Radiological Examination of Postoperative Cervical Alignment and Stability in Patients with Dialysis-Associated Spondylosis Excluding Destructive Spondyloarthropathy: Comparison with Patients with Cervical Spondylotic Myelopathy

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Abstract:

Introduction: Several reports have demonstrated the surgical treatment strategy for patients with dialysis-associated spondylosis in the cervical spine (CDAS) with destructive spondyloarthropathy (DSA). However, studies focusing on the clinical outcome of patients with CDAS without DSA remain scarce. We aimed to review the treatment strategy of patients with CDAS but without DSA.

Methods: The clinical data and surgical records of consecutive patients with CDAS without DSA (n = 9; D-group) and cervical spondylotic myelopathy (CSM) (n = 30; C-group) who underwent modified double-door laminoplasty(DDL) were reviewed retrospectively. We investigated four radiologic factors in the pre-and postoperative periods that have been reported to be the risk factors for worsening of clinical symptoms in various studies and examined statistical comparison between the D and C groups.

Results: In the D group, the pre- versus postoperative C2-C7 sagittal angles were not significantly different, and only two patients (22%) had kyphosis postoperatively. There was a significant difference in the pre- and postoperative C2-C7 angles in the two groups (P = 0.031).

Regarding the change in segmental alignment, the local open angle increased at the C4/C5 level in the D group. Also there was a significant difference in the local angles between the two groups at C4/5 and C5/6 (P = 0.00038, and 0.037), suggesting that postoperative segmental mobility at C4/5 and C5/6 was higher in the D group than in the C group.

Conclusions: In the present study, DDL in patients with CDAS without DSA did not adversely affect the postoperative alignment and stability compared with CSM patients with CSM. However, patients in the D group may have a chance to develop DSA change at the C4/5 level in the future, and careful long-term follow-up is warranted.

Keywords:

Dialysis-associated spondylosis, destructive spondyloarthropathy, cervical spondylotic myelopathy, laminoplasty

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Introduction

Patients undergoing hemodialysis often experience a condition called dialysis-associated spondylosis (DAS). Long-term dialysis stimulates various pathological conditions of the spine, such as amyloid deposition, bone resorption, and inflammatory changes of the soft tissue, resulting in the expansion of the soft tissue in the spinal canal[1)]. The expansive mass, along with destructive spondyloarthropathy (DSA), slippage of the vertebral body, and dynamic instability, may cause spinal canal stenosis of the cervical spine[1)].

In general, patients with DAS can be divided into two groups in terms of the presence or absence of DSA. Several reports demonstrated the surgical treatment strategy for pa-

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Table 1.

Stage 1	Decrease in disc height without an osteophyte is defined as stage 1.
Stage 2	Irregularity of a vertebral end plate is stage 2.
Stage 3	Stage 3 represents a loss of disc space and erosion or cystic formation adjacent to the disc space.
Stage 4	Stage 4 involves ankylosis of the vertebral bodies.

Dialysis-associated spondylosis staging was carried out in accordance to the method described by Tanizawa[8], with stage 2 or higher defined as DSA.

Figure 1. We measured the C2-C7 sagittal angle as illustrated between the horizontal line of the C2 lower end plate and the horizontal line of the C7 higher end plate of the cervical spine in an intermediate position.

tients with DAS with DSA[2-4]. However, studies focusing on the clinical outcome of patients with DAS without DSA remain scarce[5,6]. Patients with DAS of the cervical spine (CDAS) without DSA underwent cervical laminoplasty at our institution. However, it is still unclear whether exacerbation of alignment or instability occurs after surgery if only laminoplasty is performed on patients with CDAS without DSA.

Therefore, it is important to determine whether cervical laminoplasty is the optimal treatment for patients with CDAS without DSA.

In this study, we aimed to review the treatment strategy of patients with CDAS but without DSA. We retrospectively compared patients who underwent cervical laminoplasty for CDAS without DSA and those who underwent cervical laminoplasty for cervical spondylotic myelopathy (CSM).

