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CLINICAL AND RADIOLOGICAL RESULTS OF LAMINECTOMY AND POSTEROLATERAL SCREW FIXATION IN THE TREATMENT OF CERVICAL SPONDYLOTIC MYELOPATHY

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ABSTRACT

Objective: The purpose of this study was to evaluate clinical and radiological findings related to the treatment of the patients with cervical spondylotic myelopathy (CSMP) in our medical center who underwent posterior cervical laminectomy and posterolateral fusion surgery with lateral mass screw fixation (LMSF).

Materials and Methods: In this study, the postoperative clinical and radiological results of 30 patients who underwent posterior laminectomy and posterolateral fusion surgery by a single spinal surgeon with the diagnosis of cervical spondylosis in our medical center between 2015 and 2019 were retrospectively evaluated.

Results: In total, 30 patients [23 males (76.7%) and 7 females (23.3%)] were included in the study, and the follow-up period was 6 to 44 months with an average of 21.2 months. In total, 91 laminectomies were performed on the cervical vertebrae of our patients. The mean diameter of the spinal canal in the narrowest place was 5.80 mm (9.6, 2.5) in the preoperative period, and 11.16 mm (13.6-9.4) in the postoperative period. In the postoperative period, an average of 1.35 mm (0.4-3.1) spinal cord shift was observed. The mean modified Japanese Orthopedic Association scores of all patients increased postoperatively to 15.2 (8-18) from the preoperative values of 12 (6-16). While mean preoperative Cobb angle in Group A was - 23.5º (-45º/-10º), mean postoperative Cobb angle was -9.8º (-34º/+15º). While mean preoperative Cobb angle in Group B was +13.8º (+3º/+33º), mean postoperative Cobb angle was +13.3º (+32º/-5º).

Conclusion: In the treatment of patients with CSMP, adequate spinal canal decompression is created with posterior laminectomy and the LMSF technique, and these provide sufficient neurological recovery and stability. Posterolateral stabilization can preserve cervical alignment in patients with lordotic spine alignment and prevent progressive kyphosis after laminectomy; however, if anterior osteophytosis is present in patients with a preoperative loss of lordosis or kyphotic alignment, this technique may not be suitable for ideal lordotic alignment.

Keywords: Cervical spondylotic myelopathy, posterolateral fusion, cervical alignment

INTRODUCTION

Degeneration of vertebrae, discs, uncinate, and facet joints in the cervical region with aging is called cervical spondylosis (CS). While narrowing in the spondylotic cervical canal statically damages neural structures and glial cells, axons become more vulnerable to secondary injury with repeated flexion and extension movement[1]. In addition, in the spondylotic process that develops with age, vertebral artery, anterior spinal artery, and radicular artery blood flows may decrease due to compression and cause ischemic damage[2,3]. CS myelopathy (CSMP) is the most common cause of non-traumatic spinal cord dysfunction in adults[4]. Although it has a wide clinical spectrum, limited spontaneous recovery is observed in patients, while a gradual clinical deterioration is generally observed[5,6]. The Nurick scale[5], the Harsh scale[7], the Cooper scale[8], the Prolo scale[9], and the Japanese Orthopedic Association (JOA)/modified JOA (mJOA) scales[10,11] can be used for clinical evaluations of CSMP patients.

Surgical treatment aims to correct spinal compression, correct sagittal alignment and stabilize the spine[12]. The preoperative cervical sagittal alignment, the location of the spinal cord compression, the number of compressing segments, and the comorbidities present in the patient are important in determining which surgical approach to use[12,13]. In patients with cervical disc hernia, osteophytes, or ossification of the posterior longitudinal ligament, anterior surgical approaches can be preferred because they facilitate the correction of kyphotic spine segments and result in less postoperative pain[12].

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However, if the myelopathy is caused by the compression of multiple spinal segments, posterior surgical approaches are more attractive because decompressing of three or more segments using long-level anterior corpectomies may lead to increased complication risks and fusion problems[14].

