



Evaluation of MRI-based cervical alignment parameters following suboccipital decompression in adult Chiari Type 1 patients

Cervical alignment after Chiari surgery

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Abstract

Aim: Chiari malformation type 1 (CM-1) involves the craniovertebral junction and may influence cervical sagittal alignment, particularly at the upper cervical level. However, postoperative changes in sagittal alignment parameters remain unclear. This study aimed to evaluate the effect of suboccipital decompression on cervical sagittal alignment parameters in adult CM-1 patients and to investigate the possible influence of syringomyelia.

Methods: Thirty-five adult patients who underwent suboccipital decompression for CM-1 were retrospectively analyzed. We evaluated preoperative and first-year postoperative cervical MRI data. We measured cervical lordosis (CL), C2–C7 sagittal vertical axis (CSVA), C7 slope, T1 slope, and O–C2 angle using a standardized MRI protocol. We performed a subgroup analysis based on the presence of syringomyelia.

Results: No statistically significant differences were observed between preoperative and postoperative measurements of CL, CSVA, C7 slope, or T1 slope. Subgroup analysis revealed no significant differences in global sagittal parameters between patients with and without syringomyelia. However, a significant difference in O–C2 angle change was observed between patients with and without syringomyelia, with a significant decrease in patients without syringomyelia.

Conclusion: Suboccipital decompression was not associated with significant changes in cervical sagittal alignment parameters in adult CM-1 patients at one-year follow-up. Although a significant difference in O–C2 angle change was observed according to syringomyelia status, further studies are needed to clarify its significance.

Keywords

Chiari malformation, sagittal balance, suboccipital decompression, magnetic resonance imaging, neurosurgery

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Introduction

Chiari malformation (CM) is a craniovertebral junction anomaly characterized by the herniation of the cerebellar tonsils through the foramen magnum into the spinal canal. Different types of Chiari malformations have been identified. Cases in which cerebellar tonsillar herniation exceeds 5 mm into the spinal canal are classified as Type 1 Chiari malformation, which is the most common type.^{1,2} These cases are typically asymptomatic and rarely require surgical intervention. The standard surgical procedure for CM-1 involves suboccipital craniectomy, C1 laminectomy, and, when the cerebellar tonsils extend below C2, partial C2 laminectomy. Additional procedures such as duraplasty and occipitocervical fusion may be included in the surgical technique.³

The cervical spine is the most mobile segment of the spinal column, facilitating head movement in various directions while surrounding critical structures such as the medulla spinalis and vertebral artery. It is divided into two segments: the upper cervical block, comprising the occiput, C1, and C2 vertebrae, and the lower cervical block, spanning from the inferior end plate of C2 to the inferior end plate of C7. These two blocks differ in biomechanics and mobility, and changes in one may affect the other.^{4,5} Common parameters used to assess cervical sagittal balance include cervical lordosis (CL), the C2–C7 sagittal vertical axis (CSVA), the occiput-C2 angle, the condylar-C2 SVA, the thoracic inlet angle (TIA), the C7 slope, and the T1 slope.

Chiari malformation type 1 requires surgical decompression of the craniovertebral junction, which may affect the upper cervical block (i.e., occiput–C2 region). Given this region's key role in overall cervical alignment, it remains unclear how such surgical interventions affect global cervical sagittal balance. In clinical practice, surgeons are often concerned about the potential impact of posterior decompression on cervical sagittal alignment and postoperative neck pain. Whether preservation of posterior muscular and ligamentous structures can prevent deterioration in cervical alignment remains an important clinical question. The aim of this study was to evaluate the effect of suboccipital decompression on cervical sagittal alignment in adult CM-1 patients.

Materials and Methods

This retrospective study was approved by the Educational Planning Board (EPB) of our hospital (Protocol No: E-62977267-771-240826572) and was conducted in accordance with the principles of the Declaration of Helsinki.

