Original Article

Role of preoperative cervical alignment on postoperative dysphagia after occipitocervical fusion

Midori Miyagi[1], Hiroshi Takahashi[2], Hideki Sekiya[3], Satoru Ebihara[1]

Departments of [1]Rehabilitation Medicine and [2]Orthopaedic Surgery, Toho University Graduate School of Medicine, [3]Department of Oral Surgery,

Toho University Omori Medical Center, Ota-ku, Tokyo, Japan.

E-mail: *Midori Miyagi - midori.miyagi@med.toho-u.ac.jp; Hiroshi Takahashi - drkan@med.toho-u.ac.jp; Hideki Sekiya - sekiya-h@med.toho-u.ac.jp; Satoru Ebihara - satoru.ebihara@med.toho-u.ac.jp

*Corresponding author:
Midori Miyagi,
Department of Rehabilitation Medicine, Toho University Graduate School of Medicine, Ota-ku, Tokyo, Japan.

midori.miyagi@med.toho-u.ac.jp

ABSTRACT

Background: Dysphagia is one of the most serious complications of occipitocervical fusion (OCF). The previous studies have shown that postoperative cervical alignment, documented with occipito (O)-C2 angles, C2-C6 angles, and pharyngeal inlet angles (PIA), impacted the incidence of postoperative dysphagia in patients undergoing OCF. Here, we investigated the relationship of preoperative versus postoperative cervical alignment on the incidence of postoperative dysphagia after OCF.

Methods: We retrospectively reviewed the clinical data/medical charts for 22 patients following OCF (2006–2019). The O-C2 angles, C2-C6 angles, PIA, and narrowest pharyngeal airway spaces (nPAS) were assessed using plain lateral radiographs of the cervical spine before and after the surgery. The severity of dysphagia was assessed with the functional oral intake scale (FOIS) levels as documented in medical charts; based on this, patients were classified into the nondysphagia (FOIS: 7) versus dysphagia (FOIS: 1–6) groups.

Results: Seven patients (35%) experienced dysphagia after OCF surgery. Preoperative PIA and nPAS were smaller in the dysphagia group. Spearman rank correlation showed a positive correlation between preoperative PIA and FOIS and between preoperative nPAS and FOIS.

Conclusion: This study suggests that preoperative cervical alignment may best predict the incidence of postoperative dysphagia after OCF.

Keywords: Deglutition, Occipitocervical fusion, Preoperative cervical alignment, The functional oral intake scale

INTRODUCTION

Dysphagia is one of the most serious complications of occipitocervical fusion (OCF).[2,5,15,17,18] In a previous study, postoperative cervical alignment was evaluated utilizing the occipito (O)-C2 and C2-C7 angles, and the narrowest pharyngeal airway space (nPAS) was recognized as a major factor contributing to postoperative dysphagia for patients undergoing OCF.[2,5,17]

This study aimed to investigate how differences between preoperative and postoperative cervical alignment contribute to the frequency and severity of postoperative dysphagia following OCF.

MATERIALS AND METHODS

Subjects

With IRB approval (No. M18017), we retrospectively reviewed the medical charts of patients who underwent OCF at our institute from 2006 to 2019. The major clinical data included; duration of surgery, length of intensive care unit (ICU) stay, duration of ventilator use, and presence or absence of tracheostomy, among others [Table 1]. There were several exclusion criteria as well [Table 2].

Dysphagia evaluation

The severity of dysphagia was assessed using the functional oral intake scale (FOIS) levels determined from the medical chart descriptions of the food intake status of patients.[1] In our institution, patients with FOIS levels 6–7 are monitored by nurses belonging to the respective wards, and patients with FOIS levels 1–5 are monitored by the institutional team for dysphagia rehabilitation and are thoroughly examined using fiber-optic endoscopic and/or video fluoroscopic evaluation of swallowing. The severity of dysphagia was evaluated within 1 week of OCF with the patient in a sitting position where possible.

According to the FOIS level, patients were classified into nondysphagia (FOIS level: 7) and dysphagia (FOIS level: 1–6) groups. FOIS levels are defined as shown in Table 3.[1]

Radiographic measurements

We reviewed plain lateral radiographs of the cervical spine before and after OCF to measure the O-C2 angle, C2-C6 angle, PIA, and nPAS as indicators of the pharyngeal space [Table 4 and Figure 1].[6]

Differences (Δ) in the O-C2 and C2-C6 angles, PIA, and nPAS were calculated as the difference between the postoperative and preoperative values.

