ABSTRACT
Objective: To test the hypothesis that there is no difference in the pharyngeal airway width and the position of the maxillofacial skeleton between prognathic and normal children.

Materials and Methods: Twenty-five girls with prognathism (mean, 7.9 ± 0.9 years old) and 15 girls with normal occlusion (mean, 8.4 ± 1.5 years) participated in this study. On each girl's lateral cephalogram, the coordinates of all points were marked and systematically digitized using a mechanical three-dimensional digitizing system. An independent-groups t-test was used to detect significant upper and lower pharyngeal width differences between the two groups. Correlations between the horizontal positions of each point and upper and lower pharyngeal widths were examined.

Results: Prognathic girls had a significantly wider lower pharyngeal airway compared with those with normal occlusion (P = .01). Furthermore, the horizontal coordinate of Ar was significantly positively correlated with lower pharyngeal airway width in both groups of girls.

Conclusions: The hypothesis is rejected. The mandible in prognathic girls tends to be positioned more anteriorly, resulting in a wider lower pharyngeal airway. (Angle Orthod. 2011;81:75–80.)

KEY WORDS: Cephalometry; Children; Airway obstruction; Prognathism

INTRODUCTION

It is accepted that maxillofacial growth and development in children is affected by both genetic and environmental factors. Familial aggregation and genetic background have been shown to contribute to prognathism12 and other facial and occlusal growth patterns.2-6 On the other hand, normal respiratory activity influences the growth of maxillofacial structures, favoring their harmonious growth and development.6,7 The presence of any obstacle in the respiratory system, especially in the nasal and pharyngeal regions, causes respiratory obstruction and forces the patient to breathe through the mouth.8 The close association between mouth breathing and maxillofacial morphology9-12 suggests that more attention should be paid to the effect of an obstructed airway on maxillofacial growth and development in children.

Some articles have assessed the nasal and pharyngeal airway from lateral cephalograms.13-16 Class II patients have a tendency for a narrower anteroposterior pharyngeal dimension, specifically in the nasopharynx at the level of the hard palate and in the oropharynx at the level of the soft palate and the mandible.13 The Class II division 1 malocclusion is associated with a narrower upper airway structure without retrognathia.17 However, there are few reports relating airway width and prognathism, especially in children. Therefore, an understanding of prognathism's etiology is crucial for its clinical correction.

Jacobson et al.18 suggested that prognathism was due to not only a longer mandible but also a mandible positioned more anteriorly relative to the maxilla.
McNamara\textsuperscript{19} noted that in 8-year-old children, (1) the wider the lower pharyngeal airway, the more anterior the position of the tongue in the oral cavity, either as a result of habitual posture or due to an enlargement of the tonsils, and (2) prognathism can be associated with a forward tongue position and enlarged tonsils. In other words, habitual mandibular posturing associated with the enlargement of the tonsils might be associated with prognathism. Therefore, the aim of this study was to examine whether pharyngeal airway width was associated with anteroposterior mandibular position in prognathic children.

**MATERIALS AND METHODS**

**Human Subjects**

Twenty-five subjects with prognathism (mean age, 7.9 ± 0.9 years), who visited Kanomi Orthodontic & Pediatric Dental Clinic (Himeji-City, Hyogo-Prefecture, Japan) to receive orthodontic treatment, and 15 subjects with normal occlusion (mean age, 8.4 ± 1.5 years), who had visited the Pediatric Dental Clinic, Kagoshima University Hospital (Kagoshima city, Kagoshima prefecture, Japan) in the past, participated in this study. All subjects were Japanese girls with mixed dentition. Informed consent to participate in this study was obtained from the parents of all girls. Prior to entering the study, approval by the clinical ethics committee of Kagoshima University Hospital was obtained.

Prognathism was defined as at least three incisors with negative overjet. In the normal-occlusion group, subjects had no obvious signs or symptoms of temporomandibular joint dysfunction, and their incisors had normal overlap. There was no history of orthodontic treatment in the normal-occlusion group. Lateral cephalograms were taken with each girl’s head immobilized in a wall-mounted cephalostat and the eye-ear plane parallel to the floor at rest while she was asked to maintain an intercuspal position by keeping her mouth closed without swallowing.

