ORIGINAL ARTICLE

 Decompressive Cervical Laminectomy and Lateral Mass Screw-Rod Fusion for Multisegmental Cervical Spondylotic Myelopathy with Flexible Sagittal Cervical Alignment

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Abstract

Background data: Posterior cervical laminectomy and lateral mass screw-rod fusion techniques were classically recommended in flexible sagittal cervical alignment relying on indirect decompression via posterior cord shift.

Purpose: This study aims to investigate the efficacy of posterior cervical laminectomy with lateral mass screw-rod fixation for treating multisegmental cervical spondylotic myelopathy (MCSM) with flexible sagittal cervical alignment.

Study design: This was a prospective clinical cohort study.

Patients and methods: In total, 38 patients with clinically symptomatic MCSM with instability and/or flexible kyphosis were admitted to our Zagazig University hospitals for posterior cervical laminectomy and lateral mass screw-rod fusion (long-segment instrumented fusion ≥ 3 segments) and completed the 24-month follow-up period between April 2014 and June 2018, and the last follow-up visit took place in October 2020. Patients were categorized into lordotic, straight, and kyphotic groups according to the shape of the cervical spine curve on a neutral lateral radiographic view.

Results: A total of 266 lateral mass screws were inserted in 134 levels in 38 patients (three levels in 20 patients, four levels in 16 patients, and five levels in two patients); all the patients had a good fusion, and the cervical spine was stable, based on the absence of hardware failure or subsidence. All 38 (100%) patients gained more lordosis with a variable degree according to the preoperative cervical sagittal alignment. The mean percentage of neck pain improvement according to the visual analog scale for the lordotic group was 69.1%, for the straight group was 43.8%, and for the kyphotic group was 15.8%. The mean percentage of neurological function improvement (Japanese Orthopedic Association score) for the lordotic group was 83.17%, for the straight group was 43%, and for the kyphotic group was 17%. The mean percentage of disability improvement (Neck Disability Index score) for the lordotic group was 47.66%, for the straight group was 24.5%, and for the kyphotic group was 16.66%.

Conclusion: Decompressive cervical spine laminectomy with lateral mass screw stabilization is effective in treating MCSM with flexible sagittal cervical alignment (2022ESJ259).

Keywords: Cervical myelopathy, Decompressive laminectomy, Lateral mass fusion, Spinal fixation

Introduction

Spondylosis is defined as ‘vertebral osteophytesis secondary to degenerative disc disease.’ Spondylosis is a natural process of aging and is therefore seen in 95% of individuals by the age of 65 years [1–3]. Cervical spondylotic myelopathy (CSM) is the most common cause of neurological spinal impairment in people over 55 years of age [4,5].

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To date, there is a continuous debate regarding the optimal approach for handling multilevel CSM. Operative management in patients with CSM aims to decompress the spinal cord, restore sagittal alignment, and stabilize the spine. The anterior, posterior, and combined approaches have advantages and disadvantages specific to each case of CSM [6].

Anterior cervical disectomy and fusion (ACDF) surgery is still one of the best options for cervical spondylosis when disk herniation or spondylosis is limited to the disk level; however, it does not adequately decompress the posterior intervertebral foramen. Although multilevel ACDF or anterior corpectomy can correct in a limited way the local kyphosis, both have a high incidence of cord injury, cerebrospinal fluid leakage, implant complications, dysphagia, pseudoarthrosis, grafted bone extrusion and subsidence, and adjacent segment disease [1,7,8].

Posterior cervical laminectomy and lateral mass screw-rod fusion techniques became one of the most common procedures of posterior cervical fusion worldwide and were classically recommended in flexible sagittal cervical alignment relying on indirect decompression via posterior cord shift [9].

To date, the optimal surgical approach and procedure for managing multisegmental cervical spondylotic myelopathy (MCSM) with kyphotic deformity remains controversial because of the shortcomings of each surgical approach. This prospective study aimed to investigate the efficacy of posterior cervical laminectomy with lateral mass screw fixation for treating MCSM with flexible sagittal cervical alignment.

