Original Article

Changes in cervical sagittal alignment and the effects on cervical parameters in patients with cervical spondylotic myelopathy after laminoplasty

ABSTRACT

Objective: To monitor changes in cervical parameters before and after laminoplasty surgery. Cervical parameters and health-related quality-of-life (HRQOL) values that may be affected after laminoplasty were examined before and after surgery. The clinical and radiological course of these values was monitored, and their interaction with all spinal radiological parameters was revealed.

Materials and Methods: Nineteen patients who underwent clinical and radiological evaluation for 2 years were followed in this study. Neck disability index, visual analog scale, and short form 36 scores were determined to evaluate HRQOL. For radiological parameters, the C0-C2 angle, C2-C7 angle, cervical sagittal vertical axis, T1 slope angle, neck tilt (NT) and thoracic inlet angle were used. The results of the 4-month, 1 year and 2-year follow-ups were statistically evaluated.

Results: Both the HRQOL and cervical radiological parameters deteriorated in the first 4 months and returned to normal in the 2nd year. Statistically, all parameters were meaningful ($P < 0.05$), except for NT.

Conclusion: Cervical parameters and HRQOL values, which deteriorated in the early period, recovered in the late period in the long-term follow-up of patients undergoing laminoplasty. The important point is that preoperative cervical parameters suitable for laminoplasty should be present, and spinopelvic parameters should be normal.

Keywords: Cervical canal stenosis, cervical health-related quality-of-life, cervical parameters, cervical spondylotic myelopathy, laminoplasty

INTRODUCTION

Cervical canal stenosis due to cervical spondylosis is one of the most common causes of spinal cord compression. Laminoplasty is also one of the most commonly used surgical treatment methods. The greatest advantage of laminoplasty is that it protects the anatomy and movement of the neck and prevents the development of a postlaminectomy membrane. The greatest disadvantage of laminoplasty is neck pain that occurs after surgery, which is difficult to treat, and the subsequent decrease in health-related quality-of-life (HRQOL) scores. It is thought that this is due to instability caused by disruption of the posterior tension band.[1,2]

In this article, we tried to determine to what extent cervical parameters were affected early and late after laminoplasty by reviewing the literature.

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MATERIALS AND METHODS

In this study, cases diagnosed with cervical canal stenosis due to cervical spondylosis and expansive laminoplasty were

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evaluated. In this study, 19 cases with 2 years of radiological and clinical follow-up were included among 50 total cases.

Expansive laminoplasty was performed on the patients with a unilateral approach using a mini plate (i.e., open-door laminoplasty). The surgical technique can be found throughout the literature. The radiological and HRQOL scores of the patients were evaluated preoperatively and in the 4th month and 1st and 2nd years postoperatively. Two years is considered to be sufficient time for the spine to take its final shape.

The parameters that were examined on X-rays before and after the surgery were as follows: (1) C0–C2 angle: the angle formed between the McGregor line and the line passing through the lower margin of the C2 body; (2) C2–C7 lordosis: The angle between the tangent line passing through the lower margin of the C2 body and the tangent lines passing through the lower margin of the C7 body (Cobb method); and (3) sagittal vertical axis (SVA) (C2–C7 SVA): The distance between the C2 plumb line and C7; (4) neck tilt (NT): The angle between the vertical line drawn from the sternum and the line connecting the midpoint of the upper margin of the C7 body; (5) thoracic inlet angle (TIA): The angle between the vertical line drawn on the midpoint of the upper margin of the T1 vertebra and the line connecting this point to the sternum; and (6) T1 slope: The angle between the tangent line drawn on the upper margin of the T1 body and the vertical line that crosses this line passing through the midpoint of the upper margin of the T1 body. These measurements are labeled in Figure 1.

Pre- and post-operative lateral standing radiographic measurements were taken by using standard lateral cervical X-rays. The protocol is undertaken with the patients standing in a neutral position while looking straight ahead.

HRQOL measures, including the neck disability index (NDI), visual analog pain scale, and short form (SF) 36 physical component scores, were applied to the groups. Pearson product-moment correlation coefficients were calculated between pairs of radiographic measures and HRQOL scores.

The cervical sagittal sequences of the patients were evaluated by direct radiography taken preoperatively, 4 months after surgery, and 12 and 24 months later. Measurements were made by an independent observer using Surgimap.

