors have no relevant financial relationships to disclose.

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