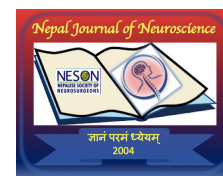


Does Surgical Intervention on Posterior Cervical Muscles During Posterior Cranial Fossa Surgery Alter Cervical Sagittal Alignment?

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Abstract

Introduction: Posterior cervical muscles play a crucial role in maintaining cervical lordosis and may be disrupted by posterior cervical surgery. Numerous studies have explored the relationship between muscle preservation and cervical lordosis following posterior cervical surgeries. However, limited attention has been paid to the changes in cervical sagittal alignment after posterior cranial fossa surgery. This study assessed the impact of posterior cranial fossa surgery on cervical sagittal alignment.

Materials and Methods: This study included 21 patients who underwent lateral suboccipital craniotomy at our institution. Radiographic assessments were performed preoperatively and at 12 and 24 months postoperatively, using cervical lateral radiographs. Cervical alignment parameters, including the Cobb angle between the C2 and C7 inferior endplate (C2–7 Cobb angle), were measured over time. Patients were divided into two groups: lordosis (C2–7 Cobb angle $\geq 10^\circ$, $n = 14$) and straight or kyphosis (C2–7 Cobb angle $< 10^\circ$, $n = 7$) groups.

Results: The Wilcoxon signed-rank test showed no significant differences between the pre-and postoperative data across all measured parameters ($p > 0.05$). However, when patients were stratified by their preoperative C2–7 Cobb angle, the postoperative C0–7 Cobb angle was significantly smaller than the preoperative value in patients in the straight/kyphosis group relative to those in the lordosis group ($p = 0.03$, Wilcoxon signed-rank test).

Conclusion: Sagittal cervical alignment was preserved after lateral suboccipital craniotomy. However, in patients with a straight or kyphotic alignment, posterior cranial fossa surgery can significantly affect occipitocervical parameters, warranting careful postoperative monitoring.

Key words: Cervical alignment, Cervical lordosis, Posterior cranial fossa, Posterior cervical muscles, Sagittal balance

INTRODUCTION

The importance of cervical sagittal balance has been recognized in both normal and diseased states.^{1,2} Therefore, increasing attention is being focused on the factors associated with maintaining cervical lordosis.³ For example, posterior cervical muscles play an important role in maintaining cervical lordosis.^{4,5} Detachment of these muscles, including

the semispinalis cervicis muscle on the C2 spinous process, is known to contribute to kyphotic alignment following posterior decompression surgery.⁶ Growing awareness of the importance of functional cervical muscles has led to the development of various techniques to maintain muscle attachment to spinous processes.^{7,8}

In contrast, posterior cranial fossa surgery necessitates detachment of the insertion points of several muscles, including the splenius capitis, semispinalis capitis, rectus capitis, and superior oblique capitis muscles.⁹ These muscles play an important role in stabilizing the head in an upright position, maintaining the lordotic alignment of the cervical spine, and facilitating dynamic head and neck movements.^{5,10} Preservation of the posterior cervical musculature in posterior cervical surgeries, such as laminoplasty, influences postoperative cervical lordosis and range of motion (ROM).^{7,8} However, relatively limited attention has been paid so far to cervical sagittal alignment following posterior cranial fossa surgery.

If cervical alignment is affected by an invasive procedure involving the posterior cervical muscles, the operative procedure should naturally be re-evaluated and revised. To our knowledge, no previous study has evaluated the changes in cervical sagittal alignment following posterior cranial fossa surgery, compared to the preoperative condition. The purpose of

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the present study was to examine the impact of posterior cranial fossa surgery on sagittal cervical alignment.

Materials and Methods

This study was approved by the ethics committee of our institution. Informed consent for the use of their data in general research was obtained from all patients. This study included 21 patients who underwent posterior cranial fossa surgery at our institution between August 2016 and February 2019. The inclusion criteria were: (1) patients with posterior fossa craniotomy; (2) patients with benign disease not requiring postoperative chemotherapy or radiation therapy. We excluded patients with previous cranial or cervical spine surgeries, and patients with severe neck malalignment (sagittal vertical axis > 40 mm).