Statistical analysis

The statistical analyses of the data obtained were evaluated with Minitab software (version 18; Minitab Ltd., Coventry, United Kingdom). In the comparisons between groups, whether there was a difference between the averages was tested with analysis of variance. For the significant "F" values, which groups were different from each other and what the source of this difference was between the groups were examined by postoperative comparison tests, including Tukey's honestly significant difference test. The results after the descriptive analysis are presented as the mean, standard error of the mean, standard deviation, minimum and maximum. Since the variables in the data obtained were obtained with a proportional or intermittent scale and were normally distributed, Pearson correlation analysis was performed. While all comparisons were reported with a 95% confidence interval, the alpha significance value was accepted as <0.05.

RESULTS

Of the 19 patients included in the study, 5 were female, and 14 were male, with an average age of 56.11. Preoperative X-rays of these patients and their HRQOL scores, including their NDI, Visual Analog Scale (VAS) and SF 36 scores, were evaluated. These scores were re-measured in the 4th month and 1st and 2nd years postoperatively, and the preoperative and postoperative values are given in Table 1.

While the preoperative VAS scores of the patients were 6.79 preoperatively, they decreased significantly to 2.95

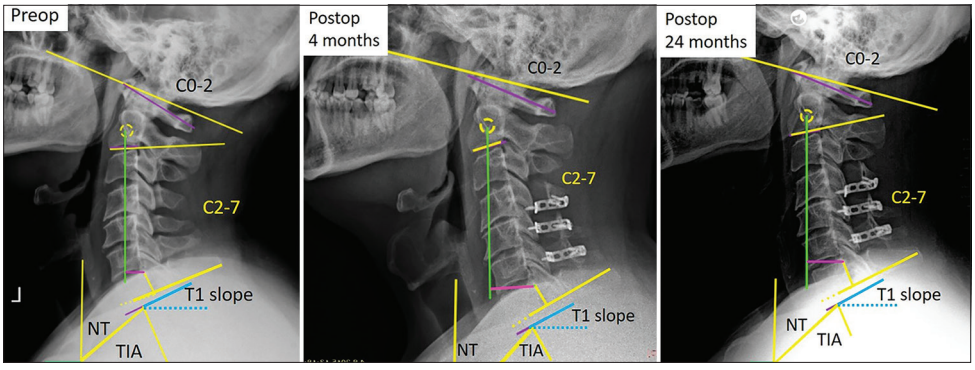

Figure 1: C0–2 angle, C2–7 angle, cervical sagittal vertical axis, T1 slope angle, neck tilt and thoracic inlet angle are labelled (patient 3)

Table 1: Health-related quality-of-life 2 years postoperative Visual Analog Scale, neck disability index and short form-36

VAS				NDI				SF-36 percentage physical function			
Preoperative	Postoperative 4 months	Postoperative 1 year	Postoperative 2 years	Preoperative	Postoperative 4 months	Postoperative 1 year	Postoperative 2 years	Preoperative	Postoperative 4 months	Postoperative 1 year	Postoperative 2 years
8	5	2	1	23	6	6	4	25	70	80	80
7	3	2	2	18	3	3	2	40	45	75	80
6	4	1	0	23	17	6	6	45	65	85	75
5	2	2	1	26	6	6	4	30	60	70	70
7	3	0	0	33	8	8	4	40	75	100	95
8	2	1	1	27	18	4	3	25	65	75	75
5	3	2	1	23	3	3	4	30	45	65	75
6	4	2	2	23	18	2	1	45	75	95	100
7	4	1	0	29	6	6	3	20	80	95	95
9	3	2	1	17	8	3	3	35	70	100	100
8	2	1	2	8	0	0	1	40	95	95	100
6	4	1	1	16	4	4	2	25	80	85	95
5	1	1	2	20	8	6	5	30	65	65	75
6	3	0	0	18	2	2	3	40	60	70	80
7	2	1	1	18	1	1	0	25	45	75	75
7	0	0	1	17	8	2	2	20	70	70	70
7	3	0	1	8	6	0	1	35	75	80	80
8	5	2	1	18	16	8	8	40	80	95	100
7	3	0	0	6	1	1	3	30	80	80	95
6.79	2.95	1.11	0.95	19.53	7.32	3.74	3.11	32.63	68.42	81.84	85.00

VAS - Visual Analog Scale, NDI - Neck disability index; SF-36 - Short form-36

in the 4th month and to 0.95 at the end of the 2nd year. The NDI decreased from 19.53 preoperatively to 7.32 in the 4th month and to 3.11 in the 2nd year. Despite the deterioration of the posterior tension band of the patients, quality of life improved significantly in the 2nd year. While the SF 36 scores were determined increase from 32.63 in the 4th month to 68.42, they reached 85.00 in the 2nd year. This shows that a 2-year period is important in terms of pain relief, and as with the NDI, pain decreases with time.

