Original article

Assessment of hyoid bone position among different skeletal patterns

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\textbf{A B S T R A C T}

\textbf{Purpose:} To determine the hyoid bone position in subjects with various skeletal patterns.

\textbf{Materials and methods:} Conventional pre-treatment lateral cephalograms of 100 subjects aged 18-25 years were selected from the files of orthodontic patients based on anteroposterior skeletal pattern and facial divergence pattern. Subjects with Class I skeletal pattern (ANB 1-4°) were categorized into group A and group B depending on the measurements of Frankfort Mandibular Plane Angle (FMA) of 22-30° (normo divergence) and greater than 30° (hyper divergence) respectively. Likewise subjects with Class II skeletal pattern (ANB >4°) were categorized into group C and D, based on the above same divergence. The angular and linear measurements were recorded and measured. Statistical assessments include unpaired Student t-test and one-way analysis of variance (ANOVA).

\textbf{Results:} The vertical position of hyoid bone was not affected by nature of horizontal or vertical growth pattern of the face. The mean anteroposterior position of the hyoid bone among the 4 groups of subjects was statistically significant (p < 0.05). The position of hyoid bone in group D was significantly backward compared with the subjects in group A (p < 0.05) or group C (p < 0.05). The mean hyoid axis angle among subjects in the hyper divergent group (group B and group D) was high but insignificant.

\textbf{Conclusion:} The position of hyoid bone was most posterior in subjects with skeletal Class II malocclusion associated with mandibular retrognathism.

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1. Introduction

The hyoid bone is a horseshoe-shaped bone situated in the anterior midline of the neck between the chin and the thyroid cartilage and represents a link between the head and neck. It consists of five segments, namely, a body, two greater cornua, and two lesser cornua. It is connected to the pharynx, tongue, mandible and cranium through muscles and ligaments and forms a part of oropharyngeal complex. Though hyoid bone has no bony articulation, its muscle attachments play an important role in the maintenance of the pharyngeal airway, deglutition and phonation [1-3]. The position of tongue relative to upper and lower jaw is regulated in part by the position of the hyoid bone.

Hyoid, thus, functions as an anchoring structure and plays an important role in maintaining patent airway and regulating deglutition and mandibular movement [4]. Opdebeeck et al. attributed that many characteristics of long face syndrome to be associated with clockwise rotation of mandible “in concert” with the hyoid, tongue, pharynx and cervical spine [5]. Mandibular set back surgeries in hyperdivergent facial type demonstrated close association between hyoid position and concomitant mandibular position [6]. The stability of the surgical results could be attributed to the specific orientation and function of the associated muscles anchored to the hyoid and other functional cranial components. The relationship of hyoid to the skeletal and soft tissue composition of the head and neck exemplifies its pivotal role in the craniofacial complex.

Previous investigations have attempted to clarify the interaction between facial types and skeletal malocclusion and hyoid position, but no definite consensus exists. It was demonstrated that subjects with Class II skeletal pattern had a posterior position of hyoid [1,7,8]. However, the nature and composition of Class II pattern with reference to the extent of maxillary or mandibular contribution to Class II anomaly was not considered in any of the earlier investigations. Thus, with the existence of protean characteristics in skeletal Class 2 malocclusion, the intent of the present investigation was to examine the position of hyoid in different anteroposterior and vertical craniofacial patterns.

All the subjects were conveniently divided equally into 4 groups, based on anteroposterior skeletal pattern and facial divergence. Subjects with Class I skeletal pattern (ANB 1–4°) were categorized into group A and group B depending on the measurements of Frankfort Mandibular Plane Angle (FMA) of 22–30° (Normo divergence) and greater than 30° (Hyper divergence) respectively. Likewise subjects with Class II skeletal pattern (ANB >4°) were categorized into group C and group D, based on the above same divergence factor. The type of molar relationship was not considered when subjects were selected for the study.

All the lateral cephalograms were taken using the same radiographic unit (X — Mind Panceph, Satelec). The x-rays were shot using the standard operating procedures that involved guiding the subjects to remain standstill with the lower jaw in rest position while the head was fixed in the cephalostat. The magnification factor was set at 1.3 in the scale. They were manually traced on acetate paper with 0.5mm lead pencil. The landmarks used in this study to evaluate the hyoid position were included from previous investigations [1,7]. The angular and linear measurements are represented in Fig. 1. Ethical committee clearance from the Institutional review board and ethical committee of Vishnu...
Dental College, India, was obtained for the use of orthodontic pre-treatment lateral cephalograms of 100 subjects in this study.

2.1. Statistical analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 17.0 (SPSS Inc., Chicago Il). The Kolmogorov-Smirnov test was used to test the normality. As the distribution was normal, parametric tests were applied. Descriptive statistics like mean and standard deviation were calculated for every group. Group differences were analyzed using one-way analysis of variance (ANOVA). For multiple comparisons, Tukey post hoc test was used. When the P value was less than 0.05, the statistical test was regarded as significant. For error testing, 5 patients were selected from each group and the 20 radiographs were traced and retraced by the same operator, a minimum of 20 days later. The tracings were analyzed, and the differences in measurements between the two tracings of the same radiograph were calculated. Pearson coefficients were calculated to analyze the repeatability of the measurements. The coefficients were found to be close to 1.00.