Patient demographics and diagnoses are listed in Table 1. All patients underwent lateral suboccipital craniotomy in the lateral decubitus position.

Table 1: Patient demographics and their diagnoses

Total	21
Men/Women	6/15
Average age	61.9 ± 12 years
Diagnoses	Schwannoma 8 Meningioma 4 Trigeminal neuralgia 5 Hemifacial spasm 4

Surgical Procedures

After induction of general anesthesia, patients were positioned laterally with the head secured in a Mayfield head frame. A lazy-S-shaped skin incision was made posterior to the mastoid process. The subcutaneous tissue was sharply undermined to widen the skin incision. After harvesting a thin layer of subcutaneous tissue for dural closure, the sternocleidomastoid muscle was dissected and reflected anteriorly. The insertion of the splenius capitis muscle, extending from the superior nuchal line to the mastoid process, was detached, split along its fibers, and retracted bilaterally. The lateral margin of the semispinalis capitis muscle was subsequently dissected and retracted. The third layer of the suboccipital muscle was detached from the inferior nuchal line and retracted inferiorly. A free bone flap was created with two burr holes, and the surgical procedure was performed. After completion of the intradural procedure, the bone flap was restored using titanium plates. Detached muscle insertions were repositioned as fully as possible using absorbable sutures. A cervical collar was not applied postoperatively.

Radiographic Evaluation

Radiographic assessments were performed preoperatively and at 12 and 24 months postoperatively, using dynamic lateral cervical radiographs. All lateral cervical radiographs (neutral, flexed, and extended) were obtained in standardized sitting positions. The patients sat on a stool with their arms hanging down loosely, and their heads were upright with a horizontal gaze. The evaluated imaging parameters included the C0–2, C0–7, C1–2, C1–7, C2–7 Cobb angle, ROM, C7 slope, and C2–C7 sagittal vertical axis (SVA) (Figure 1).

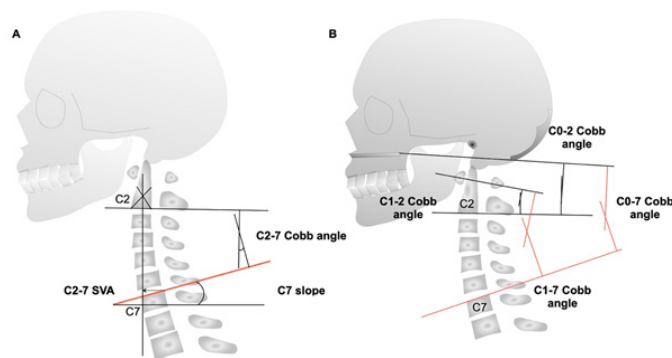


Figure 1: Measured radiographic parameters in the patient population

A: Schema showing the C2–7 Cobb angle, C2–7 SVA, and C7 slope.

B: Schema demonstrating the C0–2, C0–7, C1–2 and C1–7 Cobb angle.

The Cobb angles between the McGregor line and the C2 lower endplate (C0–2 Cobb angle), McGregor line and C7 lower endplate (C0–7 Cobb angle), the C1 line (the line connecting the centers of the anterior and posterior arch of the atlas) and C2 lower endplate (C1–2 Cobb angle), the C1 line and C7 lower endplate (C1–7 Cobb angle), and the lower end plates of C2 and C7 (C2–7 Cobb angle) were measured on X-ray images. We also evaluated the C7 slope (the angle between the horizontal line and the C7 lower endplate) and C2–7 SVA (the distance from the posterosuperior corner of C7 and the vertical line from the center of the C2 body). Lordosis was recorded as positive and kyphosis as negative. The cervical ROM was defined as the sum of the C2–7 Cobb angle at flexion and extension on lateral radiographs.

Based on their preoperative C2–7 Cobb angle, the 21 patients were divided into two groups: the lordosis group (C2–7 Cobb angle ≥ 10°) (n = 14) and the straight/kyphosis group (C2–7 Cobb angle < 10°) (n = 7).