The radiological evaluation of the patients is reported in Table 2. In Table 2, the values before and 2 years after surgery were compared.

While the CO–C2 high cervical angle values of the patients were 15.15° preoperatively, they were 19.97° in the 4th month after surgery and 18.96° in the 2nd year ($P < 0.005$). The preoperative cervical lordosis C2–C7 angle was found to be 8.99; its value in the 4th month was 13.61°, and its value in the 2nd year was 12.66°. The results before surgery and the 4th month and 2nd year after surgery were statistically significant in terms of improvement ($P < 0.5$) [Figure 2]. Cervical SVA (cSVA), which is one of the most commonly used parameters, was 5.73 mm before surgery, 9.57 mm in the 4th month after surgery and 8.49 mm in the 2nd year after surgery. There was a statistically significant difference in this value ($P < 0.05$) [Figure 3]. While the T1 slope angle was 23.25° preoperatively, by the 4th month after surgery, it increased to 29.68°; that is, it recovered and was statistically significant ($P < 0.05$) [Figure 3]. NT values were found to be 46.23° in the preoperative evaluation, 43.12° after surgery and 44.47° in the 2nd year after surgery. A statistically significant difference was found ($P < 0.05$) [Figure 3]. The TIA value was determined to be 69.16° preoperatively, 69.14° in the 4th month after surgery and 69.15° in the 2nd year after surgery, and it was accepted as an unchanged parameter.

DISCUSSION

Laminoplasty is one of the most important methods in the treatment of spinal cord compression due to cervical canal stenosis. Its greatest advantage is that it preserves neck movement and prevents the formation of a postlaminectomy membrane. With the development of the laminoplasty technique, adjacent segment degeneration problems caused by fusion surgery have been reduced to a minimum.[3] However, the greatest problem is neck pain, which is resistant to conservative treatment after surgery. The deterioration of the posterior tension band and impairment of cervical sagittal alignment and the associated instability have been considered the causes of neck pain.[1,2] In addition, it has been stated that dissection of the muscles adhering to C2 and C7 depends on instability and causes neck pain.[4,5] Therefore, it is more appropriate to expand the canal by performing a partial mini laminectomy to C2 from the proximal side and to C7 from the distal side instead of laminoplasty that requires muscle dissection.

As a result of the disruption of the posterior tension band between C3 and C6 following laminoplasty, a deterioration in cervical parameters occurs in patients. This is evident in the 4th postoperative month in the controls. Recovery in the parameters is not very clear in the 1st year, but when the results of the 2nd year are examined, there is an obvious recovery in these values in all patients. HRQOL values follow the same pattern as the radiological parameters and also recover gradually throughout the process.

cSVA is an important parameter in the measurements of spine deformity. For the first 4 months, we observed that the cSVA increased and developed a flexion deformity. While the deterioration was worse in the 4th month than it was before surgery, we found that it recovered slowly by the 2nd year.

We found that there was an increase in the C0–C2 angle with the deterioration. An increased C0–C2 angle means that the patient was trying to look straightforward.

We found that if the T1 slope angle was large in a kyphotic thoracic spine, the angle C2–C7 also increased during the process in the horizontal plane. This assessment was consistent with the results of Patwardhan's cadaveric studies.[6] The T1 slope angle was followed the same trend as the cSVA value. The increase in the T1 slope angle in the 4th month recovered towards the 2nd year. In this context, NT recovered, though there was a small increase in the 4th month. Kim *et al*. stated that if the preoperative T1 slope angle was too high, the postoperative cervical lordosis angle was increased.[7] They stated that the T1 slope angle does not affect the angle of cervical kyphosis, but its relationship with spinopelvic parameters has not been evaluated.[7]

In these results, the TIA remained constant, and we determined that this angle did not change at all like the pelvic incidence, and it was considered a stable indicator.