Between 2017 and 2023, 61 patients underwent surgery for Chiari malformation type 1 (CM-1) at our institution. Of these, 35 adult patients with complete preoperative and postoperative one-year cervical magnetic resonance imaging (MRI) examinations were included in the study. As a tertiary referral and training hospital

serving a wide geographic area, a substantial proportion of our patients are referred from outside the local region. Of the 61 patients who underwent surgery during the study period, 26 could not be included because complete preoperative and/or one-year postoperative cervical MRI examinations were unavailable in the hospital records or accessible electronic health records, or because adequate follow-up imaging could not be obtained. Patients with a history of cervical trauma or previous cervical spine surgery were also excluded. Consequently, 35 adult patients with complete preoperative and one-year postoperative cervical MRI examinations were included in the final analysis. The cohort consisted of 7 men and 28 women.

All patients underwent suboccipital decompressive craniectomy and C1 laminectomy. No patient required C2 laminectomy. During surgery, the occipital and paravertebral muscles between the inion and the C2 spinous process were dissected bilaterally in a subperiosteal manner. Particular attention was paid to preserving the muscular and ligamentous attachments to the C2 spinous process in all patients in order to maintain posterior cervical tension-band integrity. In patients without syringomyelia, the dura was not opened. In patients with syringomyelia, we opened the dura, performed duraplasty, and, when present, released underlying arachnoid bands. No manipulation or resection of the cerebellar tonsils was performed in any patient.

We retrospectively obtained clinical and radiological data from hospital records. We evaluated preoperative and first-year postoperative midsagittal cervical MRI scans. We measured cervical lordosis (CL), C2–C7 sagittal vertical axis (CSVA), O–C2 angle, C7 slope, and T1 slope using a standardized MRI protocol. We assessed the presence of syringomyelia; 15 patients had syringomyelia, 20 did not, and subgroup analyses were performed accordingly.

The same surgeon performed all radiological measurements using a standardized protocol to ensure consistency. Interobserver and intraobserver reliability were not formally assessed.

Ethical Approval

This study was approved by the University of Health Sciences Haydarpasa Numune Training and Research Hospital Educational Planning Board (Date: 26.03.2024, Decision No: E-62977267-771-240826572).

Statistical Analysis

Data analyses were performed using IBM SPSS Statistics for macOS, Version 30.0 (IBM Corp., Armonk, NY, USA). We used the Kolmogorov–Smirnov test to assess the normality of continuous variables. Categorical variables were presented as n (%), and continuous variables as mean (SD) or median (interquartile range [IQR]), as appropriate. We used the independent-samples t-test or Mann–Whitney U test for comparisons between independent groups. We used the paired-samples t-test or Wilcoxon signed-rank test for preoperative and postoperative comparisons, as appropriate.

Table 1. Distribution Of Preoperative And Postoperative Clinical Findings

Variables (N = 35)	Pre-op Mean ± SD	Pre-op Median (IQR)	Post-op Mean ± SD	Post-op Median (IQR)	P value
Cervical lordosis	8.22 ± 7.3	6.1 (2.4-11.2)	9.91 ± 5.78	9.3 (5.6-13.4)	.081 ^a
CSVA	12.92 ± 5.6	11.7 (7.8-17.7)	12.91 ± 6.1	13.1 (7.4-16.6)	.994 ^b
C7 Slope	13.96 ± 6.9	12.5 (8.8-18.3)	12.87 ± 6	11.8 (9.1-17.7)	.163 ^b
T1 Slope	18.66 ± 6.96	18.2 (11.6-24.3)	18.42 ± 6.7	17.6 (12.5-24.9)	.778 ^b
O-C2	29.00 ± 3.01	29.5 (27.1-31.4)	28.04 ± 3.28	28.2 (26.8-30.4)	.072 ^b

SD, Standard deviation; IQR, Interquartile range; a, Wilcoxon Signed Rank Test; b, Paired Sample T Test.