Materials and Methods

Patients

Our institutional review board approved this retrospective study. The clinical data and surgical records of consecutive patients with CDAS without DSA (n = 9; D group) and CSM (n = 30; C group) who underwent modified double-door laminoplasty were reviewed retrospectively. Patients were excluded from the study if they had undergone previous cervical surgery or if follow up could not be conducted for more than 6 months. All patients presented with physical symptoms of myelopathy and were confirmed to have multisegmental cervical spondylotic stenosis based on imaging studies, including magnetic resonance imaging (MRI), myelography, and computed tomography (CT) with or without myelography between the C2-C3 and C7-T1 disc levels.

Surgical technique for double-door laminoplasty

Canal expansive double-door laminoplasty of the involved vertebral laminae was performed using the technique of Kurokawa et al[7]. The muscles attached to the C2 spinous processes were preserved without detachment. Spinous processes were resected and longitudinal grooves were chiseled in the center of the laminae and bilaterally at the intersection of each lamina and facet using a high-speed drill and a cutting burr. The laminae were split in the center, and bone flaps were raised away from the laminae to decompress the spinal cord. Decompression was performed en bloc by splitting the spinous process and yellow ligaments. The bone flaps were stabilized to the paravertebral muscles with non-absorbable sutures.

Radiological examination

Assessment of DAS in the D group

To determine the stage of DAS, we used the classification of Tanizawa[8]; stage 2 or higher was defined as DSA (Table 1). Plain radiography, myelography, CT, and MRI were performed. Hypertrophy of the ligamentum flavum; intraspinal canal masses; and spinal destructive changes, such as disc height changes, segmental subluxation, cystic changes at the vertebral bodies, and the facet joints, were investigated. All patients in the D-group were confirmed to have stage 1 disease.

Sagittal alignment

We evaluated cervical sagittal alignment by measuring the lordotic angle between C2 and C7 in the neutral position (Fig. 1). Lateral view X-rays were taken preoperatively and at the final follow-up, and the lordotic angle was measured using the Cobb method, with positive and negative lordotic