We also estimated the presence of soft-tissue swelling in the prevertebral area on plain lateral radiographs of the cervical spine. Rojas *et al.* documented the normal range of prevertebral soft-tissue thickness; accordingly, we considered thicknesses >6 mm at C2, 7 mm at C3, or 18 mm at C6 on plain lateral radiographs to represent prevertebral soft-tissue swelling.[10]

Statistical analysis

The differences in values were compared using the two-tailed *t*-test, the Mann–Whitney *U*-test, or χ^2 test adequately. Spearman correlation coefficients were used to determine the correlation of the FOIS level with the preoperative cervical alignments. Pearson correlation coefficients were used to evaluate the correlation of continuous variables. Statistical significance was set at $P < 0.05$. We used SPSS version 17.0 software (SPSS, Chicago, IL, USA) for all analyses.

RESULTS

Based on the FOIS level, the incidence of dysphagia after OCF surgery was 35% [Table 1]. Interestingly, no patient required ICU admission, tracheostomy, or a ventilator.

Radiographic analysis

Table 5 shows radiographic analysis. Preoperative PIA and preoperative nPAS were significantly smaller in the dysphagia group than in the nondysphagia group ($P = 0.028$ and 0.025, respectively). In contrast, no significant differences in

Table 1: Comparison of clinical data obtained from the medical charts of patients.

Clinical data	Total	Nondysphagia group (*n*=13)	Dysphagia group (*n*=7)	*P*-value
Age (years)	70.1±7.2	68.5±6.7	73.0±7.0	0.195[b]
Female/male	8/12	3/10	5/2	0.062[a]
Body mass index (kg/m^2)	22.7±3.9	23.7±3.7	20.9±3.7	0.143[b]
Duration of surgery (h)	5.9±3.4	5.8±3.4	6.0±3.4	0.926[c]
Thoracic fusion (*n*)	5	2	3	0.176[a]
C2 fracture (*n*)	2	0	2	0.111[a]
Prevertebral soft-tissue swelling (*n*)	3	1	2	0.270[a]
Reason for performing occipitospinal fusion				
Cervical spondylosis (*n*)	6	5	1	0.277[a]
Rheumatoid arthritis (*n*)	5	2	3	0.101[a]
Trauma (*n*)	3	1	2	0.212[a]
Retro-odontoid pseudotumor (*n*)	2	0	2	0.411[a]
Other (*n*)	4	3	1	0.639[a]
Comorbidity				
Hypertension (*n*)	6	3	3	0.613[a]
Diabetes (*n*)	2	2	0	0.521[a]

Values represent mean±standard deviation (range in parentheses). [a]χ^2 test, [b]two-tailed *t*-test, [c]Mann–Whitney U-test

Table 2: Exclusion criteria.

Exclusion criteria	n
1. 1Severe dementia (mini-mental state examination score <10)	0
2. Neurodegenerative disease	0
3. Obvious cerebral infarction	0
4. Spinal cord injury of Grade A or B according to the Frankel classification	1
5. Confused state (Richmond Agitation-Sedation Scale below −2 or above +2)	0
6. Preoperative dysphagia	1

Table 3: The functional oral intake scale.[1]

Level 1	Nothing by mouth
Level 2	Tube dependent with minimal attempts of food or liquid
Level 3	Tube dependent with consistent oral intake of food or liquid
Level 4	Total oral diet of a single consistency
Level 5	Total oral diet with multiple consistencies, but requiring special preparation or compensations
Level 6	Total oral diet with multiple consistencies without special preparation, but with specific food limitations
Level 7	Total oral diet with no restrictions

Table 4: Representative plain lateral radiograph of the cervical spine.

