ORIGINAL STUDY

Radiographic Analysis of the Cervical Spine Sagittal Alignment in Degenerative Cervical Myelopathy 24-month After Posterior Cervical Laminectomy Without Fusion: A Retrospective Study and Review of Literature

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Abstract

Background data: **Degenerative cervical myelopathy (DCM) is the leading cause of spinal cord dysfunction among the elder group of the population. DCM is a degenerative disease that slowly progresses with time; in addition, moderate-to-severe symptomatic patients usually require decompression surgery to relieve the compressed cord. Posterior cervical laminectomy (PCL) without fusion is a known and commonly practiced surgical procedure for multiple levels of DCM. Concerns were raised for the post-PCL without fusion kyphosis as a sequel to laminectomy, as several authors reported the occurrence of post-PCL without fusion kyphosis, which may be reflected in the clinical and radiological outcome.**

Purpose: **This study aims to study the cervical spine sagittal alignment post-PCL without fusion and correlate this to preoperative radiological parameters.**

Study design: **Retrospective analytical cohort study.**

Patients and methods: **The surgical database of our institution hospital was used to retrieve the data of DCM patients who underwent PCL (C3−C6) without fusion. Demographic data of the patients were reported and analyzed. The radiological evaluation used the Cobb angle from C2 to C7 on lateral cervical X-ray, and a comparison between pre-ad postoperative angles was analyzed. The sagittal vertical axis "Csva" of C2-C7 and C7 slope angles were measured. All measurements were done using Surgimap v2.3 (Nemaris, New York, USA).**

Results: **Total number of patients was 48 after 24 months, the Cobb angle increased from 22.02 ± 14.4 to 22.24 ± 9.121 ($P = 0.304$), the cSVA increased significantly from 14.32 ± 10.3 to 18.25 ± 11.46 ($P = 0.013$), and the C7 slope angle increased from 27.84 ± 11.35 to 29.18 ± 6.95 ($P = 0.649$). Only 14 patients (29.1%) had their cervical Cobb angle decreased after 24 months. Both C2-C7 Cobb and C7 slope angles correlated to the decreased cervical Cobb angle after 24 months.**

Conclusion: **Preoperative cervical Cobb angle and C7 slope angle may correlate to the decreased postoperative cervical Cobb angle. In light of the study findings, it is recommended that long-term follow-ups of PCL without fusion surgeries are very crucial to truly reflect the natural senile process effects on the cervical sagittal balance.**

Keywords: Cervical Cobb angle, Sagittal alignment, Cervical kyphosis, Degenerative cervical myelopathy, Posterior cervical laminectomy

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Introduction

Degenerative cervical myelopathy (DCM) is the leading cause of spinal cord dysfunction among the elder group of the population [1,2]. DCM is a degenerative disease that slowly progresses with time; in addition, moderate-to-severe symptomatic patients usually require decompression surgery to relieve the compressed cervical cord. Posterior cervical laminectomy without fusion (PCL) is a known and commonly practiced surgical procedure for multiple levels of DCM [3,4]. In the 1980s, concerns were raised regarding the post-PCL without fusion kyphosis as a sequel to laminectomy without fusion. Many authors, including Mikawa et al. [5], Ishida et al. [6], Matsunaga et al. [7], and Kaptain et al. [8], have reported 14%, 24%, 34%, and 47% of post-PCL without fusion kyphosis, respectively. Post-PCL without fusion kyphosis has led the spine community to start considering new techniques in spine decompression, for example, open-door laminoplasty, double-door laminoplasty, selective laminectomy, and laminectomy with fusion [9–11].

Several studies have reported that preoperative hypolordosis or kyphosis has a negative impact on postoperative cervical curves and outcomes. Various factors explain this, such as decreased anterior decompression, reduction of posterior spinal shifting, increased intramedullary pressure, and reduction of arterial filling [12–17]. Interestingly, van Geest et al. [18] reported that 15% of PCL without fusion developed cervical kyphosis, especially those with preoperative Cobb angle <20°. However, the development of post-PCL without fusion kyphosis is not yet explained.