Table 2. Distribution Of Demographic And Clinical Findings According To Gender

Characteristics (N = 35)	Male Mean ± SD	Male Median (IQR)	Female Mean ± SD	Female Median (IQR)	P value
Age (y)	41 ± 13	43 (28-49)	42 ± 12	42 (33-50)	.779 ^a
Cervical Lordosis					
Pre-op	11.73 ± 11.05	8.7 (2.2-31.5)	7.34 ± 6	5.7 (0.7-21.2)	.300 ^b
Post-op	10.97 ± 8.57	6.8 (1.8-25.6)	9.65 ± 5.04	9.45 (1.7-19.8)	.952 ^b
P value (within group)	.735 ^c		.042 ^c		
(Post-Pre)	-0.8 ± 4.1	-0.8 ± 4.1	2.3 ± 6.3	2.3 ± 6.3	.235 ^a
CSVA					
Pre-op	10.91 ± 3.59	10.9 (6.4-16.9)	13.42 ± 5.95	11.8 (3.5-25.8)	.297 ^a
Post-op	8.54 ± 4.49	7.4 (4.2-14.1)	14 ± 6.01	15.4 (5.1-25.4)	.032 ^a
P value (within group)	.246 ^d		.598 ^d		
(Post-Pre)	-2.4 ± 4.9	-2.4 ± 4.9	0.6 ± 5.8	0.6 ± 5.8	.223 ^a
C7 Slope					
Pre-op	18.99 ± 7.56	18.5 (8.2-29.9)	12.7 ± 6.25	11.8 (3.8-33.1)	.029 ^a
Post-op	16.16 ± 4.06	16.5 (11.6-21.5)	12.05 ± 6.18	10.95 (2.5-30)	.107 ^a
P value (within group)	.180 ^d		.439 ^d		
(Post-Pre)	-2.8 ± 4.9	-2.8 ± 4.9	-0.7 ± 4.4	-0.7 ± 4.4	.258 ^a
T1 Slope					
Pre-op	26.41 ± 4.99	25.2 (20.6-34.4)	16.72 ± 6	15.85 (8-29.5)	<.001 ^a
Post-op	24.81 ± 5.2	24 (19.1-32.5)	16.82 ± 6.1	16.35 (6.7-27.7)	.003 ^a
P value (within group)	.293 ^d		.921 ^d		
(Post-Pre)	-1.6 ± 3.7	-1.6 ± 3.7	0.1 ± 5.3	0.1 ± 5.3	.428 ^a
O-C2					
Pre-op	26.5 ± 3.6	26.7 (23.7-29.2)	29.6 ± 2.6	29.6 ± 2.6	.011 ^a
Post-op	24.8 ± 2.9	26 (22.3-27.4)	28.9 ± 2.9	28.9 ± 2.9	.002 ^a
P value (within group)	.403 ^d		.112 ^d		
(Post-Pre)	-1.6 ± 4.8	-1.6 ± 4.8	-0.8 ± 2.5	-0.8 ± 2.5	.520 ^a

SD, Standard deviation; IQR, Interquartile range; ^a, Independent Sample T Test; ^b, Mann Whitney U Test; ^c, Wilcoxon Signed Rank Test; ^d, Paired Sample T Test.

Changes in measurements (Δ ; postoperative minus preoperative values) were compared between groups using the independent-samples *t*-test or Mann–Whitney *U* test, as appropriate. A two-sided *P* < .05 was considered statistically significant.

Reporting Guidelines

This study was reported in accordance with the STROBE guideline.

Results

The study included 35 patients, 7 men (20%) and 28 women (80%). The median age was 42 years (IQR: 32–50), ranging from 19 to 69 years.

