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Clinical Studies

Laminectomy and fusion better maintains horizontal gaze than laminoplasty in cervical spondylotic myelopathy

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A R T I C L E I N F O

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A B S T R A C T

Background: Laminectomy and fusion (LF) and laminoplasty (LP) are common treatments for cervical spondylotic myelopathy and myeloradiculopathy. While both procedures show similar clinical improvement, LF requires bony fusion while LP offers motion preservation. Cervical sagittal alignment and horizontal gaze maintenance are key outcome measures, but their comparative effects between LF and LP remain unclear. This study evaluated postoperative horizontal gaze and cervical sagittal alignment in patients undergoing either procedure.
Methods: In this retrospective cohort study at 2 academic centers, patients underwent either LF or LP. Pre/postoperative cervical sagittal alignment parameters were collected, including C2–7 lordosis, C2–7 SVA, Occiput-C2 angle, and T1-slope. The McGregor slope measured horizontal gaze, with 8° flexion to 13° extension as normal range. Primary outcome was horizontal gaze maintenance at minimum 1-year follow-up. Secondary outcomes included changes in cervical spine alignment parameters.
Results: Sixty-four patients (30 LF, 34 LP) completed minimum 1-year follow-up. Pre/postoperative sagittal alignment measures showed no significant differences between groups. Within cohorts, LP increased C2–7 sagittal vertical axis (29.1–37.6 mm, p=.04) while LF decreased C2–7 lordosis (11.5°–5.00°, p=.04). Postoperatively, LF showed significantly more optimally aligned patients (90.0%) versus LP (57.8%) (p<.01). Multivariate analysis indicated LP predicted postoperative horizontal gaze malalignment (OR 13.90 [2.10–286.62], p=.022).
Conclusions: While both procedures yielded comparable cervical sagittal alignment outcomes, LF demonstrated superior maintenance of horizontal gaze. These findings suggest that laminectomy and fusion may preserve horizontal gaze better than laminoplasty.
Level of Evidence: III.

Introduction

Cervical spondylotic myelopathy and myeloradiculopathy are common degenerative conditions that often require surgical intervention via posterior approaches such as laminoplasty (LP) or laminectomy and fusion (LF). While both techniques lead to favorable outcomes, the impact on cervical sagittal alignment and horizontal gaze is not understood. Quantifying radiographic deformity to correlate with patient-reported outcomes is a key aspect of understanding indications for cervical spine surgery and assessing postoperative outcomes [1]. Sagittal alignment parameters are commonly used to assess the severity of deformity and provide goals for adequate treatment.

There is a growing body of literature establishing cervical sagittal alignment and horizontal gaze parameters. The cervical spine is dynamic and changes in the subaxial cervical spine produce reciprocal changes in the upper cervical spine and craniocervical junction as evidenced by a high degree of correlation between sagittal vertical axis (SVA) with changes in Occiput-C2 and McGregor slope (McGS) [2]. McGs and Slope line of sight (SLOS) have been shown to vary substantially between patients with symptomatic and asymptomatic cervical pathology [3]. In patients with symptomatic cervical spines, Occiput-C2 angle significantly correlates with Neck Disability Index [4]. Historically, horizontal gaze has been measured through the chin-brow vertical angle (CBVA), however, this measurement is not readily obtainable on most

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radiographs of the cervical spine as it requires the anterior skull and mandible to be included within the field of the radiograph. Recent studies have shown the utility of the Occiput-C2 angle (C0–C2), McGS, SLOS measurements as accurate, and more readily obtainable, surrogates of CBVA from standard cervical spine radiographs [1,5].

The aim of this study was to compare cervical sagittal alignment parameters and horizontal gaze and in patients undergoing laminoplasty (LP) versus laminectomy and fusion (LF) for cervical spondylotic myelopathy or myeloradiculopathy. We hypothesized that there would be no significant difference in horizontal gaze maintenance between the 2 groups. Elucidating the impact of these surgical techniques on horizontal gaze may have important implications for patient counseling, surgical planning, and optimizing functional outcomes.

