Spine

SPINE Volume 46, Number 9, pp 567–570

CERVICAL SPINE

A Comparison of Three Different Positioning Techniques on Surgical Corrections and Postoperative Alignment in Cervical Spinal Deformity (CD) Surgery

Kyle W. Morse, MD,[a] Renaud Lafage, MS,[a] Peter Passias, MD,[b] Christopher P. Ames, MD,[c] Robert Hart, MD,[d] Christopher I. Shaffrey, MD,[e] Gregory Mundis, MD,[f] Themistocles Protopsaltis, MD,[b] Munish Gupta, MD,[g] Eric Klineberg, MD,[h] Doug Burton, MD,[i] Virginie Lafage, PhD,[a] and Han Jo. Kim, MD[a], International Spine Study Group

Study Design. Retrospective review of a prospective multicenter cervical deformity database.

Objective. To examine the differences in sagittal alignment correction between three positioning methods in cervical spinal deformity surgery (CD).

Summary of Background Data. Surgical correction for CD is technically demanding and various techniques are utilized to achieve sagittal alignment objectives. The effect of different patient positioning techniques on sagittal alignment correction following CD remains unknown.

Methods. Patients with sagittal deformity who underwent a posterior approach (with and without anterior approach) with an upper instrumented vertebra of C6 or above. Patients with Grade 5, 6, or 7 osteotomies were excluded. Positioning groups were Mayfield skull clamp, bivector traction, and halo ring. Preoperative lower surgical sagittal curve (C2–C7), C2–C7 sagittal vertical axis (cSVA), cervical scoliosis, T1 slope minus cervical lordosis (TS–CL), T1 slope (T1S), chin-brow vertebral angle (CBVA), C2–T3 curve, and C2–T3 SVA was assessed and compared with postoperative radiographs. Segmental changes were analyzed using the Fergusson method.

Results. Eighty patients (58% female) with a mean age of 60.6 ± 10.5 years (range, 31–83) were included. The mean postoperative C2–C7 lordosis was 7.8° ± 14 and C2–C7 SVA was 34.1 mm ± 15. There were overall significant changes in cervical alignment across the entire cohort, with improvements in T1 slope ($P < 0.001$), C2–C7 ($P < 0.001$), TS–CL ($P < 0.001$), and cSVA ($P = 0.006$). There were no differences postoperatively of any radiographic parameter between positioning groups ($P > 0.05$). The majority of segmental lordotic correction was achieved at C4–5–6 (mean 6.9° ± 11). Additionally, patients who had bivector traction applied had had significantly more segmental correction at C7–T1–T2 compared with Mayfield and halo traction (4.2° *vs.* 0.3° *vs.* –1.7° respectively, $P < 0.027$).

Conclusion. Postoperative cervical sagittal correction or alignment was not affected by patient position. The majority of segmental correction occurred at C4–5–6 across all positioning methods, while bivector traction had the largest corrective ability at the cervicothoracic junction.

Key words: bivector traction, cervical spinal deformity, cervicothoracic kyphosis, halo, mayfield, surgical planning.

Level of Evidence: 4

Spine 2021;46:567–570

The purpose of this study was to examine the differences in sagittal alignment correction between three positioning methods in cervical spinal deformity (CD) surgery. With the complexity of CD surgery, patient

---

From the [a]Department of Orthopaedic Surgery, Hospital for Special Surgery, New York, NY; [b]Department of Orthopaedic Surgery, New York University Hospital for Joint Diseases, New York; [c]Department of Neurological Surgery, University of California, San Francisco, San Francisco, CA; [d]Department of Orthopaedic Surgery, Oregon Health and Science University, Portland, OR; [e]Department of Neurosurgery, Duke University, Durham, NC; [f]San Diego Center for Spinal Disorders, La Jolla, CA; [g]Department of Orthopaedic Surgery, Washington University, St Louis, MO; [h]Department of Orthopaedic Surgery, University of California, Davis, Sacramento, CA; and [i]Department of Orthopaedic Surgery, University of Kansas Medical Center, Kansas City, KS.

Acknowledgment date: June 26, 2020. First revision date: August 23, 2020. Second revision date: September 27, 2020. Acceptance date: October 8, 2020.

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

The International Spine Study Group Foundation grant funds were received in support of this work.

Relevant financial activities outside the submitted work: board membership, consultancy, grants, royalties, payment for lectures, travel/accommodations/meeting expenses.