**Patients and methods**

A total of 42 patients with clinically symptomatic MCSM with instability and/or flexible kyphosis were admitted to our hospital for posterior cervical laminectomy and lateral mass screw-rod fusion (long-segment instrumented fusion ≥3 segments). All of the included patients fulfilled the inclusion criteria for this prospective observational study based on their preoperative and postoperative clinical and radiological data. Patients were treated at the Orthopaedic Department of Zagazig University Hospitals in Egypt between April 2014 and June 2018, and the last follow-up visit took place in October 2020. Only outcome data of patients, who completed at least 24 months of follow-up, were analyzed.

The inclusion criteria were as follows: patients with (a) clearly documented physical examination findings consistent with progressive myelopathy or myeloradicalopathy, (b) a history of disability that limited everyday activity and work, (c) failed to improve on nonoperative measures for at least a 3-month period, (d) radiographic (MRI) confirmation of cord compression at three or more cervical levels, and (e) flexible kyphotic or straight sagittal alignment with evidence of instability. The exclusion criteria were as follows: patients with (a) inability to give informed consent, (b) stenotic single level, (c) patients whose presenting complaint was axial neck pain alone, (d) traumatic fractures, (e) tumor, (f) metabolic disorders, (g) fixed kyphotic deformity, and (h) previous anterior cervical spine procedures.

In total, 30 men and 12 women aged from 45 to 71 years (mean of 63.1 ± 5.8 years) participated in the study. The duration of the preoperative symptoms ranged from 12 to 36 months, with a mean duration of 29.86 ± 5.5 months. All patients underwent a trial of nonsurgical treatment in the form of limited duty, NSAIDs, muscle relaxants, neurotrophic drugs, opioid analgesics, and a comprehensive course of 20 sessions of physiotherapy (mean of the duration of nonsurgical treatment: 9.6 ± 2.6 months). The number of levels involved in cervical laminectomy and fusion ranged from two to five levels, with a mean of 3.5 ± 0.6 levels.

Determination of the general indications for surgery was made by two experienced spine surgeons who were not affiliated with the study to eliminate the selection bias. Only 38 patients who completed 24 months of follow-up were included in the final analysis of the study. All surgeries were performed by the authors, who have considerable experience in the surgical technique. All the participants gave their written consent in accordance with the Helsinki Declaration [10].

**Clinical evaluation**

A thorough medical history taking and any known medical conditions were documented. Complete general and neurological examinations were performed preoperatively and postoperatively for all the patients. Patients were categorized into lordotic, straight, and kyphotic groups according to the shape of the cervical spine curve on a neutral lateral radiographic view.

Primary clinical outcome data were as follows [1]: visual analog scale (VAS) for neck pain where the worst imaginable pain takes 10 points, whereas no pain takes 0 points; [2]: Japanese Orthopedic
Association (JOA) score for neurological function (normal score $= 17$); and [3] Neck Disability Index (NDI) to measure activities of daily life (Score: $50$ transform to percentage score $\times 100 = \%$points) [11].

Secondary objective outcome data included the following: preoperative and postoperative radiographic evaluation, blood loss, length of hospital stay, time to return to work/activity, revision, and complication rate.

**Radiographic evaluation**

The outcomes for standard lateral standing radiographs for preoperative and postoperative assessment of the quantity of the cervical sagittal alignment were as follows. Preoperative radiographic dynamic views were used to evaluate the flexibility and stability of cervical spine alignment. $C_2$–$C_7$ Cobb’s angle and supplemented with the modified Toyama method [12,13] were used to describe the shape of the cervical sagittal alignment (A line was drawn from the posterior and inferior part of the vertebral body of $C_2$ to the upper posterior part of the vertebral body of $C_7$) (Fig. 2). A lordotic curve was present if the posterior wall of the vertebral bodies of $C_3$–$C_6$ was anterior to this line. The cervical spine was considered straight if the posterior part of the vertebral bodies of $C_3$–$C_6$ was on that line, and it was kyphotic if the posterior part of the vertebral bodies was posteriorly projected to this line. The modified Toyama method has been shown by Donk et al. [14] to be reliable, easily applied, and of utmost importance in surgical decision making when supplemented with other radiographic parameters. Signs of instability and flexibility were detected using dynamic radiographic views. Patients were categorized into lordotic, straight, and kyphotic groups according to the shape of the cervical spine curve on a neutral lateral radiographic view. We used preoperative radiographic dynamic views to evaluate the flexibility and stability of cervical spine alignment.