Materials and methods

This retrospective cohort study examined patients with a primary diagnosis of cervical spondylotic myelopathy or myeloradiculopathy who underwent either laminectomy and fusion or laminoplasty between 2017 and 2019 at 2 academic medical centers. The decision to proceed with either of the 2 procedures was at the discretion of the treating surgeon, factors which were documented as favoring laminectomy and fusion were axial neck pain and baseline kyphotic deformity but were not available on retrospective review for all patients included in the study. Institutional review board approval was granted before the study began. Patients who had undergone previous cervical spine procedures, underwent constructs that instrumented cranial to C2 or caudal to T1, or underwent surgery for trauma, tumor or infection were excluded. Patients were also excluded if they did not have radiographic follow-up greater than 1 year postoperatively or if radiographs were insufficient to visualize landmarks including the opisthion, hard palate, and T1.

The primary outcome measure was the postoperative horizontal gaze as assessed via McGS. McGS was defined as the angle between the posterior aspect of the hard palate to the opisthion, or the inferior border of the occiput, and a horizontal line (Figure 1). SLOS was defined as the angle between the Frankfort line from the anteroinferior orbit to the top of the external auditory meatus and a horizontal line. Occiput-C2 was defined as the angle between a line from the posterior aspect of the hard palate to the opisthion and a line at the inferior endplate of C2. The relationship between these measures and cervical sagittal alignment parameters was examined as well [5].

Data collection

Baseline patient characteristics were collected for all patients including age, gender, race, body mass index, smoking status, and Charlson comorbidity index. Surgical characteristics collected included the cranial level of operation, the caudal level of operation, the type of surgery performed, estimated blood loss and the length of postoperative follow-up. Pre- and postoperative cervical sagittal alignment parameters including C2–7 lordosis, C2–7 SVA, and T1 slope were measured by 4 clinical reviewers. Pre- and postoperative horizontal gaze measures including Occiput-C2 angle, McGS, and SLOS were measured by 2 clinical reviewers. Inter- and intraclass correlation coefficients (ICCs) were calculated across reviewers which were >0.9 for both reviewing groups, consistent with strong agreement. Degrees of flexion were categorized as positive while degrees of extension were categorized as negative. Degrees of lordosis were categorized as positive while degrees of kyphosis were categorized as negative. Utilizing the cranial alignment criteria postulated by Oe et al, the pre and postoperative McGregor slope were categorized as optimally aligned for patients with less than 13 degrees of extension or 8 degrees of flexion and suboptimally aligned if the McGregor slope was outside of these criterion [6].

Statistics

Baseline patient and surgical characteristics were compared using Student *t*, Chi-squared or Fisher exact tests, where appropriate. Secondary outcomes were analyzed using chi-squared tests for categorical outcomes and student t-tests for continuous outcomes. Data normality was assessed using Quantile-Quantile plots. All analyses were 2-tailed with a $p<.05$ considered significant. Linear regression was utilized, where appropriate, to examine the relationship between postoperative horizontal gaze alignment and preoperative alignment measures including Occiput-C2 angle, C2–7 Lordosis, C2–7 Sagittal Vertical Axis, horizontal gaze alignment, and type of surgical intervention. All statistical calculations were performed in R (version 4.3.1, Rstudio Inc, Boston, MA). Missing data were excluded from the analysis.

Results

Sixty-four patients met the final inclusion and exclusion criteria. Ultimately, 30 patients who underwent LF and 34 underwent LP were included in analysis. The demographic comparison is detailed in Table 1. The mean age in the LP cohort was 62.8 (± 11.3) years and 65.0 (± 7.88) years in the LF cohort. There was a higher percentage of male patients in the LP cohort (61.8% vs 46.7%, p=.34). Similarly, there were no significant differences between cohorts with respect to smoking status, race, or Charlson comorbidity index. There was significantly less average estimated blood loss in the LP cohort (198 cc vs 377 cc, p=.04) despite operative duration remaining similar between groups. Patients in the LF cohort had significantly greater operative levels than the LP cohort (p=.01) and EBL was significantly associated with the number of operative levels in analysis of variance (p=.03). There were 2 complications in the laminectomy and fusion cohort, infection and cerebrospinal fluid leak, and 2 complications in the laminoplasty cohort, infection and epidural hematoma.

Preoperative and postoperative radiographic parameters were compared between the laminoplasty (LP) and laminectomy and fusion (LF) cohorts (Table 2). There were no significant differences in any of the preoperative or postoperative sagittal alignment measures between the 2 groups, including slope line of sight (−4.50° vs −5.14°, p=.86), McGregor slope (0.265° vs −1.37°, p=.5), occiput-C2 angle (26.6° vs 27.6°, p=.82), C2–7 lordosis (9.65° vs 5.00°, p=.18), C2–7 sagittal vertical axis (37.6 mm vs 35.8 mm, p=.69), T1 slope (30.9° vs 32.9°, p=.43), and T1 slope minus cervical lordosis (21.2° vs 27.9°, p=.12).