Address correspondence and reprint requests to Kyle W. Morse, MD, Hospital for Special Surgery, 535 East 70th Street, New York, NY 10021; E-mail: morsek@hss.edu

DOI: 10.1097/BRS.0000000000003851

TABLE 1. Radiographic Parameters and Additional Criteria for Study Inclusion

Radiographic Parameters	Measurement
Lower surgical sagittal curve (C2–C7)	$<0^o$
C2–C7 sagittal vertical axis (cSVA)	>4 cm
Cervical scoliosis	$>10^o$
T1 slope minus cervical lordosis (TS–CL)	$>20^o$
Chin-brow vertebral angle (CBVA)	$>25^o$
Additional inclusion criteria	
Available postoperative lateral radiographs	
Intraoperative positioning data	
Posterior approach (with and without anterior approach)	
Upper instrumented vertebral level (UIV) of C6 or above	

positioning may ultimately impact sagittal correction. Multiple positioning techniques are currently utilized, including bivector traction, halo ring, and the Mayfield skull clamp. We hypothesized that there would be no difference between cervical positioning techniques and the degree of postoperative sagittal correction achieved.

MATERIALS AND METHODS

Study Design

A multicenter retrospective analysis of a CD database (2013–2016) that utilized preoperative and postoperative lateral radiographs in patients at least 18 years of age undergoing surgical correction above the C6 level was performed. Inclusion criteria included at least one of the radiographic and additional criteria listed in Table 1. Patients were excluded if they underwent Grade 5, 6, or 7 osteotomies.[1]

Patients and Data Collection

Eighty patients were included in the study. Patient demographic and surgical data are listed in Table 2. Preoperative and postoperative radiographs were reviewed and C2–C7, C2–C7 sagittal vertical axis (cSVA), cervical scoliosis, T1 slope minus cervical lordosis (TS–CL), T1 slope (T1S), chin-brow vertebral angle (CBVA), C2–T3 curve, and C2–T3 SVA were recorded.

Statistics

All data analysis was performed using SPSS Version 20.0 (International Business Machines [IBM], Armonk, NY). Statistical tests were utilized as displayed in Table 3. Alignment was compared between positioning groups and segmental alignment was analyzed using the Fergusson method.[2,3] Segmental correction between C2 and T5 was analyzed and Pearson correlations were performed to determine a relationship between the number of levels fused and segmental correction. Statistical significance was defined as $\alpha = 0.05$.

TABLE 2. Patient Demographic and Surgical Data

Patient Demographic and Surgical Data	N (%)
Sex	
Female	46 (58%)
Male	34 (42%)
Age	60.6 ± 10.5 years (range, 31–83)
BMI	29.2 ± 8.0 kg/m^2 (17–58)
Surgical positioning	
Mayfield skull clamp	48 (60%)
Bivector traction	20 (25%)
Halo ring	12 (15%)
Approach	
Posterior only	39 (49%)
Combined anterior and posterior	41 (51%)
Primary or revision surgery	28 (35%)
Primary surgery	52 (65%)
Revision surgery	28 (35%)

RESULTS

Baseline Characteristics and Postoperative Radiographic Parameters

There were no differences in baseline cervical radiographic parameters, demographics, primary *versus* revision surgery, or preoperative sagittal flexibility between groups ($P > 0.05$). The most common Upper Instrumented Vertebral (UIV) levels were C2 (59%) and C3 (28%). The bivector traction group had the most levels fused compared with halo ring and Mayfield (13.8 *vs.* 8.9 *vs.* 8.9 levels, $P < 0.004$, respectively).

Cervical alignment improved across the entire cohort, however, neither the difference between preoperative to postoperative radiographic parameters nor postoperative alignment achieved were different amongst position groups (Table 4). Lastly, while there was a trend towards smaller postoperative C2–T3 SVA in the halo ring group, the difference was not statistically significant compared with bivector traction and Mayfield.

Segmental Correction

There was lordotic correction in the cervical spine with the majority of segmental correction achieved at C4–5–6 (Figure 1). Patients who had bivector traction applied had significantly more segmental correction at C7–T1–T2

TABLE 3. Statistical Tests

Variable	Statistical Test
Demographics	Descriptive statistics
Categorical variables	Pearson Chi-Square
Scale variables	Analysis of Variance

TABLE 4. Mean Preoperative and Postoperative Radiographic Parameters Between Positioning Groups