This study aims to study the cervical spine sagittal alignment post-PCL without fusion in patients with DCM and correlate this to preoperative radiological parameters.

Patients and methods

This is a retrospective analytical cohort study of patients with DCM who underwent posterior cervical laminectomy (PCL) without fusion between January 2017 and January 2020 at our institution. After the formal consent forms of the patients were revised and hospital management acceptance is granted, the surgical database of the hospital was used to find the data for DCM patients underwent PCL without fusion (C3–C6) regardless of their preoperative clinical status or Cobb angle. This study included all patients with complete medical records for at least 24 months postoperatively; any age or gender group was included. This study excluded patients who underwent instrumented fusion, revision cervical surgeries, and posterior laminectomy for pathologies other than DCM, such as tumors, syringomyelia, and patients with T-score > -2.5. Demographic data of the patients were collected and analyzed.

Radiological evaluation was performed using a standard lateral cervical spine X-ray. We measured the Cobb angle from C2 to C7, and a comparison between pre-ad postoperative angles was analyzed. Decreased cervical Cobb angle is defined when the difference between the pre- and postoperative Cobb angle is more than 1° [19].

The cervical sagittal vertical axis (cSVA) of C2–C7 and C7 slope angles were measured. All measurements were done using Surgimap v2.3 (Nemaris, New York, USA).

Operative technique

All patients underwent the same procedure under general anesthesia in a prone position on the spine frame with the head fixed on the Mayfield fixator. Standard surgical sterilization and draping were conducted. Midline posterior incision followed by interfascial dissection until exposing the desired spinal levels. C2 was palpated for leveling. Laminectomy was done in all cases from C3 to C6 by Leksell and Kerrison rongeurs with total removal of the spinous process, lamina in a piecemeal fashion until reaching the lateral masses. After adequate hemostasis, the wound was closed in a multilayer fashion and a suction drain was inserted. All patients wore standard hard neck collars for 3 weeks postoperatively.

Statistical analysis

The data collected from medical records were coded and entered using Microsoft Excel Software. Collected data were processed using SPSS version 19 (SPSS Inc., Chicago, IL, USA). The quantitative data were expressed as means ± SD, while the qualitative data were expressed as numbers and percentages (%). The test of normality by the Shapiro–Wilk test (Table 1) and correlation tests were done by Spearman's correlation. Nonparametric test procedures were done by the Wilcoxon-signed ranks test. A probability value of p value < 0.05 was considered statistically significant.

Results

The total number of patients who underwent PCL without fusion was 71 from January 2017 to January

Table 1. Tests of normality.

Parameters	Kolmogorov–Smirnov[a]			Shapiro–Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre Cobb	0.167	47	0.002	0.923	47	0.004
Pre-cSVA	0.219	47	0.000	0.880	47	0.000
Pre-C7 slope	0.192	47	0.000	0.908	47	0.001
Post–Cobb	0.210	47	0.000	0.863	47	0.000
Post-cSVA	0.284	47	0.000	0.598	47	0.000
Post-C7 slope	0.268	47	0.000	0.831	47	0.000

[a] Lilliefors significant correction.

Table 2. Summary of demographic data (n = 48).

Parameters	Results
Age/years	56.1 ± 7.5 (48–63)
Sex	Females 12 (25%)
	Males 36 (75%)
BMI kg/m^2	28.4 ± 3.8 (24.8–33.6)
Smoking	21 (43.75%)

2020. Only 48 met our inclusion criteria and were reported. The demographic data are summarized in Table 2. The mean age was 56.1 ± 7.5 years. In total, 12 patients were females and 36 were males. The mean BMI was 28.4 ± 3.8 kg/m^2, and 21 patients (43.75%) were smokers.