The purpose of our study was to evaluate clinical and radiological findings related to the treatment of CSMP patients in our medical center who underwent posterior cervical laminectomy and posterolateral fusion surgery with lateral mass screw fixation (LMSF).

MATERIALS AND METHODS

Study Population

This study was conducted upon receiving approval from the Ethics Committee for Clinical Studies of Ordu University (number: 2020/161). In this study, postoperative clinical and radiological findings of patients who underwent posterior laminectomy and fusion surgery by a single spinal surgeon in our hospital between 2015 and 2019 were retrospectively evaluated. Cases of CS with two or more levels of disc herniation from the anterior of the spinal cord and posterior longudinal ligament calcification as well as signs of compression of the spinal cord from the posterior were included in the study. At least two levels of laminectomy and three levels of lateral mass screws were applied to patients with kyphotic or lordotic spine alignment. Patients who underwent posterior decompression and fusion due to trauma or tumor were excluded from the study. In total, 30 patients (23 males, 7 females) were included in the study, and the follow-up period was 6 to 44 months (mean: 21.2 months). Informed consent was obtained from our patients for our study.

Surgical Technique

All cases were operated on in the prone position with a head holder after intubation. Paravertebral muscles were lateralized after the midline skin incision. A C arm was used for distance determination in operation. Then, the screws were placed at the required level using the Magerl technique (Osimplant, Turkey). Next, an extended laminectomy was performed using 1 and 2 mm Kerrison rongeurs, and the medial edges of the facet joints and neural foramen were decompressed (Figure 1). The lordotic inclined rods and screws were bilaterally stabilized. For fusion to the posterolateral side, the bones revealed by spinous process excision and laminectomy were mixed with synthetic graft and placed on the lateral side of the rods after decortication of the lateral masses. The wound was closed in layers in accordance with the anatomical position, and the patients were mobilized at the sixth postoperative hour. A cervical neck collar was used for six weeks.

Evaluations

Radiological Measurements

Neutral radiographs, dynamic radiographs, cervical computerized tomography (CT), and cervical magnetic resonance imaging (MRI) examinations were used for radiological evaluation. Cervical spine alignments were evaluated in terms of the Cobb angle. The calculations were obtained from vertical lines connecting the parallels drawn to the inferior end-plates of the C2 and C7 corpus (Figure 2). Lordotic angle values were evaluated as negative (-), and kyphotic angle values were evaluated as positive (+). Postoperative screw malpositions were evaluated with cervical CT. A mid-sagittal T2 cervical MRI was used for the narrowest location of the preoperative cervical canal and for postoperative enlargement of this region and enlargement of the anterior epidural space (Figure 3). In addition, each patient's lumbar spinal MRI was evaluated.