Radiographic Parameter	T1 Slope, °	C2–C7, °	cSVA, mm	TS–CL, mm	C2–T3, °	C2–T3 SVA, mm
Preoperative lateral						
Mayfield	28.8 ± 17.1	−11.3 ± 20.8	38.0 ± 19.6	40.2 ± 20.5	−19.8 ± 19.9	76.6 ± 40.1
Bivector	31.5 ± 16.4	−7.7 ± 20.4	41.5 ± 19.2	39.2 ± 19.5	−16.5 ± 24.7	73.4 ± 32.4
Halo	25.7 ± 15.3	−13.5 ± 25.6	32.5 ± 17.6	39.2 ± 16.8	−15.8 ± 20.3	58.4 ± 34.4
Total	29.0 ± 16.6	−10.7 ± 21.2	38.1 ± 19.2	39.8 ± 19.5	−18.3 ± 21.1	73.2 ± 37.4
Preoperative extension						
Mayfield	27.7 ± 14.3	2.2 ± 19.1	30.3 ± 20.7	25.3 ± 20.9	–	–
Bivector	26.7 ± 18.5	0.5 ± 21.4	33.8 ± 18.3	26.5 ± 19.1	–	–
Halo	20.5 ± 20.7	−2.6 ± 29.8	18.5 ± 18.0	17.3 ± 11.3	–	–
Total	26.4 ± 16.3	1.0 ± 21.4	29.3 ± 20.0	24.4 ± 19.4	–	–
Postoperative lateral						
Mayfield	38.7 ± 18.7	8.2 ± 14.0	35.6 ± 14.9	30.5 ± 15.2	−0.7 ± 13.0	84.0 ± 33.3
Bivector	36.7 ± 11.4	9.4 ± 10.9	35.0 ± 13.3	27.2 ± 14.2	−0.8 ± 16.0	73.0 ± 24.5
Halo	29.2 ± 14.8	3.4 ± 20.9	27.0 ± 16.5	25.8 ± 12.9	−5.0 ± 13.6	57.7 ± 32.6
Total	36.8 ± 16.8***	7.8 ± 14.5***	34.1 ± 14.9***	29.0 ± 14.6**	−1.5 ± 13.9	76.2 ± 32.1

Radiographic parameters include T1 slope, lower surgical sagittal curve (C2–C7), C2–C7 sagittal vertical axis (cSVA), T1 slope minus cervical lordosis (TS–CL), C2–T3 curve (C2–T3), and C2–T3 sagittal vertical axis (C2–T3 SVA).

***$P < 0.01$.*

****$P < 0.001$ from baseline.*

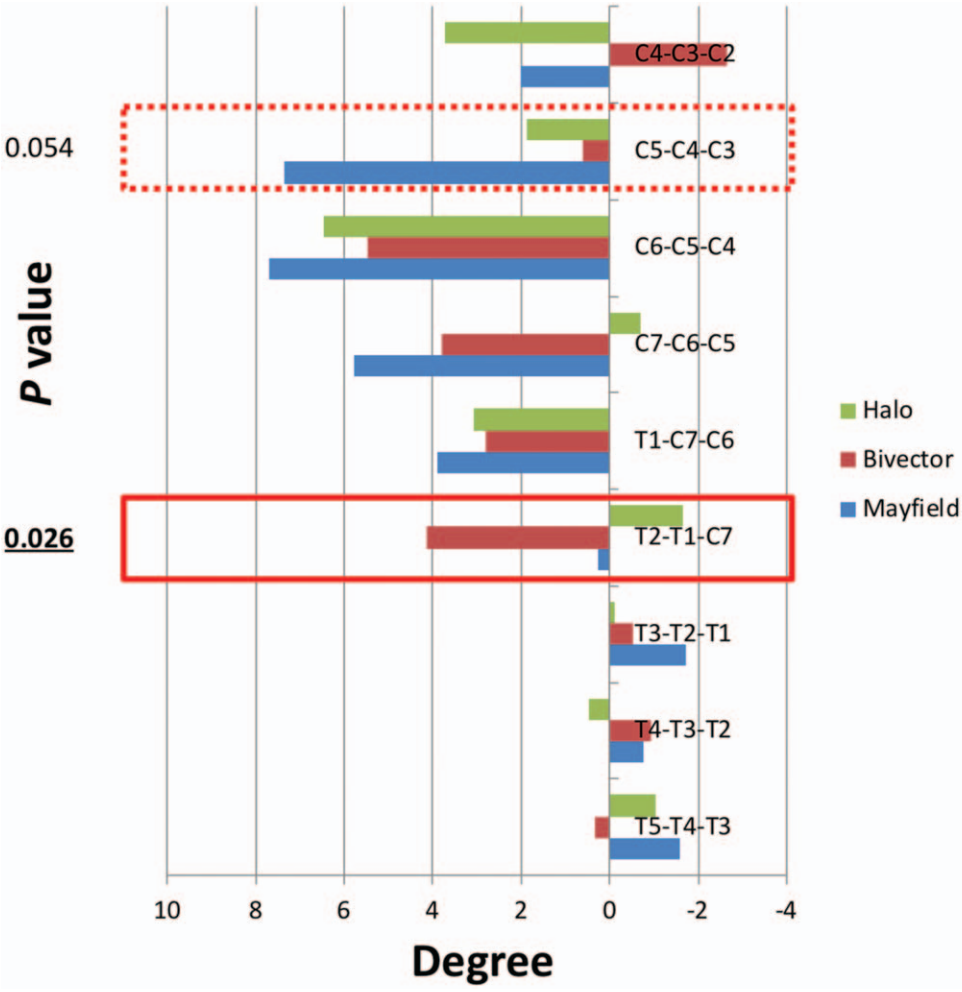

Figure 1. Comparison of segmental correction between three different intraoperative positions: Mayfield skull clamp, bivector traction, and halo traction.