Computed tomography (CT) with sagittal reconstruction was used in patients where $C_7$ was invisible in plain radiographic radiographs and in patients with a kyphotic curve to identify ossified posterior longitudinal ligament. Preoperative MRI was performed for all patients to detect radiological signs of spondylotic myelopathy and other cord conditions such as diastematomyelia, syringomyelia, and tethered cord.

**Surgical technique**

Under general anesthesia and with the patient in a prone position, a posterior midline incision followed by a bilateral subperiosteal exposure was created to the lateral margins of the facet joints. Lateral mass screws entry points were marked, and trajectories were made before decompression. Moreover, the motion segments to be fused had their facet joints decorticated.

Laminectomy was then performed with a ‘no touch technique’ (no canal intrusion with instruments). The trough was cut through the outer cortical and cancellous layers of bone using a high-speed diamond-head burr. The final thin inner cortical bone was removed with a 1-mm Kerrison rongeur. The floating lamina was then carefully elevated off the dura with a Penfield dissector to separate adhesions between the ligament and dura.
In the cases where foraminal stenosis was causing radiculopathy, foraminotomies were performed (Fig. 1a).

Afterward, screws were inserted (Fig. 1b, c), and the bicortical purchase was intended in cases with osteoporotic bone or when kyphotic deformity needing correction existed. Gentle compression between screws was applied when the more lordotic alignment was needed under fluoroscopic control. Another maneuver to adjust alignment was applying gentle traction and extension to the patient's head by a spine surgeon colleague. Morselized posterior elements will be placed over the decorticated lateral masses. The surgical wound was closed in layers, and a sterile dressing was applied.

**Postoperative care and follow-up**

After careful clinical examination, when patients voided and could walk independently, they were discharged in the company of a family member after receiving wound care and rehabilitation instructions. Patients were seen in the outpatient clinic after 2 weeks for a wound check. They were instructed to avoid strenuous activities during the first month after surgery.

Follow-up data were obtained from outpatient clinic visits by two independent physicians immediately postoperative, that is, day 1 (42 patients), 3 months (41 patients), 1 year (39 patients), and 2 years (38 patients). The remaining four patients were lost to follow-up because of surgery-unrelated death.

**Statistics analysis**

Change in outcome measures from the preoperative baseline and several points during the entire postoperative period was assessed using SPSS software, version 12.0.1 (SPSS Inc., Chicago, Illinois, USA). To compare continuous quantitative variables between the preoperative and postoperative at different times of follow-up, we used Student t tests (paired and independent-sample Student t test). A positive significance level was assumed at $P$ value less than 0.05. The percentage of change was calculated as follows: 

\[
\% \text{ of change} = \frac{\text{post value} - \text{pre value}}{\text{pre value}} \times 100.
\]

**Results**

A total of 266 lateral mass screws were inserted in 134 levels in this study (three levels in 20 patients, four levels in 16 patients, and five levels in two patients). All 38 patients showed neither intraoperative vascular injury nor neural injury or dural tears. Two lateral masses of two separate patients were skipped because of iatrogenic lateral mass fracture, a C3 lateral mass in one patient and a C6 lateral mass in the other one. Four pedicle screws were inserted in the T1 pedicles in both patients.

There were no severe complications, such as cord or nerve root injury, dural tears, or thrombosis. The overall complication rate for the three groups was 18.4%. Transient urinary retention developed in one patient and was relieved within 2 days postoperatively. Two diabetic patients had superficial wound infections. Overall, the complication rate was statistically insignificant in both groups ($P = 0.08$). Moreover, 4/8 patients lost all the corrected degrees of lordosis and gained more kyphosis [three patients due to backing out of C2, C5, and C6 screws (Fig. 2) and one patient due to the development of C2–C3 forward slipping].

Mean blood loss was $332.1 \pm 261.5$ ml, and the range was 50–1100. The mean length of hospital

![Fig. 2](image-url)
stay was 9.8 ± 3.6 days, and the mean time to return to work/normal activities was 9.3 ± 2.9 days. Almost 87% (86.8%) of the patients had complete satisfaction with the procedure and outcome and would undergo surgery again for the same condition.