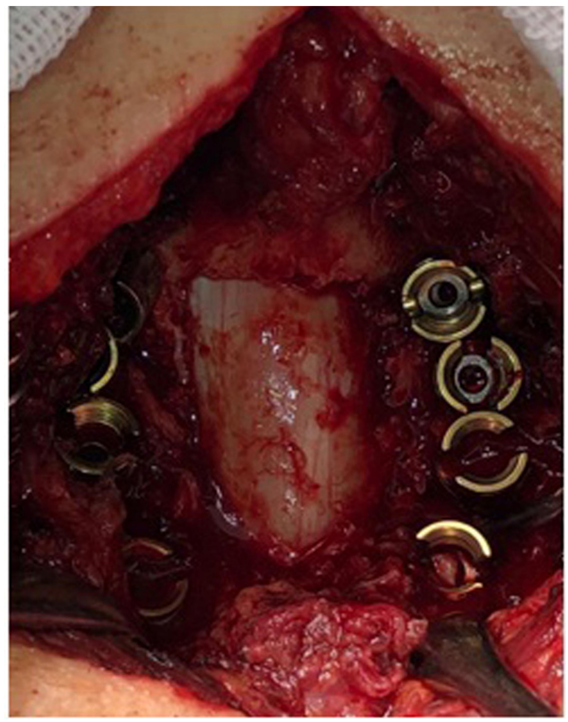

Figure 1. C4-C7 stabilization and decompressive laminectomy view

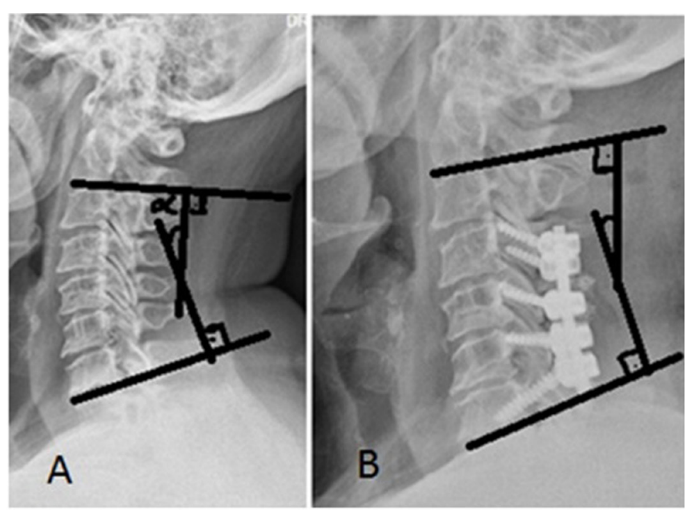

Figure 2A, B. Preoperative and postoperative Cobbs angle measurement method

Clinical Assessments

Clinical evaluations of the patients were compared according to the results of the mJOA (Table 1) and Nurick scales (Table 2) preoperatively and sixth months postoperatively. mJOA score improvements were calculated using the Hirabayashi method as follows: [(postoperative score - preoperative score)/(18-preoperative score)]x100.

Classifications

Those with preoperative lordotic spine alignment were classified as Group A, and those with kyphotic alignment were classified as Group B. Both groups were classified according to their postoperative cervical alignment, and these groups are indicated in Table 3.

Statistical Analysis

The data were analyzed statistically using the Statistical Package for the Social Sciences (IBM SPSS for Windows, V.24). Descriptive statistics for continuous variables, including mean and standard deviation, were calculated. Statistical analysis of all data was performed using the paired sample t-test. Continuous variables were presented as mean differences and 95% confidence intervals.

RESULTS

Patient Distribution Results

In total, 30 patients - 23 males (76.7%) and 7 females (23.3%) were included in the study, and the follow-up period was 6 to 44 months with an average of 21.2 months. The patients were between 40 and 80 years old (mean: 58.9), and 50% were between 50 and 59 years old. In total, 91 laminectomies were performed on the cervical vertebrae of our cases. The highest number of laminectomies were performed on the C5 vertebrae (27 cases) (Table 4).

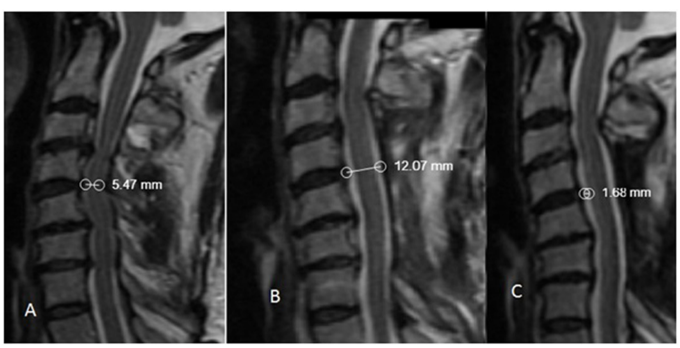

Figure 3. A) Narrowest canal diameter measurement in sagittal T2 MRI examination. **B)** Measurement of spinal canal diameter in postoperative sagittal T2 MRI examination. **C)** Measurement of the epidural distance formed in the postoperative sagittal T2 MRI examination.