In the NDI evaluation of the cases, we found that the deterioration in the cervical parameters in the early stage progressed in parallel with the compensation and that there was a significant improvement after 2 years. Considering the improvement in the VAS and SF 36 results, we found that HRQOL recovered significantly after 2 years. Our

Table 2: 2-year comparison of the radiological measurements of patients

Operated levels	C0-2 angle			C2-7 angle			Csva		
	Preoperative	Postoperative 4 months	Postoperative 2 years	Preoperative	Postoperative 4 months	Postoperative 2 years	Preoperative	Postoperative 4 months	Postoperative 2 years
C3-5	16.2	22.9	22.3	4.6	9.1	8.2	6.3	7.2	6.3
C3-6	19.4	25.1	23.4	6.2	8	7.3	5	18	15.2
C4-6	25.3	31.7	27	13	15.5	14.9	3.5	12.5	9.1
C5-7	12.4	20.3	19.5	6.8	13.1	12.8	7.8	11.7	11.4
C3-7	15.9	18.9	18.9	15.7	8.7	8.7	11	5.4	5.4
C4-7	17.5	22.1	21.6	7	14.2	13.8	8.4	14	13.4
C3-6	16.2	18.1	17.3	2.7	13.6	12.4	4.2	14.2	12.9
C5-7	17.3	19.7	18.9	8.3	19.9	17.9	4.7	9.6	6.9
C3-6	15.4	19.1	18.4	10.4	15.3	12.3	4.4	5	4.6
C4-7	12.3	18	17.7	11.8	13.9	13.2	3.5	9.1	8.6
C5-7	10.7	17.2	16.8	3.4	12.3	10.5	5.4	7.6	7.2
C4-7	13	25.8	25.4	16.1	18.9	18.4	4.3	5.7	4.8
C5-7	13.8	14.5	14.3	4.2	7.9	7.7	6.3	12.4	12
C4-7	13.6	17.8	17.5	12.5	19.2	19	5.3	3.6	3.3
C3-6	9.5	17.1	16.7	4.5	15.8	15.1	4.1	10	9.4
C4-6	14.5	17.7	17.2	22.8	21.5	21.1	7.7	8.2	7.9
C4-6	12.7	16.8	16.1	3	6.1	5.9	7.4	9.2	8.9
C3-6	18.2	23.5	18.7	10.5	17.8	13.8	4.3	9.3	5.1
C3-7	13.9	13.2	12.5	7.3	7.8	7.6	5.2	9.2	9
Mean	15.15	19.97	18.96	8.99	13.61	12.66	5.73	9.57	8.49
Operated levels	**T1 slope**			**Neck tilt**			**Thoracic inlet**		
	Preoperative	Postoperative 4 months	Postoperative 2 years	Preoperative	Postoperative 4 months	Postoperative 2 years	Preoperative	Postoperative 4 months	Postoperative 2 years
C3-5	12.7	15.2	13.2	44.8	42.5	43.9	55.1	55.6	55.3
C3-6	22.5	27.6	27	47.2	44.6	45.9	74.4	71.3	71.7
C4-6	25.8	28.4	27.8	49.5	41.2	45.3	72.6	70.1	69.9
C5-7	24.7	36.4	36	48.8	45.1	46.9	76.8	77	77.3
C3-7	23.3	30.6	30.6	47.5	46.5	46.5	78.8	76.1	76.1
C4-7	27.6	34.9	30.4	47.2	43.1	44.9	72.4	74.2	74
C3-6	18.4	23.6	21.8	49.2	43.9	45.8	74.3	73.9	74.6
C5-7	25.6	38.9	34.9	45.6	38.7	43.8	65.8	68.5	67.9
C3-6	20.1	23	22.4	43.1	39.7	41.9	72.5	73.7	73.6
C4-7	21.2	24.1	23.7	43.4	41	42.9	76.3	76.8	76.4
C5-7	27.7	34.9	34.8	45.9	44.2	44.7	66.3	66.1	66.6
C4-7	23.5	29.2	28.9	49.2	47.9	48.2	69.5	70.1	70.3
C5-7	24.8	39.9	39	49.1	45.1	45.9	71.8	68.3	71
C4-7	24.3	37.2	36.9	35.8	35.7	35.1	54.7	55.9	55.6

Contd...

Table 2: Contd...