Changes in radiographic parameters from preoperative to postoperative timepoints were assessed within each surgical cohort (Table 3). In the LP group, the C2–7 sagittal vertical axis significantly increased from 29.1 mm to 37.6 mm (p=.04), but there were no significant changes in the other parameters. In the LF group, the C2–7 lordosis significantly decreased from 11.5° to 5.00° (p=.04), while the other measures did not differ significantly between timepoints.

In the LF group, 22 (73.3%) patients met optimal gaze criteria preoperatively and 8 (26.7%) patients met suboptimal gaze criteria (Table 4). In the LP group, 25 (55.6%) patients met optimal gaze criteria and 20 (44.4%) patients had suboptimal gaze. These differences in cohort makeup did not reach statistical significance. Postoperatively, 27 (90.0%) patients met optimal gaze criteria and 3 (10.0%) met suboptimal gaze criteria in the LF cohort whereas 26 (57.8%) patients met optimal gaze criteria and 19 (42.2%) met suboptimal gaze criteria in the LP cohort. These between cohort differences in postoperative alignment were statistically significant with a p-value less than .01.

Changes in pre and postoperative cranial alignment were also examined (Table 4). In the LF cohort, 2 (6.7%) patients changed from optimal to suboptimal gaze, 7 (23.3%) patients changed from suboptimal to optimal gaze, 20 (66.7%) patients continued to have optimal gaze, and 1 (3.3%) patient continued to have suboptimal gaze. In the LP cohort, 9 (20.0%) patients changed from optimal to suboptimal gaze, 10 (22.2%) patients changed from suboptimal to optimal gaze, 16 (35.6%) patients

Table 1
Demographic characteristics of patients included in each operative cohort.

	Laminoplasty (N=34)	Laminectomy and Fusion (N=30)	p-value
Age			
Mean (SD)	62.8 (11.3)	65.0 (7.88)	.37
Median (Min, Max)	65.0 (34.0, 88.0)	63.0 (50.0, 81.0)	
Gender			
Female	13 (38.2%)	16 (53.3%)	.34
Male	21 (61.8%)	14 (46.7%)	
Body Mass Index (kg/m^2)			
Mean (SD)	28.6 (6.44)	29.9 (7.04)	.44
Median (Min, Max)	27.6 (20.0, 44.5)	28.1 (20.4, 50.6)	
Smoking Status			
Current	5 (14.7%)	5 (16.7%)	.16
Former	18 (52.9%)	9 (30.0%)	
Never	11 (32.4%)	16 (53.3%)	
Self-Identified Race			
Black	2 (5.9%)	1 (3.3%)	.38
Hispanic	1 (2.9%)	1 (3.3%)	
White	28 (82.4%)	28 (93.3%)	
Asian	3 (8.8%)	0 (0%)	
Charlson Comorbidity Index			
Mean (SD)	2.47 (1.31)	2.93 (1.68)	.23
Median (Min, Max)	2.50 (0, 5.00)	2.50 (1.00, 8.00)	
Estimated Blood Loss (cc)			
Mean (SD)	194 (148)	377 (426)	**.04**
Median (Min, Max)	150 (25.0, 800)	255 (50.0, 2000)	
Missing	0 (0%)	2 (6.7%)	
Operative Duration (min)			
Mean (SD)	164 (46.9)	154 (52.9)	.43
Median (Min, Max)	154 (98.0, 301)	144 (79.0, 286)	
Postoperative Follow-up (Months)			
Mean (SD)	20.7 (6.89)	18.3 (5.97)	.14
Median (Min, Max)	19.2 (12.1, 34.9)	17.0 (12.0, 31.9)	
Operative Levels			
3	12 (35.3%)	8 (26.7%)	**.01**
4	22 (64.7%)	14 (46.7%)	
5	0 (0%)	8 (26.7%)	

p-values less than <0.05.

Table 2
Comparison between cohorts of horizontal gaze and sagittal alignment parameters preoperatively and postoperatively.