compared with Mayfield and halo (Figure 1). No significant correlations existed between the number of levels fused and segmental correction (Pearson r, $P > 0.05$).

DISCUSSION

The purpose of this study was to examine the differences in sagittal alignment correction between three positioning methods in cervical spinal deformity surgery. We found significant improvements in postoperative alignment across the entire cohort despite the positioning method utilized (Table 4) with the majority of segmental correction occurring at C4–5–6. These results confirm our hypothesis that positioning technique did not affect postoperative sagittal correction for patients with sagittal deformity with the exception of bivector traction providing segmental correction at the cervicothoracic junction ($P < 0.027$).

Surgical positioning must allow adequate anatomic exposure, ergonomic favorability for the surgeon, the ability to visualize the spine fluoroscopically, and the prevention of positioning related injuries to the patient. CD surgery can create intraoperative instability as osteotomies are performed and control is required to prevent injury to the spinal cord.[4,5] Karikari *et al*[6] used bivector traction by adapting Gardner-Wells tongs during posterior cervical fusion. This positioning technique has several reported advantages. The patient's head can be maintained in flexion during exposure, decompression, facet decortication, and screw placement to allow for easier decortication and oblique screw trajectories and avoids excessive hyperextension, which can lead to spinal canal narrowing, ligamentum invagination, and laminae shingling.[6,7] The neck can then be moved into extension for arthrodesis. The position can also be changed without the necessity of the surgical team breaking scrub. The authors reported no complications related to this technique and improvements in cervical lordosis with the most common fusion levels between C2 and T3.[6] We report increased segmental correction at C7–T1–T2 and the use of bivector traction may be more useful for constructs that cross the cervicothoracic junction. Despite an advantage at the cervicothoracic junction, there was no overall difference in sagittal correction suggesting that surgeons should use a positioning technique that they are most comfortable with.

This study has several limitations inherent to its retrospective nature and use of a database. The sample size is relatively small and given the multicenter nature of the study, the positions utilized may be more site specific than patient specific resulting in variability. Additionally, the cohort includes both cervical and cervicothoracic deformity.

In conclusion, postoperative cervical sagittal correction or alignment was not affected by patient position. The majority of segmental correction occurred at C4–5–6 across all positioning methods, while bivector traction had the largest corrective ability at the cervicothoracic junction. These are important considerations for surgical planning in cervical deformity surgery.

➢ Key Points

- ❑ Post-operative cervical sagittal correction or alignment was not affected by patient position.
- ❑ The majority of segmental correction occurred at C4–5–6 across all positioning methods.
- ❑ Bivector traction has the largest corrective ability at the cervicothoracic junction.

References

1. Ames CP, Smith JS, Scheer JK, et al. A standardized nomenclature for cervical spine soft-tissue release and osteotomy for deformity correction: clinical article. *J Neurosurg Spine* 2013;19:269–78.
2. Kittleson AC, Lim LW. Measurement of scoliosis. *Am J Roentgenol Radium Ther Nucl Med* 1970;108:775–7.
3. Stokes IA, Aronson DD, Ronchetti PJ, et al. Reexamination of the Cobb and Ferguson angles: bigger is not always better. *J Spinal Disord* 1993;6:333–8.
4. Callahan RA, Brown MD. Positioning techniques in spinal surgery. *Clin Orthop Relat Res* 1981;22–6.
5. Cho SK, Safir S, Lombardi JM, et al. Cervical spine deformity: indications, considerations, and surgical outcomes. *J Am Acad Orthop Surg* 2019;27:e555–67.
6. Karikari IO, Bumpass DB, Gum J, et al. Use of bivector traction for stabilization of the head and maintenance of optimal cervical alignment in posterior cervical fusions. *Glob Spine J* 2017;7:227–9.
7. Manabe N, Shimizu T, Tanouchi T, et al. A novel skull clamp positioning system and technique for posterior cervical surgery: clinical impact on cervical sagittal alignment. *Medicine (Baltimore)* 2015;94:e695.