Table 1. mJOA scale

Evaluation of upper extremities	
0	No movement in your hands
1	It moves your hands but cannot eat with a spoon
2	You can eat using it with a spoon, but it cannot button the dress buttons
3	Dress can button buttons with great difficulty
4	Dress can button buttons with slight difficulty
5	Normal, no disturbances
Motor-sensory evaluation of sub extremities	
0	Complete loss of motor and sensory functions
1	Sensory functions are preserved, but they cannot move their feet
2	It can move your feet but can't walk
3	Walking on flat ground with the help of a support (cane or walker)
4	With a support, the ladder can go up and down
5	There is moderate or severe instability during the walk, but the stairs can go up and down without support
6	It has a slight instability while walking, but it can walk without help
7	No dysfunction
Sensory evaluation of upper extremities	
0	Complete loss of sensation in the hands
1	There is severe sensory loss or pain description
2	Slight loss of sensation
3	Sensory loss does not describe
Evaluation of the sfincter function	
0	Not being able to urinate voluntarily
1	Significant difficulty in urinating
2	Mild or moderate difficulty urinating
3	Normal

mJOA: Modified Japanese Orthopedic Association

Table 2. Nurick scale

Grade 0	No myelopathy, minimal radiculopathy
Grade 1	There is myelopathy, walking is normal
Grade 2	There is mild to moderate myelopathy, walking is affected, it can work
Grade 3	Moderate myelopathy, impaired walking, independent at home but unable to work
Grade 4	There is moderate to severe myelopathy, the walker and someone's support are required
Grade 5	There is severe myelopathy, in a wheelchair

Results Associated with Sagittal Alignment

While the preoperative was -23.5° (-45° and -10º), the postoperatively mean angle was -9.8° (-34° and +15º). Postoperatively, 12 cases (70.6%) had lordotic cervical alignment, and 5 cases (29.4%) had kyphotic cervical alignment. In Group A, the diameter of the spinal canal measured from the narrowest part of the spinal cord was 5.3 mm (2.5-7.3 mm) on average. This value was measured as an average of 11.3 mm (10-12.9 mm) in Group AL and an average of 11.3 mm (9.7-13.6 mm) in Group AK (Table 5). The spinal canal diameters increased in both groups. An epidural cerebrospinal fluid gap was observed in postoperative MRI examination due to an average of 1.3 mm (0.4-3.1 mm) spinal cord displacement.

Table 3. Classifications of group A and B according to postoperative alignment

	Postoperative lordotic alignment	Postoperative kyphotic alignment
Group A	AL	AK
Group B	BL	BK

Table 4. Distribution of cases by age, gender and level of laminectomy

	n	%
Gender		
Male	23	76.7
Female	7	23.3
Age range		
40-49	4	13.3
50-59	15	50
60-69	6	20
70 ve >	5	5
Vertebral level undergoing laminectomy		
C1	1	3.3
C2	1	3.3
C3	14	46.7
C4	21	70
C5	27	90
C6	24	80
C7	3	10
Distribution of screws		
C1	2	0.8
C2	2	0.8
C3-6	211	80.8
C7	38	14.5
T1	6	2.3
T2	2	0.8

While the preoperative Cobb angle in Group mean B was +13.8° (+3° and +33º), the postoperative angle mean was +13.3° (+32° and -5º). Kyphotic alignment continued in 11 cases (84.6%), and lordotic alignment developed in 2 cases (15.4%). In Group B, the diameter of the spinal canal measured from the narrowest part of the spinal cord was 6.5 mm (4.9-9.6 mm) on average. This value was measured as an average of 11.5 mm (9.4-13.6 mm) in Group BL and an average of 10.9 mm (9.5-12.9 mm) in Group BK (Table 5). The spinal canal diameters increased in both groups. An epidural cerebrospinal fluid gap was observed in postoperative MRI examination due to an average of 1.4 mm (0.4-2.8 mm) spinal cord displacement.

While the mean diameter of the spinal canal in the narrowest place was 5.80 mm (9.6, 2.5) in the preoperative period, and 11.16 mm (13.6-9.4) in the postoperative period ($p<0.001$). In the postoperative period, an average of 1.35 mm (0.4-3.1) spinal cord shift was observed ($p<0.001$).

The cervical CT and dynamic radiographs of all cases showed that posterolateral fusion developed in the sixth postoperative month.