	Preoperative			Postoperative		
	Laminoplasty (N=34)	Laminectomy and Fusion (N=30)	p-value	Laminoplasty (N=34)	Laminectomy and Fusion (N=30)	p-value
Slope Line of Sight (degrees)						
Mean (SD)	−7.00 (9.72)	−1.57 (10.3)	.25	−4.50 (7.73)	−5.14 (7.60)	.86
Median (Min, Max)	−8.00 (−20.0, 22.0)	−5.00 (−14.0, 14.0)		−5.00 (−18.0, 13.0)	−2.00 (−18.0, 3.00)	
Missing	15 (44.1%)	23 (76.7%)		18 (52.9%)	23 (76.7%)	
McGregor Slope (degrees)						
Mean (SD)	0.529 (14.1)	−4.07 (9.16)	.12	0.265 (11.8)	−1.37 (7.20)	.5
Median (Min, Max)	−2.50 (−23.0, 33.0)	−5.00 (−27.0, 18.0)		−2.50 (−16.0, 37.0)	−0.500 (−13.0, 14.0)	
Occiput-C2 Angle (degrees)						
Mean (SD)	20.6 (11.4)	22.5 (14.4)	.57	26.6 (14.9)	27.6 (19.5)	.82
Median (Min, Max)	18.0 (−3.00, 46.0)	23.0 (−28.0, 44.0)		25.0 (0, 62.0)	29.0 (−36.0, 66.0)	
C2-C7 Lordosis (degrees)						
Mean (SD)	14.9 (11.4)	11.5 (11.3)	.23	9.65 (15.5)	5.00 (12.0)	.18
Median (Min, Max)	16.5 (−9.00, 35.0)	11.1 (−12.0, 35.0)		12.0 (−25.0, 37.0)	4.50 (−16.0, 24.0)	
C2-C7 Sagittal Vertical Axis (mm)						
Mean (SD)	29.1 (17.1)	34.1 (15.8)	.23	37.6 (16.4)	35.8 (18.9)	.69
Median (Min, Max)	28.0 (−8.00, 67.0)	32.0 (11.0, 76.0)		33.5 (6.00, 82.0)	35.0 (3.00, 79.0)	
T1-Slope (degrees)						
Mean (SD)	30.4 (8.87)	31.9 (12.2)	.58	30.9 (8.98)	32.9 (11.6)	.43
Median (Min, Max)	30.9 (9.00, 48.1)	32.0 (8.00, 76.0)		32.5 (10.0, 51.5)	29.5 (5.30, 65.8)	
T1-Slope - Cervical Lordosis (degrees)						
Mean (SD)	15.5 (11.2)	20.5 (12.1)	.1	21.2 (13.7)	27.9 (19.1)	.12
Median (Min, Max)	15.1 (−8.60, 47.8)	20.3 (−1.00, 49.5)		20.0 (−8.80, 53.0)	25.5 (−16.7, 81.8)	