The preoperative and postoperative first-year measurements are presented in Table 1. Mean CL was 8.22° (7.3) preoperatively and 9.91° (5.78) postoperatively. Mean CSVA values were 12.92 (5.6) mm and 12.91 (6.1) mm, respectively. Mean C7 slope values were 13.96° (6.9) and 12.87° (6.0), while mean T1 slope values were 18.66° (6.96) and 18.42° (6.7), respectively. Mean O–C2 angle values were 29.00° (3.01) preoperatively and 28.04° (3.28) postoperatively. No significant differences were found between preoperative and postoperative values of CL, CSVA, C7 slope, T1 slope, or O–C2 angle. The demographic and radiological parameters according to sex are shown in Table 2. No significant difference in age was observed between sexes. Among preoperative measurements, C7 slope and T1 slope differed significantly between sexes (*P* = .029 and *P* < .001, respectively). In postoperative evaluations, CSVA, T1 slope, and O-C2 measurements also differed significantly by sex (*P* = .032, *P* = .003, and *P* = .002, respectively). In within-group

analyses, cervical lordosis changed significantly over time among women patients (*P* = .042) (Table 2).

Age did not differ significantly between patients with and without syringomyelia. No significant differences were found between groups in preoperative or postoperative CL, CSVA, C7 slope, T1 slope, or O–C2 angle values. However, the change in O–C2 angle differed significantly between groups (*P* = .033). In the within-group analysis, patients without syringomyelia showed a significant decrease in O–C2 angle (*P* < .001).

Discussion

Chiari malformation Type 1 (CM-1) is the most common form of Chiari malformation and is characterized by cerebellar tonsillar herniation through the foramen magnum.⁶ Surgical treatment is indicated in patients with neurological deficits, syringomyelia, or brainstem-related symptoms.^{3,7} Posterior suboccipital decompression is the standard surgical approach; however, variations such as duraplasty or fusion remain controversial and may increase complication rates.^{8–10} Since CM-1 primarily involves the craniovertebral junction, surgical decompression may influence cervical sagittal alignment by affecting posterior muscular and ligamentous structures.

The cervical spine is the most mobile part of the spinal column. It comprises two functional segments: the upper cervical block (occiput to C2 vertebra) and the lower cervical block (C2 to the lower end plate of C7 vertebra). Despite anatomical differences, these regions function together to maintain stability and coordinated

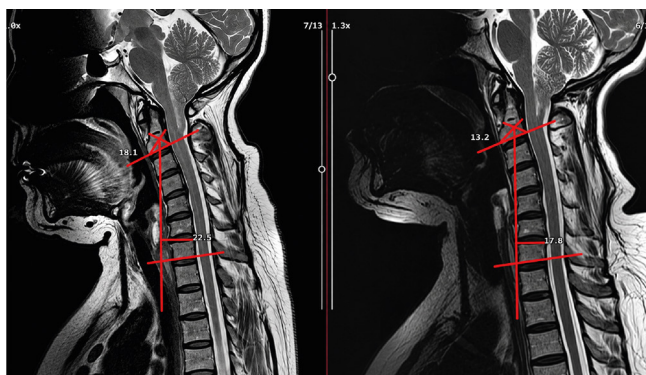


Figure 1. Preoperative (left) and postoperative (right) cervical MRI demonstrating the measurement of cervical lordosis (CL), cervical sagittal vertical axis (cSVA) on mid-sagittal MRI

study, all measurements were performed using MRI obtained with a standardized protocol. Because we aimed to compare preoperative and postoperative measurements within the same patient cohort, using a single imaging modality provided consistent and reliable intra-patient comparisons. In addition, MRI remains indispensable for diagnosing and following up CM-1 patients because of its detailed anatomical evaluation.

Previous comparative studies have demonstrated correlations between radiographic and MRI-based measurements, although certain values may vary depending on patient positioning. Liu et al. reported that despite differences between MRI and X-ray measurements, significant correlations exist, and MRI can be used to evaluate cervical sagittal balance under standardized imaging conditions.¹² We acknowledge that supine MRI does not incorporate physiological gravitational loading and therefore may not reproduce cervical alignment measured on standing radiographs. To minimize variability related to imaging modality and positioning, however, we obtained all preoperative and postoperative measurements using the same standardized MRI protocol, allowing consistent intra-patient comparisons. Nevertheless, these MRI-based measurements should not be considered equivalent to weight-bearing sagittal alignment assessed on standing radiographs.