Cervical alignment	
O-C2 angle (°)	The angle between the McGregor's line (line connecting the posterior border of the hard plate and the most caudal portion of the occipital curve) and the inferior endplate line of C2
C2-C6 angle (°)	The angle between the inferior endplate lines of C2 and the inferior endplate lines of C6
PIA (°)	The angle between the McGregor's line and the line connecting the center of the anterior arch of C1 and the apex of cervical sagittal curvature
nPAS (mm)	The narrowest anteroposterior distance of the oropharynx between the tips of the uvula and epiglottis

O-C2 angle: Occipito-C2 angle, PIA: Pharyngeal inlet angle, nPAS: Narrowest oropharyngeal airway space. Positive values for both O-C2 and C2-C6 angles indicate lordosis in the measured segments.

preoperative and postoperative O-C2 and C2-C6 angles were observed between the two groups. Moreover, no significant differences were observed in changes in the O-C2 and C2-C6 angles between the two groups [Table 5].

A positive correlation was found between preoperative PIA and FOIS level ($r = 0.474$, $P = 0.035$; Figure 2a). In addition, a positive correlation was found between preoperative nPAS and FOIS level ($r = 0.465$, $P = 0.039$; Figure 2b). A positive correlation was also found between the preoperative PIA and preoperative O-C2 angle ($r = 0.805$, $P < 0.001$; Figure 3a). A negative correlation was observed between the preoperative PIA and preoperative C2-C6 angle ($r = 0.624$, $P = 0.003$; Figure 3b).

DISCUSSION

The results of this study showed that preoperative PIA and nPAS were significantly smaller in the dysphagia group than in the nondysphagia group. Moreover, we found that both preoperative PIA and nPAS were significantly correlated with FOIS level.

The results of this study revealed that a decrease in preoperative PIA could be a predictor of postoperative dysphagia. According to a recent report by Wang *et al.*,[16] change in PIA could be used to predict postoperative dysphagia in patients undergoing OCF. The decrease in PIA is associated with three causative factors and corresponding angle movements for dysphagia [Table 6]. In our study, the O-C2 angle tended to be smaller and the C2-C6 angle tended to be greater in patients in the dysphagia group. Furthermore, the preoperative O-C2 and C2-C6 angles were significantly correlated with PIA [Figure 3].

A study analyzing the swallowing pressure in healthy participants using high-resolution manometry showed that the duration of lowered swallowing pressure at the upper esophageal sphincter is lesser during the flexion of the craniovertebral junction, which is the first factor leading to a decrease in PIA. Presumably, the bolus passage is inhibited by a decrease in tongue movement and pharyngeal contraction from the flexion of the craniovertebral junction.[8] Therefore, in the dysphagia group, the preoperative PIA could have been decreased due to the flexion of the craniovertebral junction. In fact, in this study, the O-C2 angle tended to be smaller. Therefore, tongue movement and pharyngeal contraction could have been reduced before OCF in the dysphagia group. Our previous study showed that dysphagia in patients treated with a halo-vest brace is caused by decreased O-C2 angle.[9]

The mean age of the patients in the dysphagia group was 73.0 years. A previous study with independently living older individuals showed that 27% had signs of dysphagia in the oropharyngeal phase, and 23% had dysphagia.[11] Therefore, in our study, the potential dysphagia may have become apparent after the surgery because of the additional pharyngeal trauma caused by endotracheal intubation or other surgical insults.

The previous studies on dysphagia associated with intubation have revealed that even a short intubation duration could

be a risk factor for postextubation dysphagia, and hence, endotracheal intubation could be considered a trigger for the incidence of dysphagia. In addition, a previous study reported that postoperative paralysis of the hypoglossal nerve, which
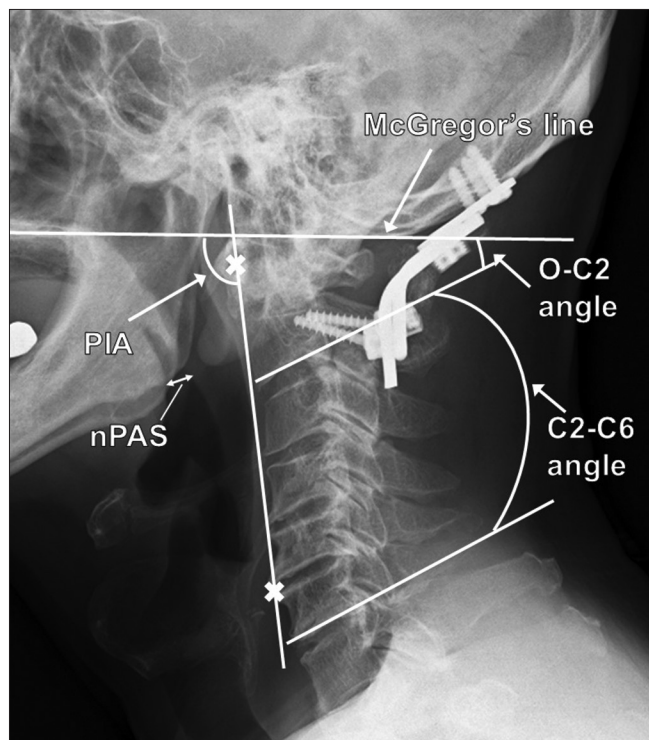
Figure 1: Representative plain lateral radiograph of the cervical spine. O-C2 angle: Occipito-C2 angle, PIA: Pharyngeal inlet angle, nPAS: Narrowest pharyngeal airway space.