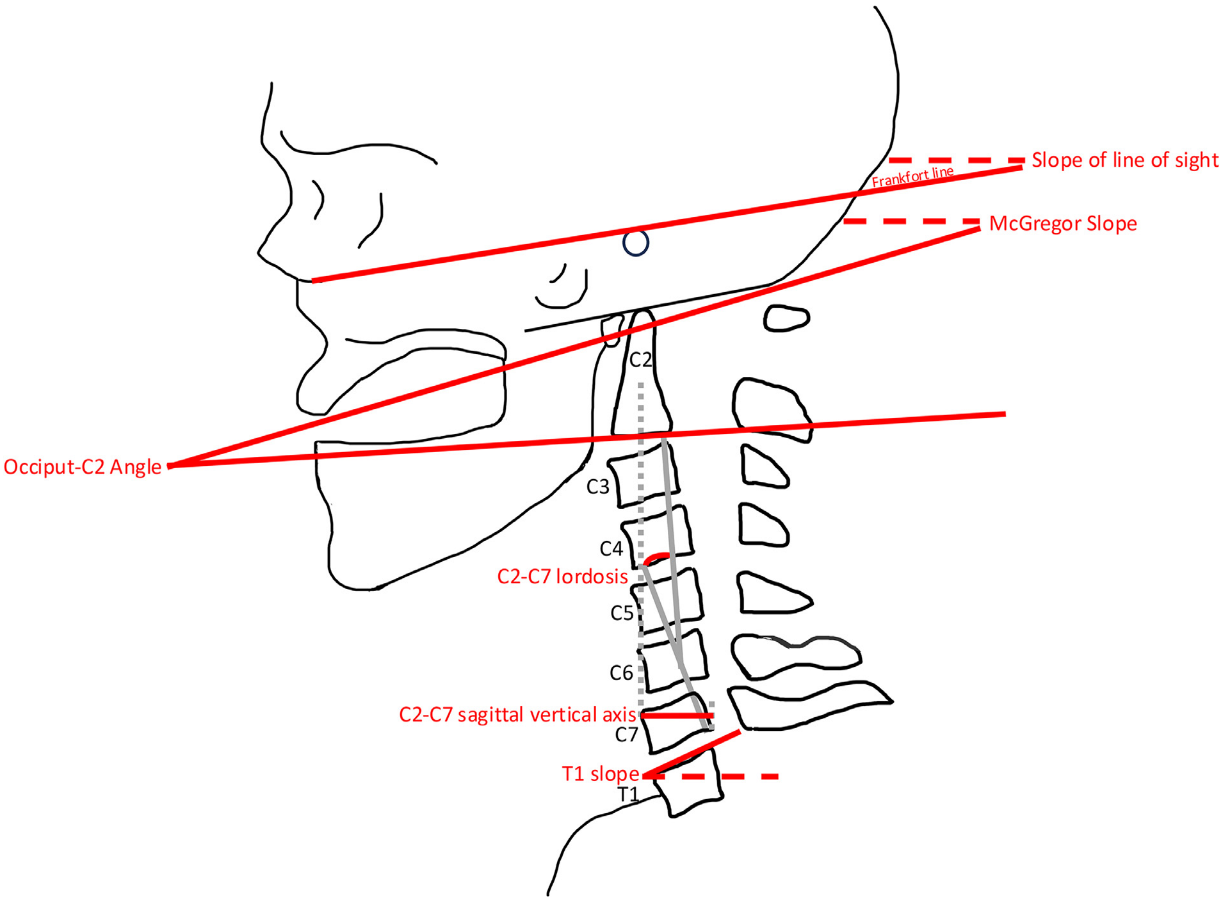

Figure 1. Schematic diagram of the cervical spine illustrating key parameters for assessing sagittal alignment, including the occiput-C2 angle, McGregor slope, slope line of sight, C2-C7 lordosis, C2-C7 sagittal vertical axis, and T1 slope.

Table 3
Comparison of pre and postoperative horizontal gaze and sagittal alignment parameters between operative cohorts.

	Laminoplasty (N=34)			Laminectomy & Fusion (N=30)		
	Preoperative	Postoperative	p-value	Preoperative	Postoperative	p-value
Slope Line of Sight (degrees)						
Mean (SD)	−7.00 (9.72)	−4.50 (7.73)	.4	−1.57 (10.3)	−5.14 (7.60)	.48
Median (Min, Max)	−8.00 (−20.0, 22.0)	−5.00 (−18.0, 13.0)		−5.00 (−14.0, 14.0)	−2.00 (−18.0, 3.00)	
Missing	15 (44.1%)	18 (52.9%)		23 (76.7%)	23 (76.7%)	
McGregor Slope (degrees)						
Mean (SD)	0.529 (14.1)	0.265 (11.8)	.93	−4.07 (9.16)	−1.37 (7.20)	.21
Median (Min, Max)	−2.50 (−23.0, 33.0)	−2.50 (−16.0, 37.0)		−5.00 (−27.0, 18.0)	−0.500 (−13.0, 14.0)	
Occiput-C2 Angle (degrees)						
Mean (SD)	20.6 (11.4)	26.6 (14.9)	.07	22.5 (14.4)	27.6 (19.5)	.25
Median (Min, Max)	18.0 (−3.00, 46.0)	25.0 (0, 62.0)		23.0 (−28.0, 44.0)	29.0 (−36.0, 66.0)	
C2-C7 Lordosis (degrees)						
Mean (SD)	14.9 (11.4)	9.65 (15.5)	.12	11.5 (11.3)	5.00 (12.0)	.04
Median (Min, Max)	16.5 (−9.00, 35.0)	12.0 (−25.0, 37.0)		11.1 (−12.0, 35.0)	4.50 (−16.0, 24.0)	
C2-C7 Sagittal Vertical Axis (mm)						
Mean (SD)	29.1 (17.1)	37.6 (16.4)	**.04**	34.1 (15.8)	35.8 (18.9)	.7
Median (Min, Max)	28.0 (−8.00, 67.0)	33.5 (6.00, 82.0)		32.0 (11.0, 76.0)	35.0 (3.00, 79.0)	
T1-Slope (degrees)						
Mean (SD)	30.4 (8.87)	30.9 (8.98)	.85	31.9 (12.2)	32.9 (11.6)	.74
Median (Min, Max)	30.9 (9.00, 48.1)	32.5 (10.0, 51.5)		32.0 (8.00, 76.0)	29.5 (5.30, 65.8)	
T1-Slope - Cervical Lordosis (degrees)						
Mean (SD)	15.5 (11.2)	21.2 (13.7)	.07	20.5 (12.1)	27.9 (19.1)	.08
Median (Min, Max)	15.1 (−8.60, 47.8)	20.0 (−8.80, 53.0)		20.3 (−1.00, 49.5)	25.5 (−16.7, 81.8)	