**Data Preparation**

The system used in this study has been described in detail elsewhere,\textsuperscript{20} but a brief description follows. Each cephalogram was traced, and 9 skeletal points and 27 soft tissue points were systematically digitized using a mechanical three-dimensional digitizing system (Micro Scribe G2X, Immersion, San Jose, Calif; Figure 1). The 27 soft tissue points consisted of 17 points on the posterior pharyngeal wall, 9 points on the posterior outline of the soft palate, and 1 point at the intersection of the posterior border of the tongue and the inferior border of the mandible. The coordinates from each subject were transformed to a standardized plane using a custom-made program written in Microsoft Visual C++ (Microsoft, Redmond, Wash). In this standard plane, Sella was the origin, the FH plane was parallel to the x-axis, and all measurement points were rotated to match this reference plane. From the 27 soft tissue points, upper pharyngeal width was measured from the posterior outline of the soft palate to the closest point on the posterior pharyngeal wall, 9 points on the posterior outline of the soft palate, and 1 point at the intersection of the posterior border of the tongue and the inferior border of the mandible. The coordinates from each subject were transformed to a standardized plane using a custom-made program written in Microsoft Visual C++ (Microsoft, Redmond, Wash). In this standard plane, Sella was the origin, the FH plane was parallel to the x-axis, and all measurement points were rotated to match this reference plane. From the 27 soft tissue points, upper pharyngeal width was measured from the posterior outline of the soft palate to the closest point on the posterior pharyngeal wall, and the lower pharyngeal width was measured from the intersection of the posterior border of the tongue and the inferior border of the mandible to the closest

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Figure 1. Standard coordinates, cephalometric skeletal landmarks, and upper (a) and lower (b) pharyngeal airway width.
point on the posterior pharyngeal wall, according to the method of McNamara (Figure 1),\textsuperscript{19} using a custom-made program written in Microsoft Visual C++\textsuperscript{.} These custom-made programs were made by coauthor Emi Inada.

**Error of the Method**

All measurements were repeated after 1 week by the same investigator, and Dahlberg's formula was used for the calculation of the measurement error.\textsuperscript{21} Method-error values of skeletal points were from 0.06 mm to 0.26 mm (mean error, 0.18 mm), corresponding to 0.5% of total variance. Method-error values of pharyngeal widths were from 0.13 mm to 0.26 mm (mean error 0.19 mm), corresponding to 1.2% of total variance. These indicated that these errors were negligible.

**Statistical Analysis**

Statistical analysis was performed using the Statistical Package for Social Science (SPSS 15.0 J, SPSS Inc, Chicago, Ill). An independent-groups \( t \)-test was used for detecting significant differences in upper and lower pharyngeal airway widths between normal-occlusion and prognathic girls. Pearson's correlation coefficients were used to detect any relationship between horizontal coordinate values of each skeletal point and the two pharyngeal widths, in order to investigate the relationship between the two pharyngeal widths and the anteroposterior position of each skeletal point. Significance was set at \( P < .05 \).

**RESULTS**

The upper and lower pharyngeal width differences between the normal-occlusion and prognathic girls are shown in Table 1. The lower pharyngeal width of prognathic girls was significantly larger than that of girls with normal occlusion (\( P = .01 \)), while there was no significant difference in upper pharyngeal width.

Correlations between the horizontal coordinates of each skeletal point and the two pharyngeal widths are shown in Table 2. A significant positive correlation was found between the horizontal coordinate of Ar and the lower pharyngeal airway width in both the normal-occlusion and prognathic girls.

**DISCUSSION**

The association between mouth breathing and craniofacial morphology has been well studied.\textsuperscript{7,10,12,22–24} The designations “adenoid face” and “long face syndrome” have been used to characterize the typical appearance in patients with obstructed airways.\textsuperscript{25} Many previous studies have shown that adenoid or tonsillar obstruction of the airway might cause abnormal maxillofacial development.\textsuperscript{9,26,27} de Freitas et al.\textsuperscript{28} suggested that patients with Class I or Class II malocclusions and vertical growth patterns had significantly narrower upper pharyngeal airways than patients with Class I or Class II malocclusions with normal growth patterns. Vargervik et al.\textsuperscript{29} showed that prognathism can be induced by mouth breathing in animals. Hultcrantz et al.\textsuperscript{30} showed that 77% of patients with open bite and 50% to 65% of patients

### Table 1. Mean Upper and Lower Pharyngeal Airway Width (mm) of Normal-Occlusion and Prognathic Girls

<table>
<thead>
<tr>
<th>Distance</th>
<th>Normal Occlusion</th>
<th>Prognathism</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Upper pharyngeal width</td>
<td>8.4</td>
<td>2.8</td>
</tr>
<tr>
<td>Lower pharyngeal width</td>
<td>11.0</td>
<td>2.9</td>
</tr>
</tbody>
</table>