The mean cervical Cobb angle was 22.02 ± 14.4°, the mean cSVA was 14.32 ± 10.3 mm, and the mean C7 slope angle was 27.84 ± 11.35°. The 24 months postoperative results in comparison to preoperative data are summarized in Table 3. The mean Cobb angle and C7 slope increased non-significantly from 22.02 ± 14.4 to 22.24 ± 9.121 and from 27.84 ± 11.35 to 29.18 ± 6.95°, respectively, after 24 months. In contrast, the mean cSVA increased significantly from 14.32 ± 10.3 to 18.25 ± 11.46 mm. Only 14 patients, 29.1%, developed a decrease in the cervical Cobb angle (difference between pre- and postoperative cervical Cobb angle >1°) after 24 months (Figs. 1 and 2).

Table 4 summarizes the Spearman correlation analysis between the radiological parameters and the decreased cervical Cobb angle. Only two radiological factors were correlated to the decreased cervical Cobb angle after 24 months which were the preoperative C2-C7 Cobb angle and the C7 slope angle. The cSVA showed no correlation to the decreased cervical Cobb angle after 24 months.

Discussion

In this study, there was a non-statistically significant increase between the preoperative cervical Cobb angle and the C7 slope angle after 24 months. Only the cSVA should a significant increase after 24 months. 14/48 patients (29.1%) were found to have decreased cervical Cobb angle after 24 months. The Spearman correlation test reported a positive correlation between decreased cervical Cobb angle after 24 months and preoperative cervical Cobb angle and C7 slope angle; however, there was no correlation with preoperative cSVA.

Posterior cervical laminectomy (PCL) without fusion is a technique used to decompress the cervical cord in multiple-level DCM. It depends on the posterior shifting of the cord and widens the cervical canal [20,21]. PCL without fusion has been reported in the literature to have disadvantages, including postoperative lost sagittal cervical lordosis and kyphotic deformity; also, it is reported by various articles to be a potential cause of worsening of the axial neck pain and neurologic deterioration [7,19,22,23]. These reported disadvantages have raised concerns regarding PCL without fusion and the utilization of fixation techniques to overcome the disadvantages of PCL [24,25].

Decreased cervical Cobb angle after PCL without fusion is reported in various literature to occur between 33% and 70.7% [7,26,27]. However, it is reported in various articles that the senile changes to the cervical spine tend to increase the cervical Cobb angle, thus influencing the long-term changes after PCL without fusion [28–32]. Lofgren et al. [33], in 2020, in their article studying the long-term changes of PCL without fusion in DCM, reported that after eight years there were no significant differences between preoperative and postoperative cervical Cobb angle. They reported the preoperative mean cervical Cobb angle was 8.6°, the immediate follow-up was 3.4°, and after 8 years was 9.6°. They supposed that the statistical reduction in the immediate follow-up could result from the spasm and pain resulting from the cervical extensor muscles

Table 3. Radiological comparison between pre- and postoperatively (n = 48).

Parameters	Preoperatively	24 months postoperatively	*P*-value
C2-C7 Cobb angle/degrees	22.02 ± 14.4 (0.6–48.3)	22.24 ± 9.121 (10.9–39.3)	0.304
cSVA/mm	14.32 ± 10.3(-5.5–33.3)	18.25 ± 11.46 (9.9–53.6)	0.013[a]
C7 slope angle/degrees	27.84 ± 11.35 (8.1–45)	29.18 ± 6.95(19.2–38.2)	0.649

[a] Significant results with a confidence interval of 95% and *P*-value <0.05.