Neck pain relief was statistically highly significant; 24 (63.2%) patients had improved VAS scores at 2-year follow-up. In total, 14 (36.8%) patients did not improve (six lost a few degrees of corrected lordosis in group S, and eight patients gained worse kyphosis in group K). The mean VAS score improved from 5.52 ± 1.03 to 2.97 ± 1.93, with a mean difference of 2.55 ± 1.7 (P < 0.001). The percentage of improvement was 46.19% (Table 1).

For the lordotic (L) group, the mean VAS score significantly improved from 4.88 ± 0.83 preoperatively to 3.59 ± 0.53 and 3.08 ± 0.9 immediately postoperatively and 24-month follow-up, respectively, with a mean difference of 1.27 ± 0.35 (P < 0.001) and 3.08 ± 0.35 (P < 0.001), respectively. The percentage of improvement was 43.8% (Table 1).

For the straight (S) group, the mean VAS score significantly improved from 5.75 ± 0.70 preoperatively to 3.16 ± 0.71 and 3.08 ± 0.90 immediately postoperatively and 24-month follow-up, respectively, with a mean difference of 2.33 ± 0.65 (P < 0.001) and 2.41 ± 1.37 (P < 0.001), respectively. The percentage of improvement was 43.8% (Table 1).

For the kyphotic (K) group, the mean VAS score significantly improved from 6.33 ± 0.88 preoperatively to 4.25 ± 0.62 immediately postoperatively, with a mean difference of 2.08 ± 0.66 (P = 0.000), and insignificantly changed to 5.33 ± 2.49 at 24-month follow-up, with a mean difference of 1.00 ± 2.13 (P = 0.132). The percentage of improvement was 15.8% (Table 1).

Neurological function improvement of the three groups collectively was statistically highly significant; 100% of patients showed JOA improvement in the immediate postoperative period and then decreased significantly to 81.6% (31/38) of patients at the final follow-up (P < 0.001) owing to the negative effect of the kyphotic group on the general mean of the three groups. There was a statistically significant improvement in JAO score from 7.44 ± 1.28 to 11.36 ± 3.87 at the 24-month follow-up, with a mean difference of 3.92 ± 2.89 (P < 0.001). The percentage of improvement was 53% (Table 1).

For the lordotic (L) group, the mean JOA score significantly improved from 8.50 ± 0.51...
preoperatively to 12.42 ± 1.01 and 15.57 ± 1.08 immediately postoperatively and 24-month follow-up, respectively, with a mean difference of 3.92 ± 1.14 (P < 0.001) and 7.07 ± 1.26 (P < 0.001), respectively. The percentage of improvement was 83.17% (Table 1).

For the straight (S) group, the mean JOA score significantly improved from 7.75 ± 0.62 preoperatively to 10.91 ± 1.31 and 11.08 ± 1.67 immediately postoperatively and 24-month follow-up, respectively, with a mean difference of 3.16 ± 1.02 (P < 0.001) and 3.33 ± 1.72 (P < 0.001), respectively. The percentage of improvement was 43% (Table 1).

For the kyphotic (K) group, the mean JOA score significantly improved from 5.91 ± 0.90 preoperatively to 7.33 ± 1.07 and 6.91 ± 1.72 immediately postoperatively and 24-month follow-up, respectively, with a mean difference of 1.41 ± 0.79 (P < 0.001) and 1.00 ± 1.20 (P = 0.015), respectively. The percentage of improvement was 17% (Table 1).

The disability improvement was statistically highly significant. According to the NDI score, 34 (89.5%) patients showed improvement of at least one grade. Preoperatively, there were two (5.3%) patients with complete disability, eight (21.1%) patients with severe disability, 22 (57.9%) patients with moderate disability, and six (15.8%) patients with mild disability, which changed postoperatively to be as follows: 13 (34.2%) patients had no disability, 16 (42.1%) patients had mild disability, six (15.8%) patients with moderate disability, and three (7.9%) patients had severe disability.

Overall, there was a statistically significant improvement in the NDI score of disability percentage for the three groups from 41.36 ± 12.33% preoperatively to 29.73 ± 16.46% (P < 0.001) at 24-month follow-up, with a mean difference of 11.63 ± 9.97% (P < 0.001). The percentage of improvement for the three groups was 28.1% (Table 1).