Clinical Evaluation

The mean mJOA scores of all cases increased postoperatively to 15.2 (8-18) from the preoperative values of 12 (6-16). The increase in the postoperative mJOA scores was statistically significant ($p<0.001$). The improvement in the mJOA scores was average 63.8 (17-100). The Nurick score for all patients was on average 2.4 (0-5) in the preoperative period, and this score decreased to an average of 1.1 (0-4) in the postoperative period ($p<0.001$).

The mean preoperative mJOA scores of 14 patients with postoperative lordotic sequence increased from 11.4 (6-16) to postoperative 14.7 (9-18). Improvement in the mJOA scores in these patients was average 64.8 (25-100). While the preoperative Nurick values of these cases were average 2.8 (0-5), they decreased to postoperatively to 1.4 (0-4) (Table 6).

Table 5. Preoperative and postoperative cobbs angle changes and spinal canal diameters of cases

	Preoperative		Postoperative			
Group	A	B	AL	AK	BL	BK
n, (%)	17 (56.7)	13 (43.3)	12 (70.1)	5 (29.4)	2 (15.4)	11 (84.6)
Cobbs angle	- 45°,-10°	+3°, +33°	-34°,-5°	+2°,+15°	-5°,-5°	+3°, +32°
Mean	-23.5°	+13.8°	-17.3°	+8.2°	-5°	+16.6°
Spinal canal diameter (mm)*	2.5-7.3	4.9-9.6	10-12.9	9.7-13.6	9.4-13.6	9.5-12.9
Mean	5.3	6.5	11.3	11.3	11.5	10.9

*= It is the diameter measured preoperatively and postoperatively from the narrowest segment of the spinal canal

Table 6. mJOA score, improvement in JOA score and nurick score according to the postoperative sagittal alignment

	Preoperative mJOA (mean)	Postoperative mJOA (mean)	Improvement %	Preoperative Nurick	Postoperative Nurick
Postoperative lordotic alignment (n=14)	11.4	14.7	64.8	2.8	1.4
Postoperative kyphotic alignment (n=16)	12.5	15.7	62.5	2.1	0.8

mJOA: Modified Japanese Orthopedic Association, JOA: Japanese Orthopedic Association

The preoperative mJOA scores of 16 patients with postoperative kyphotic alignment were average 12.5 (6-16). This value increased to 15.7 (8-18) in the postoperative period. The improvement in the JOA scores was average 62.5 (17-100). The preoperative Nurick values of this group decreased from 2.1 (1-5) to 0.8 (0-4) in the postoperative period (Table 6).

Complications

C5 nerve palsy was observed in two cases; the functional loss in shoulder abduction observed in these cases improved with physical therapy at the postoperative three-months control. Postoperative wound infection was seen in one case; the infection resolved with appropriate antibiotic therapy, and reoperation was not needed. As the left C5 lateral mass was broken while applying the lateral mass screw in one case, a screw was placed in that segment from one side. There was no problem in applying screws to the vertebrae above and below the fracture on the same side. No additional procedure other than synthetic graft was used for fusion. A unilateral C7 transpedicular screw was directed to the lateral of the vertebral corpus in two cases and to the spinal canal in one case. In one case, a unilateral T1 transpedicular screw was directed to the lateral of the vertebral corpus. Vertebral artery injury or loss of neurological function due to screw application were not observed in any of our patients. Therefore, no patients were reoperated on due to screw malposition.

A total of 261 screws were applied to the patients: 2 lateral mass screws to C1, 2 transpedicular screws to C2, 211 lateral mass screws to C3-6, 38 transpedicular screws to C7, 6 transpedicular screws to T1, and 2 transpedicular screws to T2 (Table 4). Lumbar spondylosis were accompanied in 21 cases (70%).

DISCUSSION

In the treatment of CSMP caused by the cervical narrow canal, it is essential to relax the spinal cord by expanding the spinal canal. Anterior, posterior, and combined approaches have been described for the surgical treatment of CSMP. Generally, the anterior approach is preferred in kyphotic cases, while the posterior approach is preferred in lordotic cases[12]. However, in some cases it may not be clear which surgical approach will be appropriate. As in all degenerative spine diseases, multilevel stenosis is observed in cases of CSMP; multilevel decompression with the posterior approach is becoming more common in these cases. Likewise, multilevel decompression with an anterior approach, especially in corpectomy operations, may not provide sufficient stability even if stabilization is included, and a need for posterior stabilization arises[14].