p-values less than <0.05.

Table 4
Stratification of horizontal gaze alignment before and after surgery and analysis of changes in horizontal gaze alignment.

	Laminoplasty (N=34)	Laminectomy and Fusion (N=30)	p-value
Preoperative horizontal gaze			
Optimally aligned	18 (52.9%)	22 (73.3%)	.15
Suboptimally aligned	16 (47.1%)	8 (26.7%)	
Postoperative horizontal gaze			
Optimally aligned	20 (58.8%)	27 (90.0%)	**.01**
Suboptimally aligned	14 (41.2%)	3 (10.0%)	
Change in horizontal gaze			
Optimally aligned to suboptimally alaligned	5 (14.7%)	2 (6.7%)	**.03**
Suboptimally alaligned to Optimally aligned	7 (20.6%)	7 (23.3%)	
Remained optimally aligned	13 (38.2%)	20 (66.7%)	
Remained suboptimally alaligned	9 (26.5%)	1 (3.3%)	

p-values less than <0.05.

Table 5
Multivariable logistic regression examining the relationship between preoperative alignment parameters and postoperative horizontal gaze alignment.

Dependent: postoperative horizontal gaze alignment	Optimally aligned	Suboptimally aligned	OR (univariable)	OR (multivariable)
Laminectomy and fusion	27 (90.0)	3 (10.0)	-	-
Laminoplasty	20 (58.8)	14 (41.2)	6.30 (1.77-30.05, p=.009)	13.90 (2.10-286.62, p=.022)
Number of operative levels				
3	16 (80.0)	4 (20.0)	-	-
4	25 (69.4)	11 (30.6)	1.76 (0.50–7.22, p = .396)	2.27 (0.52–11.46, p = .291)
5	6 (75.0)	2 (25.0)	1.33 (0.16–8.94, p = .771)	10.54 (0.55–357.8, p = .130)
Preoperative Occ-C2 (Mean [SD])	21.8 (13.6)	20.5 (10.9)	0.99 (0.95–1.04, p=.706)	1.01 (0.96–1.07, p=.711)
Preoperative C2-7 Lordosis (Mean [SD])	12.8 (10.5)	14.6 (13.9)	1.01 (0.97–1.07, p=.574)	0.98 (0.88–1.07, p=.629)
Preoperative C2-7 SVA (Mean [SD])	31.7 (16.9)	30.7 (16.1)	1.00 (0.96–1.03, p=.827)	1.02 (0.97–1.09, p=.372)
Preoperative T1S-CL (Mean [SD])	18.9 (10.9)	14.9 (14.1)	0.97 (0.92–1.02, p=.237)	0.95 (0.85–1.05, p=.329)
Preoperative horizontal gaze aligned	33 (82.5)	7 (17.5)	-	-
Preoperative horizontal gaze malaligned	14 (58.3)	10 (41.7)	3.37 (1.08–11.07, p=.039)	2.55 (0.69–10.12, p=.167)

continued to have optimal gaze, and 10 (22.2%) patients continued to have suboptimal gaze. There were significantly more patients in the LP cohort who transitioned from optimal gaze to suboptimal gaze or continued to have suboptimal gaze ($p = 0.03$). In logistic regression, LP remained a significant predictor (OR: 13.90 [2.10–286.62], p=0.022) of suboptimal postoperative horizontal gaze when adjusting for preoperative sagittal alignment parameters as well as the number of operative levels (Table 5).