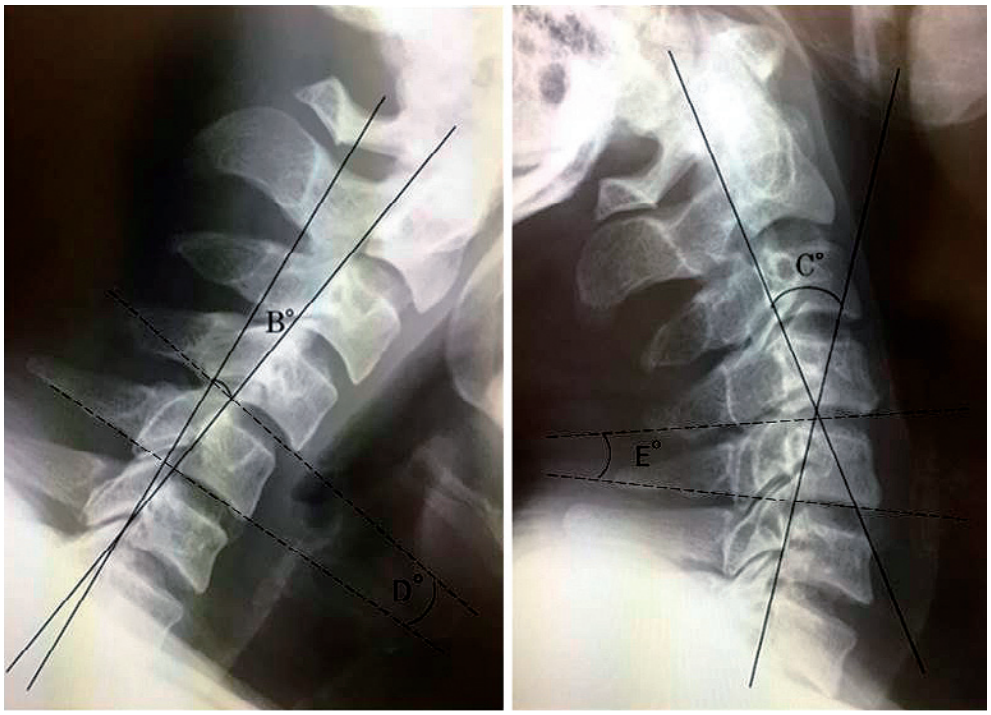

Figure 2. We measured the angle formed by the extension line of the posterior border of C2 and that of C7 as the curvature angle. Cervical vertebral ROM is expressed as the angle between two lines extending from the posterior margins on dynamic films.
The cervical ROM angle was measured by B°+C° as illustrated.
We measured the local angle of each vertebral body sagittal angle as illustrated (D°+E°) between the horizontal line of the superior vertebral body lower end plate and the horizontal line of the inferior vertebral body lower end plate of the cervical spine.

angles indicating cervical lordosis and kyphosis, respectively. The change in the alignment of the cervical spine was assessed as follows: Alignment change amount (°): (preoperative C2-C7 lordotic angle) - (postoperative C2-C7 lordotic angle). Based on the change in alignment, radiological outcomes were classified into the following three categories: more lordotic (-0°>), unchanged (0°), or more kyphotic (+0°).

Range of motion

Cervical range of motion (ROM) was defined as the angles created by a line parallel to the inferior aspect of the C 2 vertebral body and a line parallel to that of the C7 vertebral body on flexion and extension lateral radiographs. The total ROM value was obtained by summation of these angles (Fig. 2). The change in ROM was evaluated with the following equation: Change in ROM (°): (preoperative ROM) - (postoperative ROM).

The local angle of the fused segments was determined as the angle made by the two lines to the superior lower end plate of the upper vertebral body and the inferior lower end plate of the lower vertebral body (Fig. 2).

Incidence of postoperative kyphosis and progression of spondylolisthesis

The incidence of postoperative kyphosis and progression of spondylolisthesis were evaluated by images of the cervical spine taken in the neutral position at the final follow-up. The progression of spondylolisthesis was defined as worsening by 2 mm or more compared to preoperative radiographs (Fig. 3). All these measurements were performed twice with a 1-week interval by one of the authors, and the mean data were evaluated.

Statistical analysis

The Mann-Whitney U test or χ^2 test was used for statistical analysis. All P values less than 0.05 were considered statistically significant. All values are expressed as mean ± standard deviation.

Results

Patient demographics:

There were 9 men in the D group and 20 men and 10 women in the C-group. The mean ages in the D and C groups were 65.4 (52-81) and 66.3 (46-82) years, respec-