Statistical Analysis

The results are presented as mean ± standard deviation. Statistically significant differences between the preoperative and postoperative parameters were determined using the Wilcoxon signed-rank test. Intergroup comparisons between the lordosis and straight/kyphosis groups were performed using the Mann–Whitney U test. All statistical analyses were performed using SPSS ver. 21.0 (SPSS Inc, Chicago, IL, USA). Statistical significance was set at p values < 0.05.

Results

The final study population included 21 patients (6 men, 15 women). Their average age was 61.9 ± 12 years. Their clinical pathologies included 8 vestibular schwannomas, 4 posterior fossa meningiomas, 5 trigeminal neuralgias, and 4 hemifacial spasms. They successfully underwent 21 lateral suboccipital approaches (Table 1).

Table 2 shows the average cervical sagittal alignment of the patients in the study. Preoperative C2–7 Cobb angle was 10.5

$\pm 8.1^\circ$, and their cervical ROM was $45.3 \pm 15^\circ$. The average C7 slope was $22.0 \pm 5.8^\circ$, the average C2–7 SVA was 18.9 ± 9.7 mm, the average C0–2 Cobb angle was $15.5 \pm 9.9^\circ$, the average C1–2 Cobb angle was $29.3 \pm 5.1^\circ$, the average C0–7 Cobb angle was $26.0 \pm 7.0^\circ$, and C1–7 Cobb angle was $39.4 \pm 7.0^\circ$.

Table 2: Average cervical sagittal alignment in 21 patients

Parameters (n = 21)	Value	Standard deviation
C2–7 Cobb angle ($^\circ$)	10.5	8.1
Range of motion ($^\circ$)	45.3	15
C7 slope ($^\circ$)	22.0	5.8
C2–7 SVA	18.9	9.7
C0–2 Cobb angle ($^\circ$)	15.5	9.9
C1–2 Cobb angle ($^\circ$)	29.3	5.1
C0–7 Cobb angle ($^\circ$)	26.0	7.0
C1–7 Cobb angle ($^\circ$)	39.4	7.0

SVA: sagittal vertical axis

Table 3 shows a comparison of patients' preoperative and postoperative radiological parameters. Postoperative radiographs were obtained after an average of 17 months. For all measured parameters, the Wilcoxon signed-rank test showed no significant difference between pre- and postoperative values ($p > 0.05$).

Table 3: Comparison of cervical sagittal alignment between patient pre- and postoperative radiological data

Parameters (n = 21)	Preoperative	Postoperative	p value
C2–7 Cobb angle ($^\circ$)	10.5 ± 8.1	10.3 ± 12	0.63
Range of motion ($^\circ$)	45.3 ± 15	46.2 ± 13	0.75
C7 slope ($^\circ$)	22.0 ± 5.8	21.9 ± 7.8	0.99
C2–7 SVA	18.9 ± 9.7	19.1 ± 11	0.88
C0–2 Cobb angle ($^\circ$)	15.5 ± 9.9	15.1 ± 9.0	0.54
C1–2 Cobb angle ($^\circ$)	29.3 ± 5.1	29.2 ± 5.2	0.73
C0–7 Cobb angle ($^\circ$)	26.0 ± 7.0	25.6 ± 9.3	0.59
C1–7 Cobb angle ($^\circ$)	39.4 ± 7.0	39.9 ± 9.4	0.64

SVA: sagittal vertical axis

Next, we assessed the differences in preoperative and postoperative parameters classified according to preoperative cervical sagittal alignment. We divided the 21 patients into two groups: the lordosis (C2–7 Cobb angle $\geq 10^\circ$) (n = 14) and the straight/kyphosis group (C2–7 Cobb angle $< 10^\circ$) (n = 7).¹¹ Table 4 summarizes the radiological measurements of these two groups. While the lordosis group exhibited significantly greater C2–7, C0–7, and C1–7 Cobb angles ($p < 0.05$, Mann–Whitney U-test), the C0–2 Cobb angle was significantly greater in the straight/kyphosis group ($p = 0.02$, Mann–Whitney U-test). As expected from the cervical alignment data, C2–7 SVA was also greater in the straight/kyphosis than in lordosis group ($p = 0.02$, Mann–Whitney U-test).