Discussion

This study assessed cervical sagittal alignment and horizontal gaze in patients who underwent surgical intervention via either posterior laminectomy and fusion or laminoplasty for cervical myelopathy or myeloradiculopathy. There were no significant differences in preoperative or postoperative cervical sagittal alignment parameters between operative cohorts. While there was no difference in the mean McGregor slope, when grouped by the alignment criteria postulated by Oe and Magcalas, there was a significantly greater proportion of patients who maintained or achieved optimal horizontal gaze in the laminectomy and fusion cohort than in the laminoplasty cohort (90.0% vs 58.8%, p<.01) [6,7].

Horizontal gaze is an increasingly recognized factor in patient quality of life and functional outcomes following cervical spine surgery. Patients with abnormal horizontal gaze due to cervical deformity often experience discomfort, reduced mobility compromised social interaction and difficulty with activities of daily living. [11] Surrogates of horizontal gaze such as the slope line of sight have been correlated with patient reported disability and shown to be an independent risk factor for poor health-related quality of life in patients with cervical deformity [4,12,13].

Oe et al defined the anatomic variation of horizontal gaze by measuring the McGS in 354 normal subjects utilizing a mirror to unify line of sight and found an average slope of $2.2^\circ \pm 10.9^\circ$ [6]. Magacalas et al examined patients who underwent corrective surgery for adult thoracolumbar spine deformity and assessed cranial malalignment using the normal range established by Oe et al. Within the cranial malalignment cohort, patients with hyperascending gaze (>13°) had significant improvement in SVA and McGS postoperatively. Patients with hyperdescending gaze (<−8°) had significant improvement in McGS 1 year postoperatively [7]. A review of patients with complications or need for reoperation after operative cervical deformity correction found that 34% had deterioration or continued abnormal horizontal gaze measurements from preoperatively to 1 year postoperatively [8].

The relationship between cervical sagittal alignment and horizontal gaze is complex, with prior studies demonstrating the interdependence of occipitocervical and subaxial alignment parameters [12,13]. T1 slope and C2–7 sagittal vertical axis (SVA) have been associated with inferior health-related quality of life in patients with cervical myelopathy, highlighting the importance of global cervical alignment [3,18]. However, there is a paucity of literature comparing the impact of different posterior decompression techniques on horizontal gaze and cervical sagittal alignment in this population. Multiple studies have examined the role of horizontal gaze in cervical kyphotic deformity resulting in "dropped head syndrome", however few, if any, to our knowledge have assessed horizontal gaze as an outcome following surgery for more common cervical degenerative disorders such as myelopathy and myeloradiculopathy [9,10].

Multiple works over the last decade have attempted to define the relationship between occipital alignment and sagittal cervical alignment. Kim et al postulated the occipital incidence which incorporated global sagittal balance with cervical sagittal alignment [14]. Sagittal balance has been demonstrated to impact patient reported outcomes and increased cSVA and T1 slope are associated with inferior health-related quality of life at presentation among patients with cervical myelopathy [15]. The dynamic between the occipital incidence and other radiographic measurements has also been investigated and found to correlate with subaxial cervical spine alignment [16]. In our study, there were notable decreases in cervical lordosis in both groups with reciprocal changes in the Occiput-C2 angle. These changes may reflect the accommodation of the axial cervical spine for losses of lordosis in the subaxial cervical spine to preserve horizontal gaze.

Sagittal alignment parameters have been well studied in both laminoplasty and laminectomy and fusion. Cervical lordosis is a key parameter in predicting the success of laminoplasty as loss of lordosis and kyphosis is theorized to compromise horizontal gaze. T1 slope has also been found to be significantly correlated with kyphotic alignment and thus loss of cervical lordosis following laminoplasty. Furthermore, C2–C7 SVA is positively correlated with loss of cervical lordosis following laminoplasty and the imbalance between T1S and preoperative C2–7 angle influences the change of cSVA after cervical laminoplasty. If cSVA increases postoperatively, the Occiput–C2 angle increases to compensate and maintain the horizontal gaze [17]. In patients undergoing posterior decompression and fusion from C2 to T2, improvements in C2–7 SVA and C2–C7 lordosis were associated with improved early postoperative PROMs [18]. Cervical incidence between 14.5 and 26.5 degrees has also been reported as necessary to maintain horizontal gaze, however, neither laminoplasty nor laminectomy and fusion maintained cervical incidence postoperatively with an average increase of 5.8 and 7.2 degrees, respectively [19]. Among all patients in our study there was no significant difference in postoperative cervical incidence between the optimal and suboptimal gaze groups.