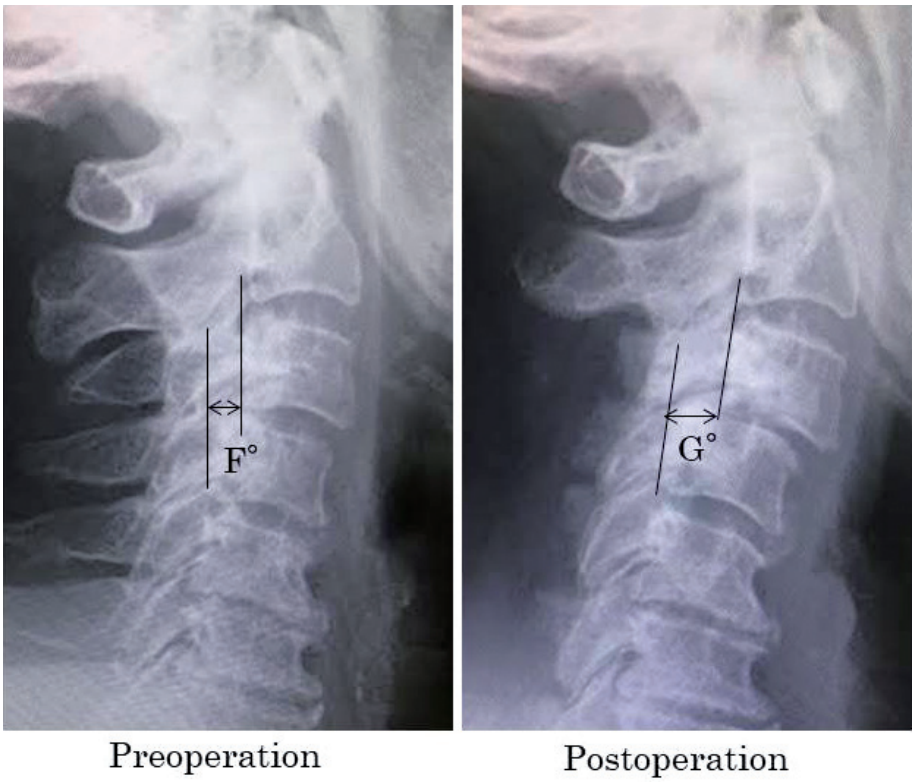

Figure 3. We investigated slippage progression in the cervical vertebrae in each vertebral body as illustrated (G°-F°). Sagittal plane translation of more than 2 mm was defined as positive progression of spondylolisthesis.

Table 2. Comparison of Demographic Data between the Two Groups.

Parameters	C group	D group	P value
Number of patients	30	9	
Mean age (y)	66.3±10.1	65.4±8.67	0.570
Sex			0.079
Male	20	9	
Female	10	0	
Number of opened laminae	4.73±0.77	4.96±0.69	0.637

tively. The number of opened laminae was 4.96 ± 0.69 in the D group and 4.73 ± 0.77 in the C group. The mean follow-up period was 19 months (6-30) in the D group and 21.1 months (12-36) in the C group. There were no significant differences in the demographic data between the two groups (Table 2). The average hemodialysis duration in the D group was 16.8 years (7-30). The clinical details of the patients in the D group are shown in Table 3. Importantly, no evident DSA progression was observed at final observation in the D group.

Sagittal alignment

The mean preoperative and postoperative C2-C7 angles were 10.0° ± 8.7° and 6.9° ± 10.1°, respectively, in the C group and 13.4° ± 9.3° and 15.1° ± 11.2°, respectively, in the D group. There was no significant difference in the pre- and postoperative C2-C7 angles in the D-group (P = 0.825). However, the difference in the change in the C2-C7 angle between the two groups was significant (P = 0.031; Table 4).

The patients then were classified into the more lordotic, unchanged, and more kyphotic groups, including six (67%), one (11%), and two (22%), respectively, in the D group, and six (20%), five (16.7%), and nineteen (63.3%), respectively, in the C group.

Cervical ROM

The mean preoperative and postoperative cervical ROM was 31.7° ± 8.0° and 25.7° ± 8.4°, respectively, in the C group and 37.1° ± 12.1° and 26.8° ± 7.4°, respectively, in the D group. The postoperative cervical ROM in both groups decreased significantly at the final follow-up. There was no significant difference in the preoperative versus postoperative cervical ROM between the two groups (P = 0.270; Table 4).

The mean local angles of C2/3, C3/4, C4/5, C5/6, and C6/7 were 10.8° ± 3.7°, 9.4° ± 3.6°, 11.0° ± 3.6°, 8.3° ± 3.3°, and 6.9° ± 3.4°, respectively, preoperatively and 8.0° ± 2.9°, 6.6° ± 3.0°, 7.3° ± 3.1°, 5.8° ± 2.9°, and 5.3° ± 2.5°, respectively, postoperatively in the C group, and 10.6° ± 5.2°, 9.8° ± 3.3°, 6.2° ± 3.5°, 7.6° ± 4.0°, and 9.0° ± 2.8°, respectively, preoperatively and 7.2° ± 3.1°, 6.6° ± 2.5°, 6.9° ± 2.6°, 6.0° ± 2.8°, 6.2° ± 2.0°, respectively, postoperatively in the D group. Details of the radiological parameters of the D-group are described in Table 5. In the C group, the

Table 3. Demographic and Clinical Data of D Group.