Numerous studies have evaluated spinal sagittal balance parameters. Preservation of cervical lordosis after surgery has been associated with improved quality of life in patients with cervical stenosis, trauma, and discopathy.^{17,18} Scheer et al. emphasized the importance of maintaining cervical sagittal balance to preserve neurological function and identified cervical lordosis as a key parameter of overall cervical alignment.¹⁹ However, because the present study did not assess clinical outcomes, the observed radiological findings cannot be directly related to postoperative symptoms or functional outcomes.

To date, studies specifically evaluating postoperative sagittal balance changes following Chiari type 1 decompression remain limited. Furthermore, the potential influence of syringomyelia on postoperative alignment has received little attention. Because syringomyelia may alter spinal biomechanics through chronic neural and muscular changes, comparing sagittal alignment parameters in patients with and without syringomyelia may provide additional insight into postoperative alignment changes.

In our study of patients undergoing surgery for Type 1 Chiari malformation, we observed no statistically significant differences in cervical lordosis (CL) between preoperative and postoperative measurements at the 1-year follow-up. Similarly, we detected no significant changes in CSVA, C7 slope, T1 slope, or O–C2 angle.

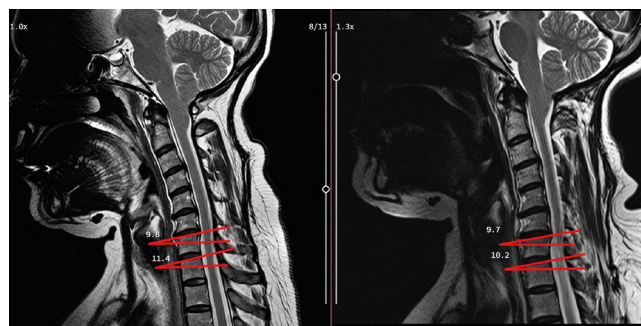


Figure 2. Preoperative (left) and postoperative (right) cervical MRI demonstrating the measurement of C7 slope and T1 slope on mid-sagittal MRI

Subgroup analysis showed that syringomyelia did not significantly affect preoperative or postoperative values of these parameters. However, the change (Δ) in the O–C2 angle differed significantly between patients with and without syringomyelia, with a significant decrease observed in patients without syringomyelia. Given the number of statistical comparisons performed and the relatively small subgroup sizes, interpret this finding within these methodological constraints. Given the role of the upper cervical region in horizontal gaze and global sagittal balance, the O–C2 angle represents an important component of cervical sagittal alignment.

Previous studies have emphasized the importance of preserving posterior muscular and ligamentous structures for maintaining cervical alignment. Surgical techniques that minimize disruption of these structures have been associated with better postoperative alignment outcomes.^{20–22} In our surgical approach, care was taken to preserve posterior muscular and ligamentous attachments, particularly at the level of C2.

Furthermore, the relationship between upper cervical (O–C2) and lower cervical alignment has been well described, with the upper cervical region contributing significantly to overall cervical lordosis.²³ Studies investigating craniocervical junction pathologies have reported variable effects of surgical intervention on cervical alignment parameters.^{24,25}

The absence of direct clinical outcome measures, such as functional or symptom-based assessments, limits the ability to determine whether these radiological changes translate into actual patient benefit. Future studies incorporating clinical outcome measures are required to better clarify the clinical relevance of these findings.

Limitations

This study has several limitations that should be considered when interpreting the findings. The relatively small sample size is particularly relevant in subgroup analyses by syringomyelia status and sex, while excluding patients without complete preoperative and one-year postoperative MRI data may have introduced selection bias. Although the same standardized MRI protocol allowed consistent preoperative and postoperative comparisons, measurements obtained in the supine position may not fully reflect physiological cervical alignment under weight-bearing conditions. Moreover, because the study focused primarily on radiological findings, clinical and functional outcomes were not assessed. Future prospective studies with larger cohorts and combined radiological and clinical assessments may help further define the significance of these findings.