Operated levels	T1 slope			Neck tilt			Thoracic inlet		
	Preoperative	Postoperative 4 months	Postoperative 2 years	Preoperative	Postoperative 4 months	Postoperative 2 years	Preoperative	Postoperative 4 months	Postoperative 2 years
C3-6	23.5	14.8	14.3	46.9	44.2	44.9	69.2	70.1	69.9
C4-6	25.3	30.8	30.4	43.8	42.1	41.8	58.4	59.9	59.2
C4-6	25.9	36.9	36.6	47.7	44.7	45.8	67.5	62.7	62.1
C3-6	22.5	27.8	24.5	48.4	45.2	47.4	67.5	70	69.2
C3-7	22.3	29.7	28.3	45.2	43.8	43.3	70.2	73.3	73.1
Mean	23.25	29.68	28.50	46.23	43.12	44.47	69.16	69.14	69.15

cSVA - Cervical sagittal vertical axis

results were compatible with the results published in the literature.[8]

In patients who underwent laminoplasty, we did not encounter serious cases of cervical deformity, as described by Matsuoka, after expansive laminoplasty.[9]

In patients with clinical signs of cervical stenosis and impaired cervical sagittal parameters, spinopelvic parameters are important. If spinopelvic parameters are also impaired, our primary choice for these patients is not laminoplasty. In our series, we think that this concept is the reason for cervical deformity after laminoplasty. It is theoretically known that deterioration in spinopelvic parameters affects the cervical spine. In patients where lumbar lordosis has disappeared, the head is pushed out of the pelvis under the effect of thoracic kyphosis. To provide a horizontal view, the angle C2–C7 increases, which means cervical lordosis increases. It is a fact that deterioration in thoracic parameters also affects the cervical spine and impairs cervical parameters. For example, as thoracic kyphosis increases, the T1 slope angle and associated cervical lordosis angle also increase.[10-16] In fact, first, the C0–C2 angle increases, and then the C2–C7 angle does.[17]

It is very unlikely that cervical pathology adversely affects all spinal parameters. In a human standing on two legs, a deformity in the pelvis affects the entire spine, and a deformity in the lumbar region affects the thoracic and cervical region. A thoracic deformity affects mainly the cervical spine. A developing deformity in the cervical region will affect the movements of the head. The chance of a cervical pathology affecting the entire spine may occur in very advanced deformities, such as drop head. In addition, it is unlikely that the entire spine will be affected by cervical pathology.[18,19] In other words, in the example given by Matsuoka, reducing the T1 slope angle corrects all spinopelvic parameters, and this is a controversial situation.[9] In such a patient, naturally, by performing lumbar or thoracic osteotomy, it will be a better choice for the improvement of cervical deformity.[20-22] In patients undergoing decompression and fusion due to cervical stenosis, it is very important to protect cervical parameters; otherwise, HRQOL can also cause serious disruption.[23]

In a patient with impaired spinopelvic parameters, as a result of the disruption of the posterior tension band due to laminoplasty, cervical parameters may be severely affected, and the probability of developing advanced deformities will be much higher. In contrast, in patients with normal spinopelvic parameters and normal or lordotic cervical

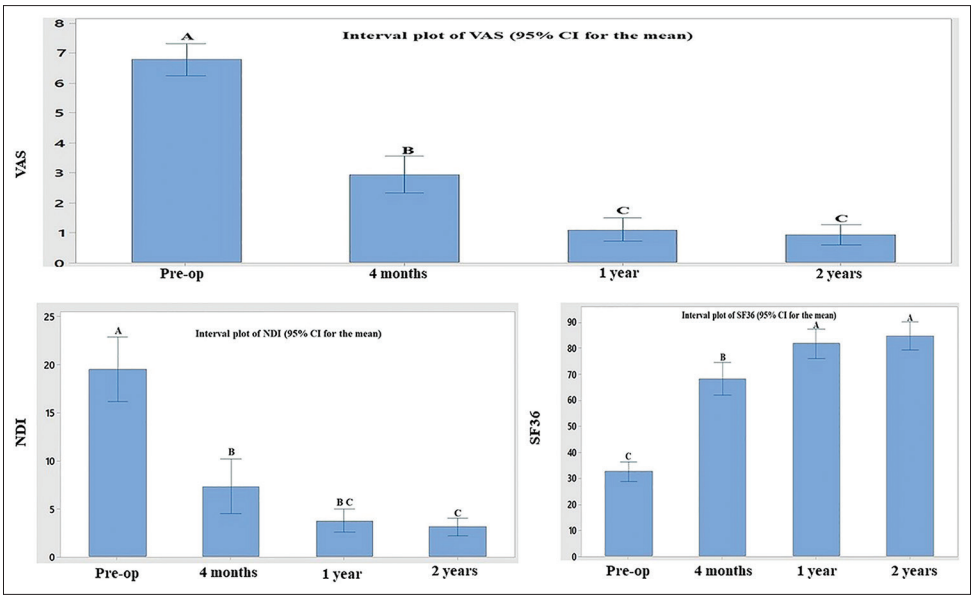

Figure 2: Health-related quality-of-life parameters: Visual Analog Scale, neck disability index, and short form 36 scores