No	Age (years)	Gender	Follow-up period (months)	Dialysis period (years)	Procedure
1	52	Male	8	8	DDL (C4-C7)
2	62	Male	30	17	DDL (C3-C7)
3	81	Male	24	7	DDL (C3-C7)
4	78	Male	30	20	DDL (C3-C7)+C7 laminectomy
5	60	Male	22	27	DDL (C3-C7)
6	70	Male	26	14	DDL (C3-C7)
7	64	Male	6	30	DDL (C3-Th1)
8	62	Male	15	15	DDL (C3-C6)+C7 laminectomy
9	61	Male	10	13	C1 laminectomy+DDL (C2-C7)

DDL, double-door laminoplasty

Table 4. Comparison of the Change Amount of Each Radiological Parameters Pre- and Post-operation between the Two Groups.

Parameters	C group	D group	P value
C2-C7 sagittal angle (°)	-2.9±7.37	0.78±3.74	0.031
Cervical ROM (°)	-5.93±9.29	-10.3±8.87	0.27
Local angle change			
C2/3 (°)	-2.87±3.57	-2.89±3.03	0.89
C3/4 (°)	-2.73±2.53	-3.22±2.30	0.57
C4/5 (°)	-3.70±2.71	0.67±2.11	0.00038
C5/6 (°)	-2.57±2.28	-0.67±-0.95	0.037
C6/7 (°)	-1.88±2.96	-2.83±1.77	0.36
Progression of spondylolisthesis	Positive: 0 Negative: 30	Positive: 1 Negative: 8	0.23

Table 5. Details of the Radiological Parameters of the D-group.

Parameters	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9
C2-C7 sagittal angle (°)									
Preoperation	15	3	36	7	21	8	11	9	11
Postoperation	20	3	40	10	24	2	15	7	15
Cervical ROM (°)									
Preoperation	34	36	48	15	24	51	50	47	29
Postoperation	27	28	43	13	27	28	28	26	21
Local angle change C2/3 (°)									
Preoperation	8	4	14	10	13	13	18	7	8
Postoperation	4	2	9	8	7	13	10	7	5
C3/4 (°)									
Preoperation	5	10	16	14	5	7	11	9	8
Postoperation	3	6	9	11	8	5	4	8	8
C4/5 (°)									
Preoperation	1	4	5	8	5	12	10	9	2
Postoperation	2	6	6	10	7	10	6	10	5
C5/6 (°)									
Preoperation	6	9	4	8	7	14	10	2	8
Postoperation	3	9	5	6	6	10	9	1	5
C6/7 (°)									
Preoperation	5	8	-	-	11	8	14	8	-
Postoperation	4	7	-	-	9	4	8	5	-
Progression of spondylolisthesis ≥2 mm	None	None	None	None	None	C3/4 6 mm → 9 mm	None	None	None