Conclusion

Suboccipital decompression in adult patients with Chiari malformation type 1 was not associated with significant changes in cervical sagittal alignment parameters at one-year follow-up. These findings suggest that overall cervical sagittal alignment remains largely preserved after surgery. A subgroup-specific difference in O–C2 angle change was observed according to syringomyelia status and may warrant further investigation.

Declarations

Animal and Human Rights Statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent

Written informed consent for the surgical procedure and clinical follow-up was obtained from all patients and/or their legal guardians.

Data Availability

The data associated with the paper are available from the corresponding author upon reasonable request.

Conflict of Interest

The authors declare no conflicts of interest.

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Author Contributions (CRediT Taxonomy)

Conceptualization: E.B.K.Ö., A.T.C.
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Resources: E.B.K.Ö.
Data Curation: E.B.K.Ö., K.D.
Writing – Original Draft Preparation: E.B.K.Ö.
Writing – Review & Editing: E.B.K.Ö., A.T.C.
Visualization: E.B.K.Ö.
Supervision: A.T.C.

AI Usage Disclosure

The authors declare that no AI-assisted technologies were used.

Abbreviations

C2: 2nd cervical vertebra
C7: 7th cervical vertebra
CBVA: Chin-brow vertical angle
CL: Cervical lordosis
CM-1: Chiari malformation type-1
CSVA: C2–c7 sagittal vertical axis
MRI: Magnetic resonance imaging
TIA: Thoracic inlet angle

References

1. Loukas M, Noordeh N, Shoja MM, Pugh J, Oakes WJ, Tubbs RS. Hans Chiari (1851-1916). *Childs Nerv Syst.* 2008;24(3):407-409. doi:10.1007/s00381-007-0535-y

2. Badie B, Mendoza D, Batzdorf U. Posterior fossa volume and response to suboccipital decompression in patients with Chiari I malformation. *Neurosurgery.* 1995;37(2):214-218. doi:10.1227/00006123-199508000-00004

3. Passias PG, Pyne A, Horn SR, et al. Developments in the treatment of Chiari type 1 malformations over the past decade. *J Spine Surg.* 2018;4(1):45-54. doi:10.21037/jss.2018.03.14

4. Le Huec JC, Thompson W, Mohsinaly Y, Barrey C, Faundez A. Sagittal balance of the spine. *Eur Spine J.* 2019;28(9):1889-1905. doi:10.1007/s00586-019-06083-1

5. Le Huec JC, Demezon H, Aunoble S. Sagittal parameters of global cervical balance using EOS imaging: normative values from a prospective cohort of asymptomatic volunteers. *Eur Spine J.* 2015;24(1):63-71. doi:10.1007/s00586-014-3632-0

6. Akar E, Kara S, Akdemir H, Kırış A. 3D structural complexity analysis of cerebellum in Chiari malformation type I. *Med Biol Eng Comput.* 2017;55(12):2169-2182. doi:10.1007/s11517-

017-1661-7

7. Speer MC, Enterline DS, Mehlretter L, et al. Review article: Chiari type I malformation with or without syringomyelia: prevalence and genetics. *J Genet Couns.* 2003;12(4):297-311. doi:10.1023/a:1023948921381

8. Karagöz Güzey F, Özer AF. Chiari malformations and syringomyelia. In: Zileli M, Özer AF, eds. *Omurilik ve Omurga Cerrahisi.* 3rd ed. İntertip Yayınevi; 2014:451-468.

9. Batzdorf U, McArthur DL, Bentson JR. Surgical treatment of Chiari malformation with and without syringomyelia: experience with 177 adult patients. *J Neurosurg.* 2013;118(2):232-242. doi:10.3171/2012.10.jns12305

10. Chen J, Li Y, Wang T, et al. Comparison of posterior fossa decompression with and without duraplasty for the surgical treatment of Chiari malformation type I in adult patients: a retrospective analysis of 103 patients. *Medicine (Baltimore).* 2017;96(4):e5945. doi:10.1097/md.0000000000005945

11. Aydın AL, Günerbüyük C, Akgün MY, Çerezci Ö, Öktenoğlu T. Cervical spinal biomechanics. *Türk Nöroşir Derg.* 2022;32(3):314-319.