For the lordotic (L) group, the mean NDI score significantly improved from 30.57 ± 2.97% preoperatively to 23.00 ± 3.21 and 16.00 ± 1.75% immediately postoperatively and at 24-month follow-up, respectively, with a mean disability improvement difference of 7.57 ± 9.97 (P < 0.001) and 14.57 ± 2.76% (P < 0.001), respectively. The percentage of improvement was 47.66% (Table 1).

For the straight (S) group, the mean NDI score significantly improved from 38.16 ± 5.74% preoperatively to 27.83 ± 2.37 and 28.25 ± 7.55% immediately postoperatively and at the 24-month follow-up, respectively, with a mean disability improvement difference of 10.33 ± 3.39 (P < 0.001) and 9.33 ± 7.20% (P < 0.001), respectively. The mean NDI score was insignificantly changed between that immediately postoperatively and at the 24-month follow-up (P = 0.656). The percentage of improvement was 24.5% (Table 1).

For the kyphotic (K) group, the mean NDI score significantly improved from 56.00 ± 9.22% preoperatively to 45.33 ± 6.73% immediately postoperatively and insignificantly improved to 46.66 ± 17.25% at the 24-month follow-up. The mean disability improvement difference was 10.66 ± 5.14% (P < 0.001) and 9.33 ± 12.65% (P = 0.027), respectively. The percentage of improvement was 16.66% (Table 1).

In patients who could not maintain the postoperative corrected lordosis till the end of the follow-up period (18 patients) and shifted back to the shape of the preoperative cervical kyphotic alignment, there was an insignificant difference between the preoperative and postoperative functional conditions.

Radiological outcome

A solid fusion mass was seen on both sides of the cervical spine in all patients during follow-up radiographs except those who had lost their degrees of correction in the straight and kyphotic groups; we used a postoperative CT scan to confirm nonunion. We chose positive angulation to indicate lordosis and negative angulation to represent kyphosis. For all patients, the mean preoperative Cobb angle was +0.36 ± 13.09°, ranging from +16° to −20°. All the patients (100%) gained more lordosis postoperatively with a mean Cobb angle equal to +9.94 ± 13.50° immediately postoperatively with a significant increase in lordosis with +9.57 ± 2.51° (P<0.001) and remained stable till the 6-month follow-up (+9.89 ± 13.44°) with insignificant change (+0.05 ± 0.32°; P = 0.324). By the 12-month follow-up, there was a significant decrease in lordosis with −2.10 ± 3.39° (P<0.001) and remained stable till the 24-month follow-up (+7.44 ± 16.24°; P = 0.156) (Table 2).

The lordotic (L) group included 14 (36.84%) patients who showed lordosis according to the modified Toyama method preoperatively and Cobb angle more than +10°; the mean preoperative Cobb angle for this group was +14.71 ± 1.54° (range, +10° to +16°). All the patients (100%) gained more lordosis postoperatively with a mean Cobb angle equal to +24.00 ± 1.46° immediately postoperatively with a
significant increase in lordosis with +9.28 ± 1.38° (P<0.001) and remained stable till the end of 24-month follow-up (+23.92 ± 1.38°) with an insignificant change of +0.07 ± 0.61° (P = 0.336) (Table 2).

The straight (S) group ranged between slightly kyphotic (−10°) to slightly lordotic (+10°) curves. It included 12 (31.57%) patients that showed flexible straight sagittal alignment according to the modified Toyama method preoperatively. The mean preoperative Cobb angle for this group was −0.75 ± 6.36° (range, −8° to +8°). All the patients (100%) gained more lordosis postoperatively with a mean Cobb angle equal to +10.75 ± 5.37° immediately postoperatively with a significant increase in lordosis with +11.50 ± 2.81° (P<0.001). By 6–12 months of follow-up, there was a significant loss of lordosis by −2.25 ± 2.89° (P = 0.021) to +8.50 ± 7.36° (Table 2).