Table 4: Radiological parameters of patients in the lordosis and the straight/kyphosis groups

Parameters (n = 21)	Lordosis group (n = 14)	Straight/kyphosis group (n = 7)	p value
C2–7 Cobb angle ($^\circ$)	15.1 ± 3.8	1.2 ± 5.8	0.00
Range of motion ($^\circ$)	45.6 ± 14	44.8 ± 18	0.64
C7 slope ($^\circ$)	22.6 ± 6.2	20.9 ± 5.1	0.54
C2–7 SVA (mm)	15.9 ± 7.6	25.0 ± 11	0.02
C0–2 Cobb angle ($^\circ$)	11.7 ± 7.2	23.0 ± 11	0.02
C1–2 Cobb angle ($^\circ$)	27.7 ± 4.4	32.5 ± 5.3	0.07
C0–7 Cobb angle ($^\circ$)	27.1 ± 7.8	23.7 ± 7.5	0.00
C1–7 Cobb angle ($^\circ$)	42.6 ± 4.0	33.0 ± 7.5	0.00

SVA: sagittal vertical axis

Table 5 shows pre- and postoperative cervical sagittal alignment in the lordosis group. There was no significant difference between preoperative and postoperative data, ($p > 0.05$, Wilcoxon signed-rank test). Postoperative alignment decreased in the straight/kyphosis group compared to preoperative values (Table 6), although this difference was not statistically significant. However, the postoperative C0–7 Cobb angle was significantly smaller than the preoperative value ($p = 0.03$, Wilcoxon signed-rank test).

Table 5: Comparison of cervical sagittal alignment in pre- and postoperative patients with lordosis alignment

Parameters (n = 14)	Preoperative	Postoperative	p value
C2–7 Cobb angle ($^\circ$)	15.1 ± 3.8	16.1 ± 9.1	0.40
Range of motion ($^\circ$)	45.6 ± 14	45.2 ± 11	0.98
C7 slope ($^\circ$)	22.6 ± 6.2	23.2 ± 7.2	0.46
C2–7 SVA (mm)	15.9 ± 7.6	16.7 ± 8.0	0.88
C0–2 Cobb angle ($^\circ$)	11.7 ± 7.2	12.6 ± 8.7	0.78
C1–2 Cobb angle ($^\circ$)	27.7 ± 4.4	28.4 ± 5.3	0.48
C0–7 Cobb angle ($^\circ$)	27.1 ± 7.8	28.6 ± 6.7	0.57
C1–7 Cobb angle ($^\circ$)	42.6 ± 4.0	44.6 ± 5.6	0.36

SVA: sagittal vertical axis

Table 6: Comparison of cervical sagittal alignment in pre- and postoperative patients with straight/kyphosis alignment

Parameters (n = 7)	Preoperative	Postoperative	p value
C2–7 Cobb angle ($^\circ$)	1.2 ± 5.8	-1.2 ± 6.4	0.59
Range of motion ($^\circ$)	44.8 ± 18	48.1 ± 18	0.50
C7 slope ($^\circ$)	20.9 ± 5.1	19.0 ± 8.9	0.40
C2–7 SVA (mm)	25.0 ± 11	23.8 ± 14	0.74
C0–2 Cobb angle ($^\circ$)	23.0 ± 11	20.2 ± 7.8	0.24
C1–2 Cobb angle ($^\circ$)	32.5 ± 5.3	30.8 ± 5.0	0.12
C0–7 Cobb angle ($^\circ$)	23.7 ± 7.5	19.5 ± 11	0.03
C1–7 Cobb angle ($^\circ$)	33.0 ± 7.5	30.7 ± 9.0	0.35

SVA: sagittal vertical axis

Discussion

This study examined cervical sagittal alignment after posterior cranial fossa surgery in 21 patients and found no significant differences between their pre- and postoperative measurements. Interestingly, when these patients were separated into two groups based on their preoperative C2–7 Cobb angle, the postoperative C0-, C1-, and C2-associated parameters were seen to be reduced in both groups, relative to their preoperative value. Further, the postoperative C0–7 Cobb angle was significantly smaller than the preoperative angle in patients in the straight/kyphosis group relative to those in the lordosis group. To our knowledge, this is the first study to investigate the impact of posterior cervical muscle detachment on cervical sagittal alignment following posterior cranial fossa surgery.