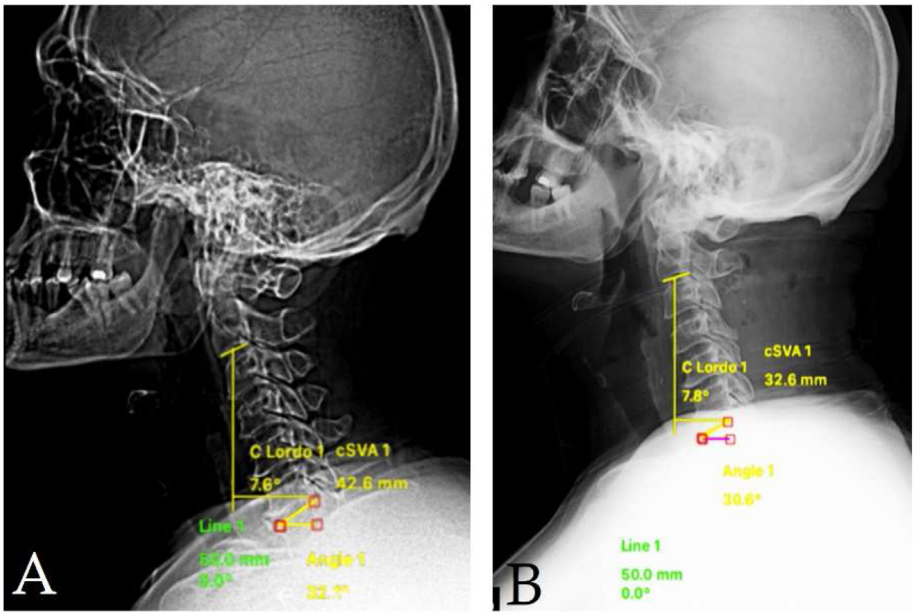

Fig. 1. (A) Preoperative sagittal parameters cervical Cobb angle = 7.6°, cSVA = 42.6 mm, and C7 slope angle = 32.1°. (B) Postoperative operative sagittal parameters cervical Cobb angle = 7.8°, cSVA = 32.6 mm, ND C7 slope angle = 30.6°.

detachment related to the posterior cervical approach. Some authors postulated that the cervical Cobb angle was found to increase naturally to compensate for the senile increase in thoracic kyphosis as a correction to the sagittal alignment of the spine to maintain a horizontal gaze [14,31,34,35]. Yoon and Shin, in 2019, in a retrospective study, reported that 74.7% of their patients developed loss of cervical Cobb angle, and 85.7% were in the laminectomy and fixation group, higher than the laminectomy without fixation group. This contradicts the role of the posterior instrumentation in preserving the sagittal balance postoperatively [36].

In addition, the cSVA and the C7 slope angle have an age-related change, as reported in earlier studies [28–32]. This could attribute to age and gender preferences, and it is also correlated with the senile increase in thoracic kyphosis [14,31,34,35]. The increase in cSVA and C7 slope in this study cannot be directly linked to the surgical approach when taking into consideration the normal increase related to the aging process. There are few published articles to