12. Liu W, Fan J, Bai J, et al. Magnetic resonance imaging: a possible alternative to a standing lateral radiograph for evaluating cervical sagittal alignment in patients with cervical disc herniation? *Medicine (Baltimore).* 2017;96(39):e8194. doi:10.1097/md.0000000000008194

13. Ünsal ÜÜ, Şentürk S, Güvenç Y, Yaman O. Cervical spine coronal-sagittal balance and parameters. *Türk Nöroşir Derg.* 2022;32(3):366-372.

14. Azimi P, Yazdanian T, Benzel EC, Hai Y, Montazeri A. Sagittal balance of the cervical spine: a systematic review and meta-analysis. *Eur Spine J.* 2021;30(6):1411-1439. doi:10.1007/s00586-021-06825-0

15. Boudreau C, Carrondo Cottin S, Ruel-Laliberté J, Mercier D, Gélinas-Phaneuf N, Paquet J. Correlation of supine MRI and standing radiographs for cervical sagittal balance in myelopathy patients: a cross-sectional study. *Eur Spine J.* 2021;30(6):1521-1528. doi:10.1007/s00586-021-06833-0

16. Xing R, Zhou G, Chen Q, Liang Y, Dong J. MRI to measure cervical sagittal parameters: a comparison with plain radiographs. *Arch Orthop Trauma Surg.* 2017;137(4):451-455. doi:10.1007/s00402-017-2639-5

17. Villavicencio AT, Babuska JM, Ashton A, et al. Prospective, randomized, double-blind clinical study evaluating the correlation of clinical outcomes and cervical sagittal alignment. *Neurosurgery.* 2011;68(5):1309-1316. doi:10.1227/neu.0b013e31820b51f3

18. Tang JA, Scheer JK, Smith JS, et al. The impact of standing regional cervical sagittal alignment on outcomes in posterior cervical fusion surgery. *Neurosurgery.* 2012;71(3):662-669. doi:10.1227/neu.0b013e31826100c9

19. Scheer JK, Tang JA, Smith JS, et al. Cervical spine alignment, sagittal deformity, and clinical implications: a review. *J Neurosurg Spine.* 2013;19(2):141-159. doi:10.3171/2013.4.spine12838

20. Deng Y, He J, Chen H, et al. Cervical alignment and range of motion change after anterior 3-level hybrid surgery compared with cervical laminoplasty: a matched cohort study. *Orthop Surg.* 2024;16(8):1893-1902. doi:10.1111/os.14120

21. Chen H, Liu H, Meng Y, et al. Short-term outcomes of anterior fusion-nonfusion hybrid surgery versus posterior cervical laminoplasty in the treatment of multilevel cervical spondylotic myelopathy. *World Neurosurg.* 2018;116:e1007-e1014. doi:10.1016/j.wneu.2018.05.150

22. Katsuura Y, Lemons A, Lorenz E, Swafford R, Osborn J, Cason G. Radiographic analysis of cervical and spinal alignment in multilevel ACDF with lordotic interbody device. *Int J Spine Surg.* 2017;11(2):13. doi:10.14444/4013

23. Nojiri K, Matsumoto M, Chiba K, et al. Relationship between alignment of upper and lower cervical spine in asymptomatic individuals. *J Neurosurg.* 2003;99(1 suppl):80-83. doi:10.3171/spi.2003.99.1.0080

24. Matsubayashi Y, Shimizu T, Chikuda H, Takeshita K, Oshima Y, Tanaka S. Correlations of cervical sagittal alignment before and after occipitocervical fusion. *Global Spine J.* 2016;6(4):362-369. doi:10.1055/s-0035-1563725

25. Zhu C, Wang LN, Chen TY, et al. Sequential sagittal alignment changes in the cervical spine after occipitocervical fusion. *World J Clin Cases.* 2022;10(4):1172-1181. doi:10.12998/wjcc.v10.i4.1172

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