** Statistically significant at \( P < .01 \).

### Table 2. Correlations Between the Horizontal Coordinates of Each Skeletal Point and the Two Pharyngeal Widths in Normal-Occlusion and Prognathic Girls*  

<table>
<thead>
<tr>
<th>Skeletal Point</th>
<th>Upper Pharyngeal Width</th>
<th>Lower Pharyngeal Width</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal Occlusion</td>
<td>Prognathism</td>
</tr>
<tr>
<td>A</td>
<td>(-0.100 (.724))</td>
<td>0.321 (.118)</td>
</tr>
<tr>
<td>B</td>
<td>(-0.065 (.817))</td>
<td>0.308 (.134)</td>
</tr>
<tr>
<td>Pog</td>
<td>(-0.055 (.845))</td>
<td>0.338 (.098)</td>
</tr>
<tr>
<td>Me</td>
<td>(-0.121 (.807))</td>
<td>0.351 (.085)</td>
</tr>
<tr>
<td>Go</td>
<td>0.052 (.853)</td>
<td>0.005 (.979)</td>
</tr>
<tr>
<td>Ar</td>
<td>(-0.009 (.974))</td>
<td>(-0.288 (.163))</td>
</tr>
</tbody>
</table>

* Probabilities are presented in parentheses.
* Statistically significant at \( P < .05 \).
with buccal crossbites and prognathism were normalized 2 years after tonsillectomy.

The evaluation of upper and lower pharyngeal widths in this study followed the method of McNamara. He noted that the standard lower pharyngeal width was 10 mm to 12 mm and that it did not change appreciably with age. In addition, he suggested that (1) apparent airway obstruction, indicated by an opening of 5 mm or less in the upper pharyngeal measurement, could be used as an indicator of possible airway impairment, and (2) lower pharyngeal airway widths greater than 15 mm, due to habitual posture or the enlargement of tonsils, might cause anterior positioning of the tongue.

Kawashima et al. reported a lower pharyngeal airway width in preschool children of 12.1 mm. Abu Allhaija and Al-Khateeb reported the average lower pharyngeal airway width of 15 skeletal class I girls from 14 to 17 years of age to be 12.9 ± 5.2 mm. The lower pharyngeal width of the normal-occlusion girls in this study is similar to these previous results. The lower pharyngeal widths of prognathic girls in this study were also similar to those of 15 older prognathic girls ranging from 14 to 17 years of age (14.9 ± 5.4 mm). Iwasaki et al. also reported that the lower pharyngeal widths of girls with Class III malocclusion were significantly larger than that of girls with Class I occlusion, while there was no significant difference in the upper pharyngeal width evaluated by cone-beam computed tomography.

The lower pharyngeal airway of prognathic girls was wider than that of girls with normal occlusion. Our results suggest that the upper pharyngeal airway does not influence prognathism, and an anterior position of the tongue or enlargement of the tonsils might be characteristics of prognathism in children about 8 years of age.

Ar, which is the point on the condylar posterior edge, could indicate whether the condyle is located more anteriorly and the lower pharyngeal airway is wider (Figure 2). However, only the horizontal coordinate of Ar in both groups was positively correlated with lower pharyngeal width. During childhood, tonsillar hypertrophy increases with age and reaches a peak at 5 to 6 years in both control and obstructive sleep apnea groups. Kawashima et al. suggested that the tongue base was more anteriorly positioned with tonsillar hypertrophy. This could maintain a normal airway cross-sectional area, even when the lateral dimension was reduced by enlarged palatine tonsils.

Any change of neuromuscular activity, such as that of positioning the tongue anteriorly, might also displace the mandible anteriorly. Although Jacobson et al. stated two causes of prognathism (a mandible that is too long and a mandible that is too far forward), our study suggests that excessive forward positioning of the mandible might compensate for the presence of an obstacle such as an enlarged tonsil.

Finally, these results indicate that the more anterior the condyle position, the wider the lower pharyngeal

Figure 2. Prognathic patients without (A) and with (B) an obstacle in their lower pharyngeal airway. Patient B has an enlarged tonsil in a wider pharyngeal airway and a more anterior condyle position relative to Sella than does patient A.
airway in children about 8 years of age. A wider pharyngeal airway could be an important factor causing prognathism. Therefore, the lower pharyngeal airway should be examined more closely for malpositioning of the tongue or enlarged tonsils in prognathic children before treatment.

CONCLUSIONS

- Prognathic girls had a significantly wider lower pharyngeal airway compared with the airways in girls with normal occlusion.
- More anterior positioning of the mandible of 7- and 8-year-old children resulted in a wider lower pharyngeal airway.

REFERENCES