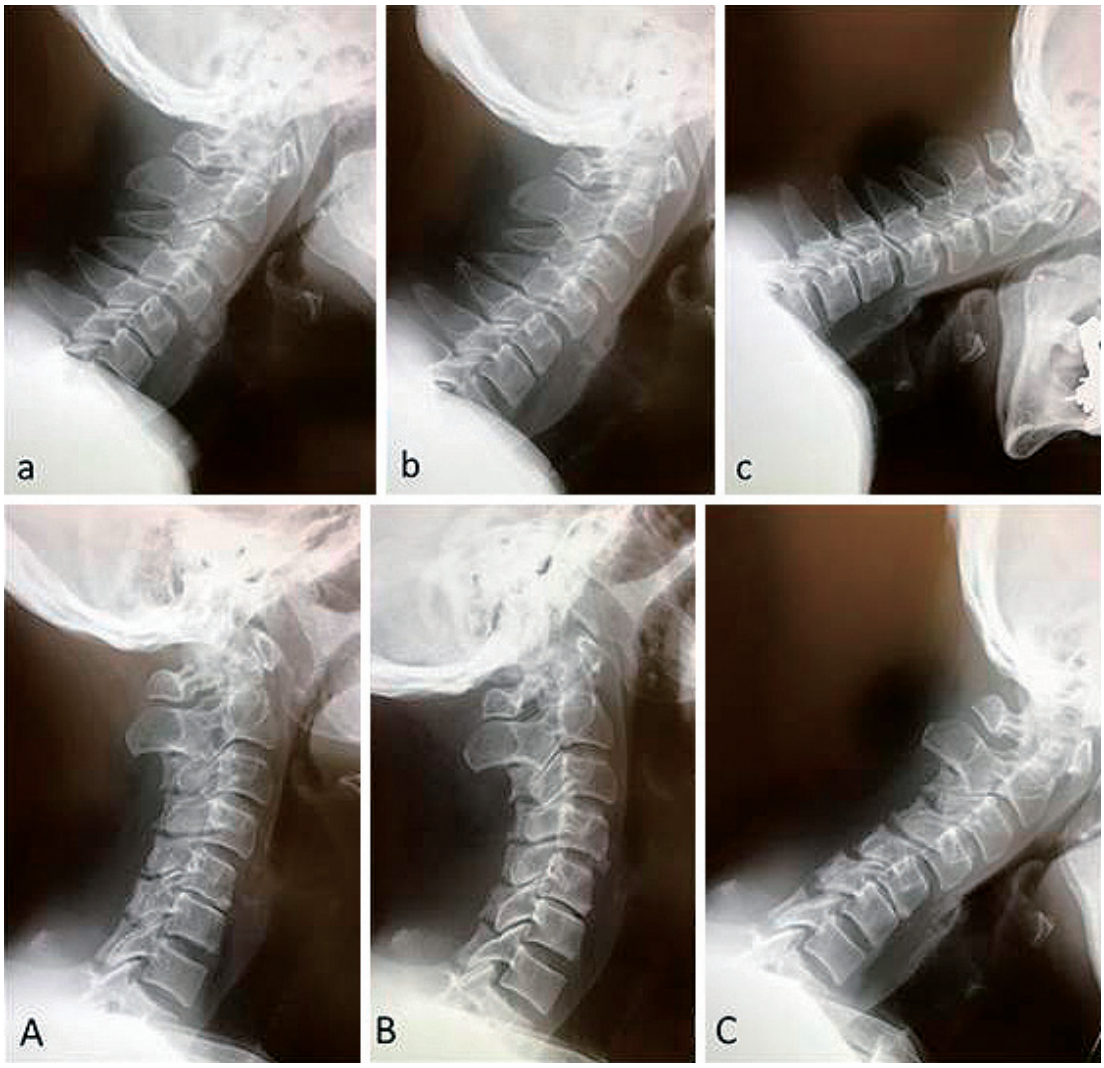

Figure 4. Preoperative lateral view: a, flexion; b, intermediate; c, extension.
Preoperative lateral view: A, flexion; B, intermediate; C, extension.

local angle was significantly reduced at almost every segment postoperatively (P = 0.029, 0.0057, 0.0001, 0.001, and 0.09, respectively). In contrast, there was no significant difference in the pre- versus postoperative local angle of all segments in the D group (P = 0.10, 0.06, 0.50, 0.37, and 0.10, respectively). However, there was a significant difference in these angles between the two groups at C4/5 and C5/6 (P = 0.00038 and 0.037; Table 4), suggesting that postoperative segmental mobility at C4/5 and C5/6 was higher in the D than in the C group.