3. Results

Mean age (years), SNA, SNB, ANB, and FMA among the four group of subjects are shown in Table 1. Within the group comparison of age (years), SNA, SNB, ANB, and FMA between Class I and Class II subjects are also mentioned in Table 1. A notable finding was the statistical significance demonstrated for SNB measurement between Class II normo divergent and hyper divergent (p<0.05). Thus, the subjects in Class II sample with hyper divergent pattern showed a more retrognathic mandible.

The vertical position of the hyoid bone was evaluated from the anterior-superior tip of hyoid bone to mandibular plane. The mean vertical distance was least in group C (Class II normo divergent) subjects but comparable with the subjects in group A, B and D (Table 2) and it was not statistically significant (p=0.174). Thus, from the result of the present study it was evident that the vertical position of hyoid bone was not affected by the nature of growth pattern of the face.

The anteroposterior position of hyoid bone was evaluated from the anterior inferior limit of third cervical vertebrae to anterior superior tip of hyoid bone. The mean anteroposterior distance among the 4 groups of subjects were statistically significant (p<0.05). The position of hyoid bone in group D was significantly backward compared with the subjects in group A (p<0.05) and group C (p<0.05). Characteristically group D represented more retrognathic mandible unlike group C, which was statistically significant (p<0.05) (Table 2). Thus, the anteroposterior position of hyoid bone may be dictated by the mandible position and less influence from vertical facial patterns.

The axial inclination of the hyoid bone was evaluated from the vertical relationship of hyoid axis to the FH plane. The mean hyoid axis angle among subjects in the hyper divergent group (group B and group D) was high but not significant at a statistical level (Table 2). However, the hyoid axis angle was comparable among subjects in normo divergent facial pattern (group A and group C) the inclination of hyoid bone was not affected by the nature of vertical growth pattern.

4. Discussion

The stimulus for this investigation was the varied notions with reference to position of hyoid and different skeletal patterns. Previous investigations have noted that the hyoid position remained in unison with mandibular position anteroposteriorly [6,9,10]. Few other studies demonstrated a posterior position of hyoid in hyperdivergent facial patterns [7,8]. However, the skeletal patterns in vertical and sagittal dimensions are not mutually exclusive in defining the craniofacial structure. In this study, we had aimed to find the position of hyoid bone in skeletal Class I and II malocclusions with normal facial divergence and hyperdivergence. It was noted that the position of hyoid bone was most posterior in subjects with Class II skeletal malocclusion with mandibular retrognathism irrespective of facial divergence. The steepness of the lower margin of mandible plays a role in the spatial position of the hyoid bone only when the

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group A</th>
<th>Group B</th>
<th>Sig</th>
<th>Group C</th>
<th>Group D</th>
<th>Sig</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>NS</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>NS</td>
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<tr>
<td>SNA (°)</td>
<td>6.8 ± 2.49</td>
<td>4.8 ± 2.12</td>
<td>NS</td>
<td>2.5 ± 2.58</td>
<td>2.1 ± 2.50</td>
<td>NS</td>
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<tr>
<td>SNB (°)</td>
<td>7.8 ± 3.19</td>
<td>7.8 ± 3.75</td>
<td>NS</td>
<td>7.6 ± 3.34</td>
<td>7.4 ± 3.86</td>
<td>S</td>
</tr>
<tr>
<td>ANB (°)</td>
<td>3.0 ± 0.68</td>
<td>3.6 ± 1.04</td>
<td>NS</td>
<td>6.9 ± 2.2</td>
<td>7.2 ± 2.15</td>
<td>NS</td>
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<tr>
<td>FMA (°)</td>
<td>2.7 ± 1.69</td>
<td>3.2 ± 2.35</td>
<td>NS</td>
<td>2.7 ± 2.35</td>
<td>3.5 ± 5.12</td>
<td>HS</td>
</tr>
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</table>

*SD denotes standard deviation; Sig, significance; SNA, angle between sella, nasion, and A point; SNB, angle between sella, nasion, and B point; ANB, angle between A point, nasion, and B point; FMA, angle between the Frankfurt Horizontal (FH) plane and a line tangent to the lower border of the mandible.

* Unpaired t test; S, significant (p<0.05); HS, highly significant (p<0.001); NS, not significant.

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Vertical position of the hyoid bone has been directly linked to pharyngeal airway depth and development of obstructive sleep apnea. A low hyoid bone position was noted in male subjects with steep and short mandible [13]. A similar result was demonstrated in young children in the age group of 3–6 years with obstructive sleep apnea syndrome [14]. A more inferior and posteriorly located hyoid was noted in subjects with upper airway obstruction [15]. In another investigation, skeletal open bite subjects with characteristic short ramus height, short posterior face height, retrusive chin and clockwise rotated mandible demonstrated low hyoid position when compared with subjects with hyperdivergent face with normal posterior heights [16]. In the present study, no difference in the vertical position of hyoid was noted among the groups. However, the sample was categorized into normal or hyperdivergent pattern based only on Frankfurt mandibular plane angle. Other vertical parameters were not considered, but could be an objective for future studies. Pae et al. reported that hyoid bone was more close to mandible vertically in brachyfacial types unlike normal or dolichofacial types [8]. In contrast, Jena et al. reported no difference in the position of hyoid between the three facial types [7]. Current study supported Jena’s findings, though brachyfacial type subjects were not analysed.