is the motor nerve of the tongue, and the vagus nerve, which innervates the pharyngeal contractile muscles, could occur after cervical spinal fusion.[3,12] Paralysis reduced the tongue movement and pharyngeal contraction after the surgery in this study. Thus, potential dysfunctions in swallowing due to aging and preoperative cervical alignment observed in this study could have been discorded by intubation.

The following preoperative factors for predicting the postoperative outcomes have been identified: (1) morbidity and severity, (2) cervical alignment, and (3) imaging findings.

In terms of morbidity and severity, the length and severity of the morbid neuropathy during the surgery are the factors contributing to the poor improvement rate.[14] This could be caused by severe long-term spinal cord damage resulting in irreversible changes in the spinal cord, which have also been demonstrated in autopsy patients with severe long-term cervical myelopathy.[4] Regarding cervical spine alignment, the improvement rate of postoperative JOA scores is poor in patients with cervical kyphosis and increased preoperative C2-7 sagittal vertical axis, that is, in patients with poor preoperative cervical spine alignment.[13] In terms of imaging findings, the transverse area and flattening ratio of the spinal cord on preoperative computed tomography correlates with the improvement rate in postoperative spinal cord symptoms.[7]

All three preoperative factors elucidated in the previous studies are indicators of irreversible functional impairment of the spinal cord. In our study, preoperative factors, rather than postoperative, were associated with postoperative dysphagia, suggesting that preoperative conditions may affect postoperative outcomes.

Table 5: Comparison of radiographic measurements.				
	Total	**Nondysphagia group**	**Dysphagia group**	*P*-value
O-C2 angle (°)				
Pre	23.3±11.8	25.7±11.7	18.9±10.5	0.237
Post	24.4±11.8	26.2±11.0	21.0±12.5	0.379
Δ	1.1±9.1	0.5±8.2	2.1±10.3	0.710
C2-C6 angle (°)				
Pre	10.2±17.1	7.2±17.5	15.7±14.8	0.314
Post	10.9±17.6	9.9±17.1	12.6±18.4	0.764
Δ	−0.2±13.1	1.4±10.8	−3.1±16.1	0.487
PIA (°)				
Pre	98.2±8.7	101.5±7.4	92.1±7.5	*P*<0.05*
Post	98.2±8.2	98.9±7.3	96.9±9.5	0.614
Δ	0.0±9.5	−2.5±7.9	4.7±10.4	0.114
nPAS (mm)				
Pre	18.7±7.1	21.1±7.0	14.3±4.6	*P*<0.05*
Post	16.5±6.3	17.4±5.9	14.7±6.6	0.386
Δ	−2.2±5.5	-3.6±3.7	0.46±6.9	0.121