Incidence of postoperative kyphosis and spondylolisthesis

Postoperative progression of spondylolisthesis was observed in one patient in both groups at the final follow-up. In patients with spondylolisthesis exacerbation, the local open angle at the sliding vertebral body level decreased, and postoperative cervical vertebrae ROM was drastically decreased. There was no significant difference in the progression of spondylolisthesis between the two groups (P = 0.23; Table 4). In addition, kyphosis developed postoperatively in six patients in the C group and in none of the patients in the D group (P = 0.30).

Pre- versus postoperative local angle between the two groups at C4/5 and C5/6 levels (P = 0.00038 and 0.037, respectively) and the difference in the C2-C7 angle between the two groups (P = 0.031) were significantly different (Table 4).

Case presentation

(Case 1)

A 60-year-old man with cervical myelopathy was admitted with the chief complaint of difficulty in walking and an uncomfortable feeling around the anus, which had lasted for 6 months. He had been undergoing hemodialysis for 27 years because of end-stage renal disease due to chronic glomerulonephritis. Preoperative X-ray showed mild degenerative change without obvious DSA (Fig. 4). Double-door laminoplasty (C3-C7) was performed, and there was no progression of DSA, kyphosis, and spondylolisthesis at 22 months postoperatively (Fig. 4).

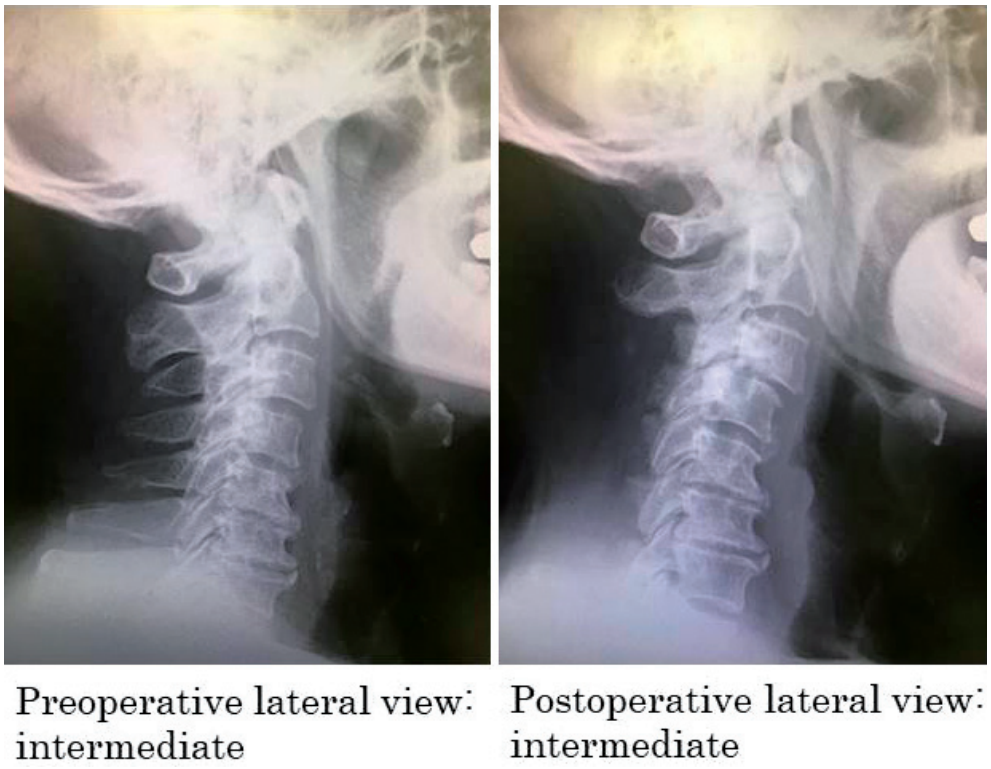

Figure 5. 3 mm of spondylolisthesis developed at C3 level.