The kyphotic (K) group included 12 (31.57%) patients that showed kyphotic sagittal alignment according to the modified Toyama method preoperatively and Cobb angle more than −10°, and the mean preoperative Cobb angle for this group was −15.25 ± 2.00° (range, −12° to −20°). All of the patients (100%) gained more lordosis immediately postoperatively with a mean Cobb angle equal to −7.25 ± 2.66° with a significant increase in lordosis with +8.00 ± 2.04° (P<0.001). By the 12-month follow-up, the degree of the corrected lordosis became statistically insignificant as the loss of the corrected lordosis was −5.83 ± 3.27° and the mean Cobb angle became −13.08 ± 4.52° (P = 0.087) and remained stable till the end of follow-up (−13.66 ± 4.79°; P = 0.171). The change between the preoperative and 24-month follow-up scores was statistically insignificant (P = 0.187) (Table 2). Moreover, all the patients in the K group [100% (12/12)] gained more lordosis by +8.00 ± 2.04° (P<0.001) and were shifted to the S group immediately postoperatively. However, only 30.3% (4/12) remained corrected till the end of the follow-up in spite of losing 3–5° of the corrected lordosis. In contrast, 66.7% (8/12) lost all the corrected degrees of lordosis by the end of the follow-up, with 4/8 patients returning to the preoperative level of kyphosis and 4/8 patients losing all the corrected degrees of lordosis and gaining more kyphosis: three patients due to backing out of C2, C5, and C6 screws (Fig. 2) and one patient due to development of C2–C3 forward slipping (Fig. 3). We found a strong correlation between the ability to maintain the postoperative corrected lordosis till the end of the follow-up period (21 patients) and the preoperative lordotic sagittal alignment.

**Discussion**

Multilevel CSM is a complex cervical spine disorder characterized by multilevel spinal cord compression caused by degenerative changes in every cervical spine component, ultimately producing myelopathy and radiculopathy [1,4,15,16]. The decision-making process of MCSM surgeries depended on several factors: the number of stenotic levels, the site of the main offending pathology, the preoperative shape of the sagittal cervical alignment, and the ability to correct a straight or mild kyphotic sagittal cervical alignment, which is usually considered crucial for successful posterior decompression and posterior cord shift [9]. Therefore, in our study, we used preoperative radiographic dynamic views to evaluate the flexibility and stability of cervical spine alignment.

![Fig. 3. (A) Early postoperative radiograph with slightly kyphotic alignment without C2–C3 translation, (B) 1-year follow-up with C2–C3 forward slippage and increase of C2–C7 kyphosis, and (C) 2-year follow-up showing no progress in kyphosis or C2–C3 instability.](image-url)
As lordosis is the natural shape of the sagittal cervical alignment, the restoration of lordosis is an essential goal of most CSM surgeries, as increasing evidence suggests that neurological outcomes, quality of life, and the rate of adjacent segment degeneration are optimized with the establishment of cervical lordosis [17–20]. Gore et al. [21] found that normal cervical lordosis range to be 15°–25° in females and 16°–27° in males in 200 asymptomatic volunteers.

In our study, we supplemented the Cobb method with the modified Toyama method for an easier description of the cervical sagittal alignment. It was clearly shown that the Cobb method or Harrison posterior tangent method [16] did not reflect the actual cervical sagittal alignment as this angle could be nearly zero or even positive, indicating a straight or even a lordotic spine. In contrast, the vertebral bodies in between C3–C6 contributed to a true cervical kyphosis [14]. Bartels et al. [12] modified the method of Toyama et al. [13] using the relation between the dorsal components of C3–C6 and the same line between C2 and C7 but with the exclusion of the measurements to be more practical and reproducible.

The results of our study concurred with Hamanishi and Tanaka [22], who considered a minimum lordosis of 10° required for adequate posterior cord shift, and with Benzel [23], who defined an effective cervical lordosis as the configuration where no dorsal component of C3–C7 crosses a line from the posterior caudal corner of C2 to an identical point on C7. In our study, we found a strong correlation between the ability to maintain the postoperative corrected lordosis till the end of the follow-up period (21 patients) and the preoperative lordotic sagittal alignment. This may be proved by the superior results of the lordotic group over the other two groups. In those patients, we also noticed a significant improvement in the functional outcome. However, in patients who could not maintain the postoperative corrected lordosis till the end of the follow-up period (18 patients) and shifted back to the shape of the preoperative cervical kyphotic alignment, there was an insignificant difference between the preoperative and postoperative functional conditions.