With the posterior surgical approach in CSMP treatment, adequate decompression can be achieved by performing posterior stabilization/fusion or laminoplasty after single-level multilevel laminectomies. Laminoplasty would be a good choice for multilevel CSMP cases with lordotic alignment[12,14,15]. Although laminoplasty provides adequate decompression in patients with kyphotic cervical spine alignment, it is not recommended because it cannot correct spine alignment. It has been reported that more kyphotic deformity develops in patients who underwent laminoplasty compared to patients operated on with an anterior approach[13,16,17]. Kim and Dhillan[18] proposed the application of fusion to reduce the risk of postoperative kyphotic deformity in patients with a loss of lordosis or kyphotic curvature. On the other hand, denervation, which occurs due to the stripping of deep extensor muscles, which is performed to provide the necessary surgical area for these approaches, is one of the common causes of a loss of lordosis after laminoplasty[19,20].

While adequate spinal canal decompression occurs with the posterior surgical approach, decompression only with laminectomy may cause segmental instability, kyphotic deformity, the emergence of perineural adhesions, and late neurological deterioration. Similarly, according to a study by Kaptain et al.[16], kyphosis may develop in 21% of patients undergoing laminectomy for CSMP, and pre- and postoperative alignment is not associated with clinical outcomes. On the other hand, adequate spinal canal decompression occurs with the posterior surgical approach, while the release of the posterior tension band increases the risk of kyphotic deformity depending on factors such as age, osteoporosis, degree of decompression, affected spine levels, and underlying pathological processes[21]. In addition, a postoperative loss of lordosis is due in part to straightening the neck during preoperative positioning. In order to prevent these adverse effects that may occur during the postoperative period, the application of fusion after posterior laminectomy has been recommended[22]. Stabilization created with posterior cervical screw fixation after laminectomy helps neurological recovery, and a cervical loss of lordosis can be prevented by strengthening the posterior tension band[23]. In addition, the large screw heads of the screws used in stabilization may prevent the necessary repositioning to ensure intraoperative sagittal alignment[24].

Posterior cervical screw fixation can be applied as transpedicular or LMSF[25-27]. It has been reported that with the application of cervical transpedicular screw fixation, the impaired cervical lordotic alignment will be improved by biomechanically stronger transpedicular screws[28]. However, the placement of transpedicular screws in the cervical region, the anatomically thin structure of the pedicles, their neurovascular neighbourhood, especially the need for an orientation of up to 45°, requires significant experience or technological support such as navigation guidance[29]. Neurovascular injury and other complications limit the use of this technique[30]. Although intraoperative CT applications have been described to reduce the complication rates of cervical transpedicular screw application, an increased cost and a high exposure to radiation are other important disadvantages[31,32].

Despite the biomechanical weaknesses of the LMSF technique compared to the stabilization systems made with transpedicular screws, it has also been reported that lordosis is preserved, especially in patients with lordotic spine sequences, and kyphotic deformity can be significantly reduced in patients with mild kyphotic sequences[33-35]. On the other hand, for the treatment of CSMP patients with advanced kyphotic angulation, fusion can be applied with multilevel corpectomy and/or decompression provided by osteotomies, which can be performed with combined anterior and posterior approaches. Although successful neurological recovery can be achieved with a combined approach, implant-related complication rates are especially high[36]. Cabraja et al.[24] found no difference in clinical improvement after anterior and posterior cervical decompression but reported less sagittal improvement in the posterior procedure than in the anterior procedure. From a clinical standpoint, it has been reported that better results were obtained in cases that included stabilization, regardless of the anterior or posterior approach[37].