(Case 2)

A 70-year-old man with cervical myelopathy was admitted with the chief complaint of difficulty in walking and right upper limb weakness/numbness. He had been undergoing hemodialysis for 14 years because of end-stage renal disease due to IgA nephropathy. Preoperative X-ray examination revealed mild degenerative changes without pronounced DSA. Double-door laminoplasty (C3-C7) was performed, and 3 mm of spondylolisthesis developed at C3 level (Fig. 5); however, there was no progression of DSA or kyphosis at 22 months postoperatively.

Discussion

The treatment of patients with CDAS is challenging in the field of spine surgery. Previous reports have demonstrated that patients with CDAS and DSA did not obtain good results with laminoplasty alone, and spinal fixation was recommended[3,9]. Previously, we reported good results in patients with CDAS treated with laminoplasty after a short-term follow-up[10]. However, that study included patients with and without DSA. Thus, the results of laminoplasty in patients with CDAS remained unclear[5,6]. In this study, we retrospectively compared patients who underwent laminoplasty for CDAS without DSA and those who underwent laminoplasty for CSM and examined the postoperative alignment change and stability.

A previous report showed that the C2-C7 sagittal angle decreases after cervical laminoplasty in patients with CSM[11], and it becomes kyphotic during the follow-up period in some cases[12]. According to this finding, the C2-C7 sagittal alignment in the C group was decreased postoperatively. However, in the D group, the pre- versus postoperative C2-C7 sagittal angles were not significantly different, and only two patients (22%) had kyphosis postoperatively. Because the postoperative progression of cervical kyphosis has been proved to be one of the poorer predictors of the clinical outcome[13], we considered that laminoplasty for patients with CDAS without DAS might not influence adverse effects on the clinical outcome.

Several reports demonstrated significantly decreased flexion- extension ROM after laminoplasty[12]. However, in a large series of patients with CSM, Machino et al.[9] reported preservation of ROM by performing early removal of cervical orthosis, postoperative rehabilitation, and surgical modifications. Interestingly, Chihara et al.[12] reported that reduction of cervical ROM may result in a braking effect of the cervical spine and reduced postoperative complications, suggesting that the clinical significance of the preservation of ROM after laminoplasty remains in debate.

In this study, we observed moderate reduction of ROM after laminoplasty (81%) in the C-group. Meanwhile, in the D-group, ROM decreased from an average of 37.1° to 26.8° (72%), with a significant difference between pre- and postoperative values (P = 0.046). It has been reported that patients with DSA are prone to experience instability after cervical spine surgery[14]. On the contrary, we considered that laminoplasty might not cause postoperative instability in patients with CDAS without DSA, and we assumed that it was attributed to the braking effect by reducing ROM after laminoplasty.

Regarding the change in segmental alignment, the local open angle increased at the C4/5 level in the D group and this might be partly due to the compensatory events against the reduction of ROM postoperatively that is, this segment would be exposed to higher stress than the preoperative condition. DSA is likely to occur in the middle and lower cervical vertebrae, such as C5/6, C6/7, and C4/5[5]. Thus, patients in the D-group may have a chance to develop DSA change at the C4/5 level in the future, and careful long-term follow-up is warranted.

Considering the above observations, we thought that cervical laminoplasty would be superior in achieving sufficient alignment and stability in patients with CDAS without DSA.

There are several study limitations. First, the study included few patients with CDAS without DSA, and the follow-up period was relatively short. Second, the clinical outcome was not evaluated preoperatively and postoperatively by the Japanese Orthopedic Association Score system for cervical myelopathy. Third, we could not consider the impact of global sagittal alignment. Therefore, further prospective studies are necessary to draw a solid conclusion relating to the efficacy of laminoplasty for patients with CDAS without DSA.

Conflicts of Interest: The authors declare that there are no conflicts of interest.

Author Contributions: Satoshi Baba wrote and prepared the manuscript, and all of the authors participated in the study design. All the authors have read, reviewed, and approved the article.

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