Postoperatively in our study, all the patients in the L group [100% (14/14)] gained significant lordosis by a mean of +9.28 ± 1.38° (P<0.001) and remained stable till the end of the follow-up. Moreover, all the patients in the S group [100% (12/12)] gained more lordosis by +11.50 ± 2.81° (P<0.001); however, only 58.33% (7/12) of the patients were shifted to the L group and remained stable till the end of the follow-up, whereas 41.7% (5/12) of the patients lost a few degrees (range 2–4°) of the corrected lordosis by the 12 months of follow-up and remained within the confines of the S group. However, this mean loss (−2.25 ± 2.89°) was statistically significant (P = 0.021). Moreover, all the patients in the K group [100% (12/12)] gained more lordosis by +8.00 ± 2.04° (P<0.001) and were shifted to the S group immediately postoperatively. However, only 30.3% (4/12) remained within the confines of the S group till the end of the follow-up in spite of losing 3–5° of the corrected lordosis. In contrast, 66.7% (8/12) lost all the corrected degrees of lordosis by the end of the follow-up, with 4/8 patients returning to the preoperative level of kyphosis and remaining stable till the end of the 24-month follow-up with no added kyphosis, and 4/8 patients lost all the corrected degrees of lordosis and gained more kyphosis (three patients due to backing out of C2, C5, and C6 screws and one patient due to development of C2–C3 forward slipping).

According to our postoperative results, the lordotic group had the best mean percentage of neck pain improvement (NRS), neurological function improvement (JOA score), and disability improvement (NDI score).

We theoretically attributed the marked improvement of the clinical outcome in all the patients of final cervical lordosis alignment and the ability to retain the corrected degrees of lordosis till the end of the follow-up to the inherent preoperative strength of the posterior neck muscles that maintained stability and flexibility and facilitated the ability to gain more lordosis by a mean of 23.9%, so that the cervical sagittal alignment had fallen in the

### Table 2. Preoperative and postoperative change in Cobb angle in three groups of patients.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Preoperative Cobb’s angle</th>
<th>Day 1 postoperative</th>
<th>6-month follow-up</th>
<th>12-month follow-up</th>
<th>24-month follow-up</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>L group</td>
<td>+17.44 ± 2.95°</td>
<td>+21.27 ± 2.44°**</td>
<td>+21.27 ± 2.44°</td>
<td>+21.16 ± 2.28°</td>
<td>+21.16 ± 2.28°</td>
<td>0.000</td>
</tr>
<tr>
<td>S group</td>
<td>−0.38 ± 7.76°</td>
<td>+8.62 ± 4.03°***</td>
<td>+8.50 ± 3.89°</td>
<td>+8.37 ± 3.85°</td>
<td>+6.00 ± 2.82°</td>
<td>0.011</td>
</tr>
<tr>
<td>K group</td>
<td>−16.83 ± 2.28°</td>
<td>−11.41 ± 6.63°***</td>
<td>−11.58 ± 6.51°</td>
<td>−13.16 ± 6.11°</td>
<td>−13.75 ± 6.48°</td>
<td>0.074</td>
</tr>
</tbody>
</table>

Difference between day 1 postoperative and 24-month postoperative follow-up means of the L group was statistically insignificant: *P = 0.163. Difference between day 1 postoperative and 24-month postoperative follow-up means of the S group was statistically significant: **P = 0.006. Difference between day 1 and 24-month postoperative follow-up means of the K group was statistically insignificant: ***P = 0.069.
normal range of cervical lordosis. Meanwhile, the patients in the straight and kyphotic groups had weaker posterior neck muscles and tended to lose postoperative instrumented lordosis as the whole burden of postoperative stability is solely thrown over lateral mass screws but proving this clinically was beyond the scope of this study.

One of the shortcomings of our study is the relatively small number of patients, as a large number of patients magnifies the outcome parameters, but this may be due to the strict following of the inclusion criteria for enrollment of patients in this study and the relatively rare nature of the MCSM with flexible sagittal cervical alignment. Another shortcoming is the absence of a controlled group that would have suboptimal outcomes as, to date, there is a continuous debate regarding the optimal approach for handling multilevel CSM proven in the literature by several studies [1,6–8]. Although multilevel ACDF or anterior corpectomy can correct in a limited way the local kyphosis, both have a high incidence of cord injury and do not adequately decompress the posterior intervertebral foramen, cerebrospinal fluid leakage, implant complications, dysphagia, pseudoarthrosis, grafted bone extrusion and subsidence, and adjacent segment disease [1,6–8,24]. Consequently, we did not want our patients to experience unnecessary complications.