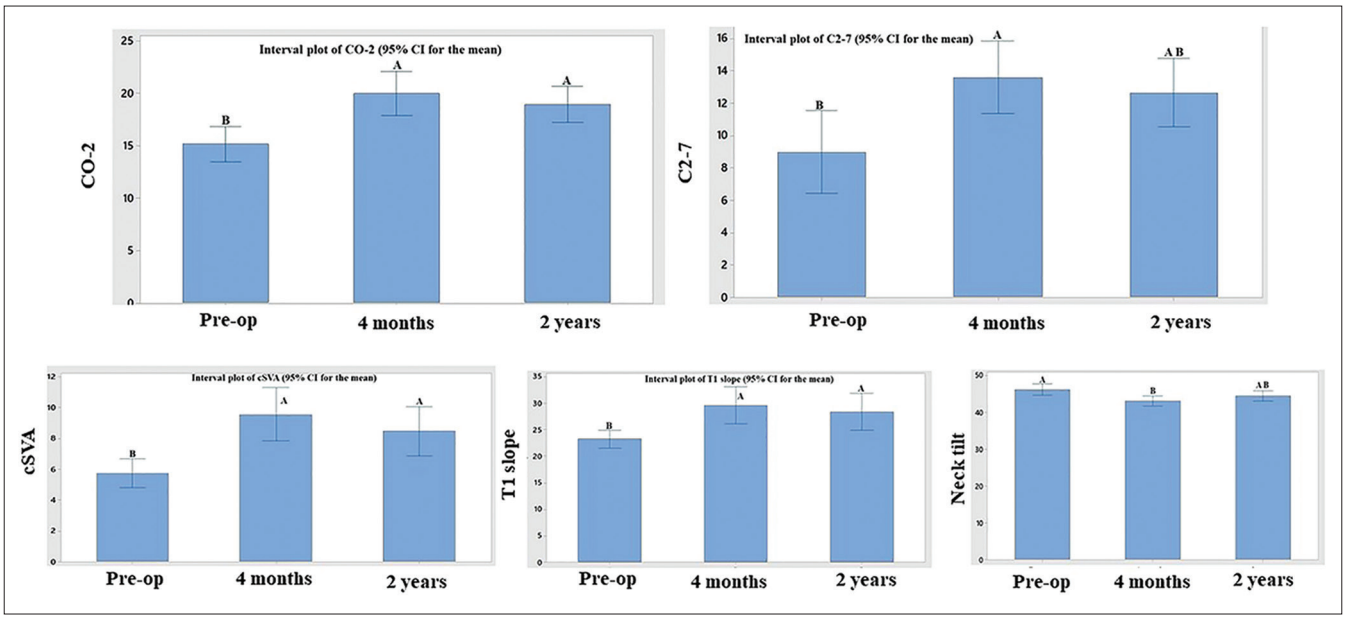

Figure 3: Cervical sagittal parameters: C0–2 angle, C2–7 angle, cervical sagittal vertical axis, T1 slope, neck tilt

alignment, laminoplasty is a much more suitable surgery. In our patient series, we found improvement in nearly all cervical parameters in most patients, as there was no progressive deformity.

As a result, the evaluation of all preoperative spinopelvic parameters of the patient is very important for a successful surgical outcome. Care should be taken to protect the muscles adhering to the C2 and C7 vertebrae during surgery. Otherwise, the deterioration in parameters may increase further, and HRQOL values may also be seriously affected. In appropriate cases, laminoplasty may cause some deterioration in cervical parameters, but this organism is very well tolerated when looking at its long-term results.

CONCLUSION

The cervical laminoplasty surgery technique is a motion-sparing surgical technique in cervical spondylomyelopathic patients whose cervical sagittal parameters are not severely damaged. Normal spinopelvic parameters are very important before surgery for a successful result. In the early postoperative period, some deterioration in the cervical sagittal parameters may occur as a consequence of disruption of the posterior

tension band; accordingly, there may be some distortion in HRQOL. Neck pain is the most obvious symptom that occurs in this period. However, over time, improvement in these clinical disorders recovered in parallel with radiological improvement. Our results need to be supported by a larger series.

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Conflicts of interest

There are no conflicts of interest.

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