Role of preoperative cervical alignment on postoperative dysphagia after occipitocervical fusion

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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 χ² 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              | 0.195ᵇ  |
| Female/male                                | 8/12           | 3/10                       | 5/2                   | 0.062ᵃ  |
| Body mass index (kg/m²)                    | 22.7±3.9       | 23.7±3.7                   | 20.9±3.7              | 0.143ᵇ  |
| Duration of surgery (h)                    | 5.9±3.4        | 5.8±3.4                    | 6.0±3.4               | 0.926ᶜ  |
| Thoracic fusion (n)                        | 5              | 2                          | 3                     | 0.176ᵃ  |
| C2 fracture (n)                            | 2              | 0                          | 2                     | 0.111ᵃ  |
| Prevertebral soft-tissue swelling (n)      | 3              | 1                          | 2                     | 0.270ᵃ  |
| Reason for performing occipitospinal fusion|                |                            |                       |         |
| Cervical spondylosis (n)                   | 6              | 5                          | 1                     | 0.277ᵃ  |
| Rheumatoid arthritis (n)                   | 5              | 2                          | 3                     | 0.101ᵃ  |
| Trauma (n)                                 | 3              | 1                          | 2                     | 0.212ᵃ  |
| Retro-odontoid pseudotumor (n)             | 2              | 0                          | 2                     | 0.411ᵃ  |
| Other (n)                                  | 4              | 3                          | 1                     | 0.639ᵃ  |
| Comorbidity                                |                |                            |                       |         |
| Hypertension (n)                           | 6              | 3                          | 3                     | 0.613ᵃ  |
| Diabetes (n)                               | 2              | 2                          | 0                     | 0.521ᵃ  |

Values represent mean±standard deviation (range in parentheses). ᵉ²² test, ᵏ-two-tailed t-test, ᵧMann-Whitney U-test
A positive correlation was found between preoperative PIA and FOIS level \((r = 0.474, P = 0.035; \text{Figure } 2a)\). In addition, a positive correlation was found between preoperative nPAS and FOIS level \((r = 0.465, P = 0.039; \text{Figure } 2b)\). A positive correlation was also found between the preoperative PIA and preoperative O-C2 angle \((r = 0.805, P < 0.001; \text{Figure } 3a)\). A negative correlation was observed between the preoperative PIA and preoperative C2-C6 angle \((r = 0.624, P = 0.003; \text{Figure } 3b)\).

**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.\[^{16}\], a 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.\[^{14}\] 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.\[^{19}\]

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

| Table 2: Exclusion criteria. |
|-------------------------------|
| **Exclusion criteria**         | **n** |
| 1. Severe 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.\[^{11}\] |
|-----------------------------------------------|
| **Level** | **Description** |
| 1 | Nothing by mouth |
| 2 | Tube dependent with minimal attempts of food or liquid |
| 3 | Tube dependent with consistent oral intake of food or liquid |
| 4 | Total oral diet of a single consistency |
| 5 | Total oral diet with multiple consistencies, but requiring special preparation or compensations |
| 6 | Total oral diet with multiple consistencies without special preparation, but with specific food limitations |
| 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 |

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].
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 is the motor nerve of the tongue, and the vagus nerve, which innervates the pharyngeal contractile muscles, could occur after cervical spinal fusion. 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. 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. 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. 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.

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
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.

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Conflicts of interest

There are no conflicts of interest.

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