We suggest an explanation to our results in the form of the ‘motion segment degeneration triad’ theory for the failed spine. This triad comprises the disc, the facet, and the paraspinal muscles. As long as the injury is limited to one triad component, the cervical spine can withstand its physiological loads without pain or disability. This was proved by the results of a radiological study that found 20–30% of symptom-free persons have demonstrable cervical disc degeneration or herniation on MRI (one component), and in an age-matched, sex-matched, and risk factor-matched group, this ratio is even higher [25]. However, if two components are affected due to trauma, tumor, degeneration, or systemic disorder, both can compromise the third component and instability of the motion segment becomes inevitable.

Likewise, in a patient with MCSM with flexible sagittal cervical alignment in which the three components are affected to variable degrees, lordotic cervical alignment has the least degenerated components, straight cervical alignment has moderately degenerated components, and kyphotic cervical alignment has the most degenerated components. Failure of this triad means instability of the involved motion segments, which will be presented clinically by unfavorable radiological and clinical outcomes even after spinal fusion techniques (failed spine syndrome).

Conclusion
Decompressive cervical spine laminectomy and lateral mass screw-rod stabilization in patients with MCSM with flexible sagittal cervical alignment were effective in improving and maintaining cervical alignment with excellent functional outcome in patients with preoperative cervical lordosis, the good functional outcome in patients with preoperative straight cervical alignment, and fair functional outcome in patients with preoperative cervical kyphosis.

Ethical approval statement
In this study we followed the World Medical Association (WMA) Declaration of Helsinki — Ethical Principles for Medical Research Involving Human Subjects. All patients were consented for the surgical intervention along with a research consent for the publishing of the medical data. The study was approved by our IRB.

Conflict of interest
There are no conflicts of interest.

Abbreviation list
MCSM Multisegmental cervical spondylotic myelopathy
CSM Cervical spondylotic myelopathy
ACDF Anterior cervical discectomy and fusion
LSS Lumbar spinal stenosis
LBP Low back pain
LMF Lumbar multilidus
MD Mean difference
NRS Numerical rating scale
JOA Japanese Orthopedic Association
NSAIDs Nonsteroidal anti-inflammatory drugs
ODI Oswestry Disability Index
CT Computed tomography
MRI Magnetic resonance imaging
PLL Posterior longitudinal ligament

References


المتخصّص العربي

استعمال الصفّحة القلية الكاملة منصب على مقارنة التحسن من حالة الفقاري والغضروف في العنقين المزود والمستويات.

البيانات الخلفية

استعمال الصفّحة القلية الكاملة منصب على مقارنة التحسن من حالة الفقاري والغضروف في العنقين المزود والمستويات.

المرض والطريق

تمّ ترتيب ثمانية وثلاثين مريضاً بwagon من اعتراف الفقاري والغضروف في العنقين المزود والمستويات.

المصبحث بأعراض سريرية مع عدم الاستمرار أو الحجم المزود في مستشفى جمعية القارئ من أجل استخدام الصفّحة القلية الكاملة منصب على مقارنة التحسن من حالة الفقاري والغضروف في العنقين المزود.

المزود: جمع المرضى (38.1%) حيث نسبة المريض عند 12.3% بين أبريل 2014 ومارس 2018.

النتائج: تم إدخال إجمالي 66 من مساعدي الكتلة الجانبية في 134 مستند في 38 رمزًا (3 مستندات في 20 رمزًا، و 4 مستندات في 16 رمزًا و 5 مستندات في 8 رمزًا). وكان لدى جميع المرضى مفتاح الفقاري جيد وكان العضو الفقاري العنقين مثبتًا, بناءً على عدم وجود خلل أو حيوان أو كسر في الساقين أو الفقاري (المرسّد). المزود: جمع المرضى (38%) حيث نسبة المريض عند 12.3% بين أبريل 2014 ومارس 2018.

الخلاصة

استعمال الصفّحة القلية الكاملة منصب على مقارنة التحسن من حالة الفقاري والغضروف في العنقين المزود والمستويات المصحوب بأعراض سريرية مع عدم الاستمرار أو الحجم المزود.