It is known that the cervical spine undergoes a loss of lordosis during the degenerative process. This process, loss of disc height, osteophyte protrusions, arthrosis of facet joints, which turn into a vicious cycle in a cause-effect relationship, becomes relatively stable, and cervical spinal stenosis also occurs. However, the emerging spondylotic cervical spine, especially the strong fusion of spondylotic osteophytes located in the anterior area, may not be possible with a posterior approach alone to provide sagittal alignment with a stabilization application[3,38]. Therefore, although corpectomy/osteotomy techniques are recommended for better lordotic alignment, it should be known that the complication rates of these techniques are high. On the other hand, stabilization of the spine has been suggested for successful clinical results, regardless of the approach used[37]. Cheung et al.[39] demonstrated that the improvement in mean JOA scores was statistically significant after the third postoperative month, and the scores decreased in the sixth month. In our study, it was observed that the preoperative mean JOA score of our patients increased from 12 to 15.2 in the sixth postoperative month. It was seen that there was an average of 63.8% improvement in the JOA score. It was observed that the Nurick score of our patients decreased from 2.4 in the preoperative period to 1.1 postoperatively. Regardless of postoperative kyphotic or lordotic alignment, clinical improvement was observed in both conditions.

It has been reported that there is a relationship between clinical results and the ability to provide anterior and posterior subarachnoid distances in the sagittal MRI scans of patients who underwent laminoplasty[1]. Similarly, sagittal alignment can be corrected with LMSF after laminectomy, and excellent neurological recovery can be achieved by the posterior displacement of the spinal cord[27]. In our patients, it was observed that the spinal canal diameter expanded from 5.8 mm to 11.2 mm in the narrowest place after laminectomy, and sufficient decompression was observed. In addition, postoperative cervical MRI revealed an average epidural CSF distance of 1.35 mm in the anterior epidural space. Posterolateral bone fusion was observed in all our cases in the sixth postoperative month. No permanent neurological damage or vascular injury was observed due to the application of lateral mass or transpedicular screws. In our clinical follow-up, no increase in kyphotic deformities was observed.

In our study, it was observed that the lordotic alignment was preserved in 70.6% of the patients with preoperative lordotic spine alignment, and postoperative kyphotic alignment developed in 29.4% of the patients. In addition, it was observed that 84.6% of our patients with preoperative kyphotic spine alignment continued to have kyphotic alignment, and postoperative lordotic alignment was achieved in 15.4% of these patients. Although lordotic alignment could not be achieved in these cases, it was observed that there was no increase in kyphotic angulation in the clinical follow-up.

There are several possible reasons why lordotic alignment was not achieved in our patients with kyphosis. In the presence of anterior fusion caused by anterior osteophytosis accompanying kyphotic deformity, adequate correction strength may not be obtained with LMSF application. In addition, preoperative positioning to facilitate surgical exploration could not be corrected sufficiently postoperatively. The absence of lordotic alignment might have also been caused by the large screw heads preventing the manipulation required to insert the lordotic curved rod.

Study Limitations

This study has some limitations. Its retrospective nature and relatively low number of participants may decrease the scientific value of the study. In addition, this study was carried out by a single surgical team, and we only selected patients from our medical center. Therefore, prospective, large-scale, multicenter clinical trials are needed to further validate our results.

CONCLUSION

In the treatment of CSMP cases, adequate spinal canal decompression is created with posterior laminectomy and the LMSF technique, and these provide sufficient neurological recovery and stability. Posterolateral stabilization can preserve cervical alignment in patients with lordotic spine alignment and prevent progressive kyphosis after laminectomy; however, if anterior osteophytosis is present in patients with a preoperative loss of lordosis or kyphotic alignment, this technique may not be suitable for ideal lordotic alignment.

Ethics

Ethics Committee Approval: This study was conducted upon receiving approval from the Ethics Committee for Clinical Studies of Ordu University (number: 2020/161).

Informed Consent: Informed consent was obtained from our patients for our study.

Peer-review: Internally peer-reviewed.

Authorship Contributions

Concept: A.D., Design: A.D., Data Collection or Processing: D.O.K., Analysis or Interpretation: D.O.K., Literature Search: D.O.K., A.D., Writing: D.O.K.

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