To our knowledge, this is the first study to examine differences between horizontal gaze following cervical laminectomy and fusion or laminoplasty. The findings in our study suggest that horizontal gaze is optimized via laminectomy and fusion. From a biomechanical perspective, we hypothesized that fusing the subaxial cervical spine in an optimal position may allow for greater accommodation of changes in cervical lordosis or sagittal vertical axis through the occipitocervical junction to maintain horizontal gaze. In contrast, with laminoplasty, continued degenerative changes in alignment of the mobile subaxial spine over time may result in less compensatory ability through the occipitocervical region to preserve forward gaze. However, our study did not demonstrate significant differences in postoperative subaxial cervical alignment between the laminoplasty and laminectomy and fusion groups to support this theory. Further research is needed to elucidate the mechanisms by which different cervical procedures may impact horizontal gaze.

Follow-up during the study period demonstrates that horizontal gaze alignment may gradually decline beyond the first postoperative year, particularly in LP patients. This decline likely occurs due to the natural progression of cervical degeneration and the continued mobility of the cervical spine in LP patients. This is evidenced by the continued increase in cSVA in patients in the LP cohort while those in the LF cohort maintained cSVA. While initial postoperative alignment may be satisfactory, patients commonly develop compensatory mechanisms to maintain functional horizontal gaze, including increased thoracic extension, pelvic tilt, and knee flexion. These compensatory strategies typically involve recruitment of the surrounding musculature and postural adjustments of the thoracolumbar spine. However, as patients age, these compensatory mechanisms become less effective due to declining muscle strength, reduced joint mobility, and progression of degenerative changes throughout the spine. The increased energy expenditure required to maintain these compensatory positions may also contribute to early fatigue and reduced functional capacity in elderly patients. Understanding this gradual decline is crucial for surgical planning and patient counseling, particularly in younger patients who may require maintenance of horizontal gaze for several decades postoperatively.

This study has limitations. First, patient inclusion was limited by adequate radiographs. While nearly all patients had radiographs which included the axial and sub axial cervical spine, a limited number had radiographs with sufficient portions of the occiput and anterior skull to allow for evaluation of surrogates of horizontal gaze. This may result in selection bias in the alignment parameters observed in patients who obtained acceptable radiographs. This was a retrospective cohort study and thus there could be potential imbalance of factors which indicated patients for either LP or LF. The number of operative levels was significantly different between the cohorts. In the laminoplasty cohort, no patients had surgery which crossed the cervicothoracic junction and this difference in operative levels reflects a surgeon preference for fusing into the upper thoracic spine rather than performing motion preserving surgeon. Given the importance of T1 slope in preserving cervical sagittal alignment, fusion at this level could offer an explanation for maintenance of horizontal gaze in the laminectomy and fusion cohort. Additional limitations include surrogates of horizontal gaze were used in this study rather than the chin brow vertical angle. Though statistically significant, the changes observed in lordosis and cSVA may not be clinically meaningful. While not statistically significant, there were differences in the preoperative horizontal gaze alignment criteria between the 2 cohorts which may be significant in larger sample sizes. This is perhaps best reflected in univariable analysis where horizontal gaze malalignment was significant and, while it was no longer significant in multivariate analysis, warrants additional scrutiny in a larger prospective study. This difference may reflect the differing criteria surgeons at the treating centers used for indicating patients for either LP or LF and would be better evaluated in a prospective study. The relatively small sample size in our study may limit the interpretability of this result. Our study also did not include patient reported outcome measures, which would add utility in determining the clinical impact of deviations in horizontal gaze.

Conclusion

While laminoplasty and laminectomy and fusion demonstrated similar impacts on subaxial cervical sagittal alignment, laminectomy and fusion resulted in a higher proportion of patients with optimal horizontal gaze based on McGregor slope. Thus, laminectomy and fusion may be advantageous for maintaining or restoring horizontal gaze compared to laminoplasty; however, further research is necessary to validate these findings and to define the long-term clinical implications. Larger prospective studies incorporating patient reported outcomes and longer follow-up would be valuable to guide surgical decision-making in this patient population.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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