Values are presented as mean±standard deviation. O-C2 angle: Occipito-C2 angle, Pre: Preoperative, Post: Postoperative, Δ: Differences between the preoperative and postoperative values, nPAS: Narrowest oropharyngeal airway space, PIA: Pharyngeal inlet angle. *Statistically significant
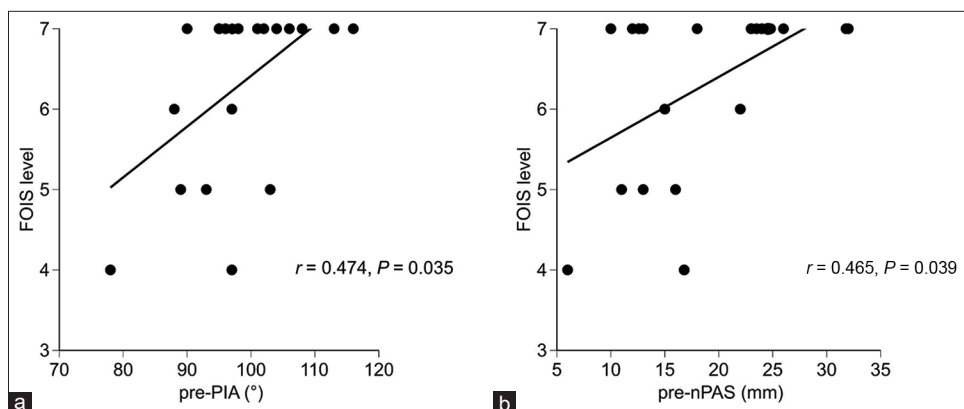
Figure 2: (a) Scatter diagram showing the association between preoperative pharyngeal inlet angle (PIA) and FOIS level. (b) Scatter diagram showing the association between preoperative narrowest pharyngeal airway space (nPAS) and FOIS level. FOIS: Functional oral intake scale
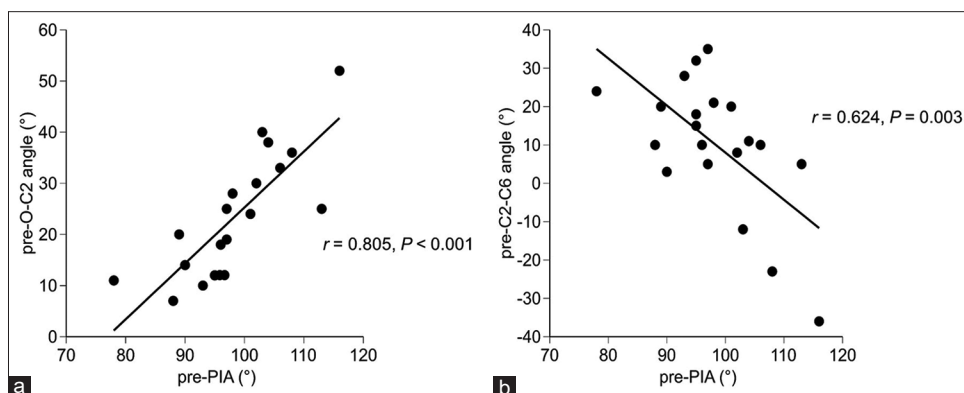
Figure 3: (a) Scatter diagram showing the association between preoperative pharyngeal inlet angle (PIA) and preoperative occipito-C2 (O-C2) angle. (b) Scatter diagram showing the association between preoperative PIA and preoperative C2-C6 angle.

Table 6: Causative factors for decrease in PIA.
1. Flexion of the craniovertebral junction, corresponding with the decrease in the O-C2 angle 2. Lordosis of the middle and lower cervical vertebrae, corresponding with the increase in the C2-C6 angle 3. Posterior movement of the anterior arch of the atlas
O-C2 angle: Occipito-C2 angle, PIA: Pharyngeal inlet angle

Since we identified the preoperative radiological measurements related to the incidence of postoperative dysphagia, the measurements might predict dysphagia after OCF surgery. They can be easily measured using the plain lateral radiographs of the cervical spine. If this is possible, performing these measurements in selected patients may help prevent dysphagia and aspiration pneumonia. Further prospective studies are required to evaluate these points.

This study had several limitations, which include its retrospective design and the relatively small sample size. In addition, fiber-optic endoscopic and/or video fluoroscopic analyses of swallowing were not performed for each patient. Another limitation is the lack of analysis using computed tomography and magnetic resonance imaging.

CONCLUSION

In this study, preoperative PIA and nPAS were significantly smaller in patients who developed dysphagia after OCF. These results suggest that preoperative cervical alignment may predict the incidence of dysphagia after OCF.

Declaration of patient consent

Institutional Review Board (IRB) permission obtained for the study.