Posterior cervical muscles are known to play an important role in maintaining cervical lordosis.^{3–8} Nolan and Sherk reported that the extensor musculature functions as a dynamic stabilizer, and that laminectomy involving removal of semispinalis attachments to the axis leads to loss of normal cervical alignment.⁴ Vasavada et al. noted that the semispinalis cervicis plays a major role in neck extension movement generating capacity.⁵ Previous clinical studies have also emphasized the importance of preservation of the semispinalis cervicis for preventing the loss of lordosis after laminoplasty.^{6–8} Presently, a certain degree of consensus has been reached regarding the importance of the alignment of the cervical spine and the cervical extensor muscles in posterior cervical surgeries. In contrast, while several posterior cervical extensor muscles are separated during posterior cranial fossa surgery, changes in cervical alignment after cranial surgery, especially in adult cases, have received limited attention. Several authors have retrospectively examined cervical instabilities following posterior fossa surgery with laminectomies in pediatric patients.^{12–14} They defined postoperative radiographical kyphotic deformity, swan neck deformity, or increased mobility as spinal deformity/instability.^{12–14} Although postoperative cervical instabilities were encountered, no instances of spinal deformity occurred following posterior fossa craniectomy, with or without C1 laminectomy. Previous studies have indicated that the number of combined laminectomies is an essential factor and that laminectomy extending below the C2 level can accelerate the risk of cervical instability.^{12–14}

In the present study, sagittal cervical alignment was preserved after lateral suboccipital craniotomy. This is in agreement with the results of previous clinical observations in which posterior cranial fossa craniotomy alone did not cause postoperative cervical instabilities. In our study, we did not perform laminectomies, even at the C1 level, which may have positively influenced cervical alignment.

Our patients underwent hemilateral suboccipital craniotomy with separation of the overlying suboccipital muscles. The splenius and semispinalis capitis muscles, which play an important role in stabilizing the head in an upright position and maintaining the lordotic alignment of the cervical spine, are occasionally affected by surgical procedures. Although surgical manipulation is limited to the operative side, the contralateral muscles remain intact and functional, and are unlikely to affect cervical alignment. Takeuchi et al. indicated in their experimental study of cervical laminoplasty that reattachment of the muscle to the original site is important for muscle reconstruction.¹⁵ In

our study, the splenius and semispinalis capitis muscles were repositioned as much as possible during wound closure, which may have contributed to alignment preservation.

In the present study, the preoperative average cervical C2–7 Cobb angle was $10.5 \pm 8.1^\circ$, indicating lordotic alignment. Patients with lordosis are expected to maintain their postoperative alignment. To assess the impact of preoperative cervical alignment, we divided the patients into two groups: lordosis and straight/kyphosis. While postoperative alignment was retained in the lordosis group, the postoperative C0-, C1-, and C2-associated parameters were lower than preoperative values in the straight/kyphosis group, with substantial differences observed in the C0–7 Cobb angle. The suboccipital muscles between the occipital bone and the atlas and/or axis are separated during surgery and are not typically restored to their original positions. These processes can degrade the function of the suboccipital muscles, affecting occipitocervical parameters in patients with straight/kyphotic alignment. Careful follow-up is recommended for patients with preoperative non-lordotic alignment.

Our study had certain limitations. The sample size was small, and the follow-up period was too short to draw definitive conclusions. We included only patients who underwent hemicraniotomy without laminectomy. Posterior fossa surgery has several variations, including bilateral suboccipital craniotomy and C1 laminectomy. A more extensive craniotomy combined with laminectomy may exert a greater impact on cervical alignment. Further investigation is warranted to elucidate this relationship.

Conclusion

This study demonstrated that sagittal cervical alignment was preserved after lateral suboccipital craniotomy. However, in patients with a straight/kyphotic alignment, posterior cranial fossa surgery can affect occipitocervical parameters, indicating that careful follow-up is required for such cases.

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Conflict Of Interest

The author(s) declare that they do not have any conflict of interest regarding the publication of this article.

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