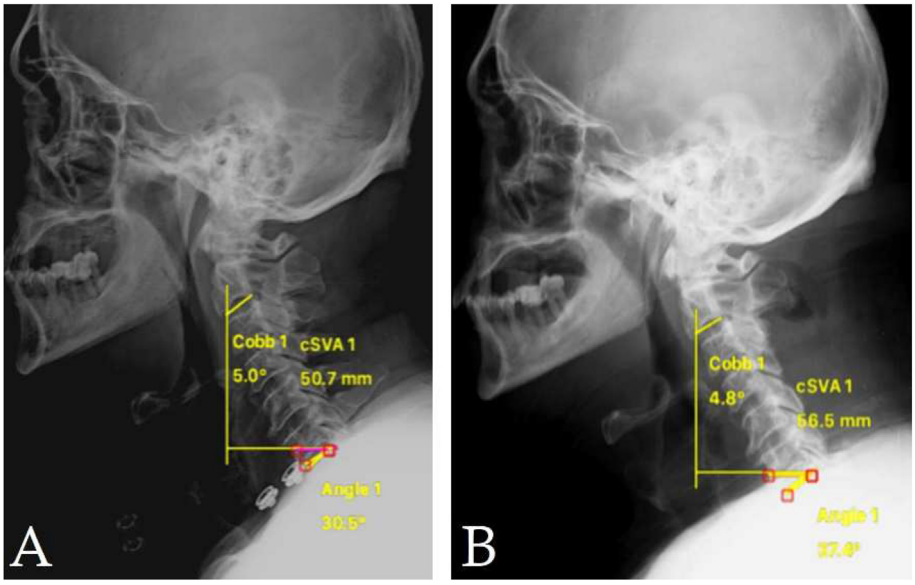

Fig. 2. (A) Preoperative sagittal parameters cervical Cobb angle = 5.0°, cSVA = 50.7 mm, and C7 slope angle = 30.5°. (B) Postoperative operative sagittal parameters cervical Cobb angle = 4.8°, cSVA = 56.5 mm, and C7 slope angle = 37.4°.

Table 4. Spearman's rho correlation test.

Parameters	Difference
Pre Cobb angle	0.673[a]
cSVA/mm	−0.67
C7 slope angle	0.618[a]

[a] Significant results with a confidence interval 95% and *P*-value <0.01.

analyze the progression of the C7 slope angle. Lofrgren et al. [33] in their study reported an increase in the cSVA and C7 slope angle after an 8-year follow-up. They analyzed their data compared to other articles and found that long-term follow-ups after PCL without fusion are affected not only by the surgery but also by the senile sagittal correction mechanisms secondary to thoracic kyphosis.

Akai et al. [37] reported increased cSVA after PCL without fusion, and they stated that this increase is unsuitable for DCM patients with preoperative compromised sagittal balance. Tang et al. [27] reported that the increase of cSVA associated with the decrease in cervical Cobb angle worsens the HRQOL and increases the debility of the patients. Several authors reported that the increased cSVA and lost cervical Cobb angle are poor predictors for PCL without fusion postoperatively [27,38]. In contrast, some authors reported that the changes in the cervical sagittal parameters are not linked to the clinical outcomes of the DCM patients postoperatively [26,39,40]. Also, Jain et al. [41], in their comparative study of the PCL in patients with and without preoperative cervical kyphosis, reported that kyphosis did not affect the surgical outcomes.

In their study, van Geest et al. [18] reported that 10/66 patients developed post-PCL without fusion kyphosis and 3/10 had >10° kyphosis. Kyphosis almost occurred in patients with their preoperative cervical Cobb angle <20°. Kaptain et al. [8] also reported that patients with preoperative, nearly straight cervical spines had twice the risk of developing post-PCL without fusion kyphosis compared to those with preserved preoperative cervical lordosis. Lofrgren et al. [33] reported no correlation between any preoperative radiological parameter and post-PCL without fusion decreased cervical Cobb angle. Farrokhi et al. [41] proposed a cut-off point to preoperative cervical Cobb angle of >10° kyphosis to perform PCL without fusion as utilization of instrumentation is recommended. Kimmel and Maurer [42] proposed that PCL without fusion should be preserved for those patients with reasonable cervical lordosis and not be considered for those with frank kyphosis; however, they did not present a specific degree of the cervical Cobb angle.

This is a retrospective study of a small sample size of patients, which affected our statistically significant results. This study focused only on the radiological parameters, not the clinical outcomes. The dropout rates in the follow-up period decreased the total sample size of the article.

Conclusion

Preoperative cervical Cobb angle and C7 slope angle may correlate to the decreased postoperative cervical Cobb angle. In light of the study findings, it is recommended that long-term follow-ups of PCL without fusion surgeries are very crucial to truly reflects the natural senile process effects on the cervical sagittal balance.

Ethics Information

The article does not contain information about medical device(s)/drug(s).

Conflict of interest

The authors report no conflicts of interest.

Author declaration of funding statement

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Abbreviations

BMI	Body mass index
CV	Cervical vertebrae
cSVA	Cervical Sagittal vertical axis
DCM	Degenerative cervical myelopathy
HRQOL	Health-related quality of life
PCL	Posterior cervical laminectomy

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