Financial support and sponsorship

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Crary MA, Mann GD, Groher ME. Initial psychometric assessment of a functional oral intake scale for dysphagia in stroke patients. Arch Phys Med Rehabil 2005;86:1516-20.
2. Ebata S, Hatsushika K, Ohba T, Nitta K, Akaike H, Masuyama K, *et al.* Swallowing function after occipitocervical arthrodesis for cervical deformity in patients with rheumatoid arthritis. Neurorehabilitation 2015;37:299-304.
3. Hong JT, Lee SW, Son BC, Sung JH, Kim IS, Park CK. Hypoglossal nerve palsy after posterior screw placement on the C-1 lateral mass. Case report. J Neurosurg Spine 2006;5:83-5.
4. Ito T, Oyanagi K, Takahashi H, Takahashi HE, Ikuta F. Cervical spondylotic myelopathy. Clinicopathologic study on the progression pattern and thin myelinated fibers of the lesions of seven patients examined during complete autopsy. Spine (Phila Pa 1976) 1996;21:827-33.
5. Izeki M, Neo M, Takemoto M, Fujibayashi S, Ito H, Nagai K, *et al.* The O-C2 angle established at occipito-cervical fusion dictates the patient's destiny in terms of postoperative dyspnea and/or dysphagia. Eur Spine J 2014;23:328-36.
6. Kaneyama S, Sumi M, Takabatake M, Kasahara K, Kanemura A, Hirata H, *et al.* The prediction and prevention of dysphagia after occipitospinal fusion by use of the S-line (swallowing line). Spine (Phila Pa 1976) 2017;42:718-25.
7. Koyanagi T, Hirabayashi K, Satomi K, Toyama Y, Fujimura Y. Predictability of operative results of cervical compression myelopathy based on preoperative computed tomographic myelography. Spine (Phila Pa 1976) 1993;18:1958-63.
8. Matsubara K, Kumai Y, Kamenosono Y, Samejima Y, Yumoto E. Effect of three different chin-down maneuvers on swallowing pressure in healthy young adults. Laryngoscope 2016;126:437-41.
9. Miyagi M, Takahashi H, Tsuchiya K, Sekiya H, Ebihara S. Role of O-C2 angle in the development of dysphagia in patients with halo-vest fixation. BMC Musculoskelet Disord 2020;21:131.
10. Rojas CA, Vermess D, Bertozzi JC, Whitlow J, Guidi C, Martinez CR. Normal thickness and appearance of the prevertebral soft tissues on multidetector CT. AJNR Am J Neuroradiol 2009;30:136-41.
11. Serra-Prat M, Hinojosa G, López D, Juan M, Fabré E, Voss DS, *et al.* Prevalence of oropharyngeal dysphagia and impaired safety and efficacy of swallow in independently living older persons. J Am Geriatr Soc 2011;59:186-7.
12. Shamji MF, Cook C, Pietrobon R, Tackett S, Brown C, Isaacs RE. Impact of surgical approach on complications and resource utilization of cervical spine fusion: A nationwide perspective to the surgical treatment of diffuse cervical spondylosis. Spine J 2009;9:31-8.
13. Shamji MF, Mohanty C, Massicotte EM, Fehlings MG. The association of cervical spine alignment with neurologic recovery in a prospective cohort of patients with surgical myelopathy: Analysis of a series of 124 cases. World Neurosurg 2016;86:112-9.
14. Tetreault LA, Karpova A, Fehlings MG. Predictors of outcome in patients with degenerative cervical spondylotic myelopathy undergoing surgical treatment: Results of a systematic review. Eur Spine J 2015;24 Suppl 2:236-51.
15. Tian W, Yu J. The role of C2-C7 angle in the development of dysphagia after anterior and posterior cervical spine surgery. Clin Spine Surg 2017;30:E1306-14.
16. Wang LN, Hu BW, Song YM, Liu LM, Zhou CG, Wang L, *et al.* Predictive ability of pharyngeal inlet angle for the occurrence of postoperative dysphagia after occipitocervical fusion. BMC Musculoskelet Disord 2021;22:54.
17. Wang X, Chou D, Jian F. Influence of postoperative O-C2 angle on the development of dysphagia after occipitocervical fusion surgery: Results from a retrospective analysis and prospective validation. World Neurosurg 2018;116:e595-601.
18. Yoshida M, Neo M, Fujibayashi S, Nakamura T. Upper-airway obstruction after short posterior occipitocervical fusion in a flexed position. Spine (Phila Pa 1976) 2007;32:E267-70.