The inclination of the hyoid axis was assessed in relation to Frankfurt horizontal plane. The hyoid axis angle was more oblique in hyperdivergent pattern, whereas in normo divergent patterns, it was less oblique. The axial inclination of the hyoid followed the pattern of craniofacial divergence and was consistent with earlier reports [7,17]. Hyoid axial inclination attempts to verify its close association with mandibular inclination and oropharyngeal complex. According to Opdebeeck et al., a significantly large SN-hyoid plane angle was found in subjects with a high FMA with no significant difference between mandibular plane and hyoid plane angle. Thus the hyoid bone was involved in overall rotational movement of the movable parts of the craniofacial complex. The more oblique axial position of the hyoid bone in hyperdivergent subjects could be due to differences in tongue position. Further, the cross section of the lower pharynx was reduced and the hyoid bone was closer to the cervical spine [5].

Wang et al. noted that hyoid bone moved backward in extraction treatment of bimaxillary protrusion cases with no difference in the position between hyperdivergent and non-hyperdivergent groups [18]. Thus, the present study assumes that any orthodontic treatment procedure that encroaches on the tongue position and mandibular inclination could

Table 2 – Hyoid bone position among groupsa.

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<tbody>
<tr>
<td>MP-H (mm)</td>
<td>9.56±4.95</td>
<td>7.6±1.5</td>
<td>7.16±5.2</td>
<td>8.2±3.27</td>
<td>1.69</td>
<td>0.17</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>C3H (mm)</td>
<td>35.24±4.3</td>
<td>33.56±3.0</td>
<td>34.72±4.07</td>
<td>31.8±1.63</td>
<td>4.97</td>
<td>0.003</td>
<td>NS</td>
<td>&lt;0.05</td>
<td>NS</td>
<td>&lt;0.05</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>HAA (°)</td>
<td>16.88±9.18</td>
<td>19.84±5.52</td>
<td>16.68±8.38</td>
<td>21.16±10.08</td>
<td>1.69</td>
<td>0.17</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

a SD denotes standard deviation; MP-H, vertical position of hyoid bone; C3H, anteroposterior position of hyoid bone; HAA, hyoid axis angle; NS, not significant (P > 0.05).

b One way ANOVA followed by Post-hoc Tukey’s test; P < 0.05, significant.

mandible is characteristically posteriorly positioned. Therefore, it is meant that the patients with posteriorly positioned hyoid bone could have a tendency toward mandibular retrognathism. In subjects with skeletal Class II malocclusion with normal mandibular position, the position of hyoid was comparable to Class I subjects.

Jena and Duggal found that the position of hyoid bone was more posterior in long face subjects [7]. However, the results of the aforementioned study should be interpreted with caution as no account of maxillo-mandibular relationship was considered in the methodology. The same tendency was evaluated by Pae in a longitudinal sample, but the results failed to corroborate with Jena [8]. The present study in an attempt to clarify the inconsistency of the hyoid bone position with reference to facial types, demonstrated that there was no particular influence of the vertical facial pattern on the hyoid position unless associated with anteroposterior maxillo-mandibular relationship. Abu Alhaja et al. reported a posterior position of the hyoid bone in Class II normodivergent subjects compared to Class I subjects. This study classified the sample based ANB angle and no elaboration of what constituted a Class II skeletal pattern was included [1]. The present study also represented backward position of hyoid only in Class II subjects if the mandible is a contributor of Class II pattern. This association strongly clarified the contention that position of hyoid is closely related to the mandibular position rather than facial type. However, Opdebeeck et al. asserted that many of the characteristics of long face syndrome could be explained by clockwise rotation of mandible in concert with the hyoid, tongue, pharynx and cervical spine [5]. The role of mandibular length was not considered, but necessitates the need for further study. Trenouth and Timms described a positive correlation between the length of the mandible with the distance between C3 cervical vertebrae and hyoid bone [11].

A previous study concluded that that there was sexual dimorphism in hyoid bone position during the period of adolescence. From the mixed dentition stage to the permanent dentition stage, the hyoid bone moved upward in females but upward and then downward in males [12]. Vertical position of the hyoid bone had a strong relationship with the ramus length and the facial angle, but the tendency differed completely between genders. In females, a larger facial angle or longer ramus length indicated a more superiorly positioned hyoid bone; in males, the indication was reversed. In the present study, the gender differences were not assessed, as the sample was predominantly females.
influence the hyoid position and subsequently pharyngeal milieu interior.

5. Conclusions

The position of hyoid bone was most posterior in subjects with skeletal Class II malocclusion associated with mandibular retrognathism.

Conflicts of interest

No conflicts of interest declared.  This research was carried out without funding.

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References