Cephalometric evaluation of hyoid bone position and pharyngeal spaces following treatment with Twin block appliance

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ABSTRACT

Objective: To evaluate the position of hyoid bone in the subjects treated with Twin block appliance.

Materials and Methods: The sample consisted of 40 Angle’s Class II division 1 subjects treated with Twin block appliance. Lateral radiographs were taken before and after treatment. According to Schudy’s facial divergence angle (SN-MP), the subjects were classified into three groups: group I (hypodivergent, SN-MP: <31° (27°-30°), n=15), group II (normodivergent, SN-MP: 31°-34°, n=15), and group III (hyperdivergent, SN-MP: >34° (35°–38°), n=10). Lateral cephalograms were traced and analyzed manually. After measurements of variables, Student’s t-test and one-way analysis of variance (ANOVA) were performed.

Results: Post treatment with Twin block therapy, hyoid bone shifted significantly (P<0.01) forward in horizontal dimension in all three groups, although it was highest in group III. However, there was no significant difference amongst the groups. In vertical dimension, hyoid bone shifted in upward direction in all three groups; however, the shift was significant (P<0.01) only in group I and there was a significant difference between group I and rest of the two groups. Width of upper airway significantly (P<0.01) increased and ANB angle significantly (P<0.001) decreased in all three groups with forward movement of mandible.

Conclusions: After treatment with Twin block appliance, significant changes occurred in horizontal dimension (anterior displacement), which resulted in significant increase in width of upper pharynx in all three groups.

Key words: Angle’s class II division 1 malocclusion, facial divergence, hyoid bone, pharyngeal spaces, twin block appliance

INTRODUCTION

In general consideration of cervicofacial skeleton, the hyoid bone tends to be overlooked or is given scant attention.[1] However, it is associated with several important functions of the human body such as deglutition, phonation, and respiration. It forms the anterior boundary of airway.[1] Hence, any change in its position can adversely affect the dimensions of airway. Orthodontic myofunctional therapy has the potential to affect the hyoid bone by altering the mandibular position. Certain studies have been conducted pertaining to change in hyoid bone position from childhood to puberty,[2-3] while others have correlated the posture of hyoid with mandibular morphology.[4,5] and its position in various skeletal types.[6-9] Studies have also compared pharyngeal size in different growth patterns and diverse malocclusions.[10,11] Effects of orthodontic and orthognathic surgical procedures on hyoid bone position have also been reported.[12]

However, very few studies have evaluated change in hyoid bone position after treatment with functional appliance.[13] Also, no single study has reported the correlation between change in hyoid bone position and pharyngeal space with functional appliance. Thus, this study was designed to evaluate the association between change in hyoid bone position with Twin
block appliance therapy and its effect on the dimensions of pharyngeal spaces.

**MATERIALS AND METHODS**

The present study was conducted on 40 subjects (22 girls and 18 boys) of Angle’s Class II division 1 malocclusion treated with Twin block appliance in the Department of Orthodontics and Dentofacial Orthopaedics, Faculty of Dental Sciences, Chhatrapati Sahuji Maharaj Medical University, Lucknow.

The subjects included were in the age range of 10–14 years (with the mean age of 11.39±1.07 years for girls and 13.01±0.30 years for boys) with Angle’s Class II division 1 malocclusion, ANB angle greater than 4° with deficient mandibular body length (<S–N +3 mm). Subjects who had any anomaly of cervical vertebra, known history or symptoms of temporomandibular joint disorder, history of any previous orthodontic treatment, or syndromic conditions were excluded from this study.

Lateral radiographs were taken before and after the treatment with Instrumentarum Cephalometer (Rotograph plus, Bologna, Italy). All subjects were positioned in the cephalostat with the sagittal plane at a right angle to the path of the X-rays, Frankfort plane parallel to the horizontal plane, teeth in centric occlusion, and the lips relaxed. During exposure of the X-ray, subjects were guided to stand still with the mandible in relaxed position to ensure that no strain or change in head posture occurred while the head was fixed in the cephalostat. Kodak X-ray films (8″ × 10″) were exposed at 80 kVp, 10 mA for 0.8 s from a fixed distance of 60 inches by following the standard technique employed. The lateral head cephalograms were traced on acetate tracing sheets 0.5 µm in thickness using a sharp 4H pencil on a view box using transilluminated light in a dark room. Any stray light dispersion was eliminated by covering the margins of the view box with a black paper, leaving only that part which is required for radiograph visibility. Each cephalogram met the following essential requirements:

i. Good definition of hard and soft tissue structures
ii. Teeth in centric occlusion

If the right and left structural outlines were lacking in superimposition on each other, then the average between the two were drawn by intersection and the cephalometric points were located in reference to the arbitrary interrupted line so obtained. The linear and angular measurements were then made to the nearest 0.5 mm and 0.5°, respectively, with the help of scale and protractor. All measurements were recorded by the same operator and were reviewed twice by other investigators for accurate landmark identification.

All subjects were divided according to Schudy’s facial divergence angle (SN-MP) [Figure 1a] into three groups, i.e. hypodivergent, normodivergent, and hyperdivergent [Table 1], as this angle is more accurate. As it was shown in previous studies that there is no sexual dimorphism in hyoid bone position, any further subgrouping into male and female was not considered in the present study. Previous studies have used various methods to evaluate hyoid bone position utilizing various cranial structures to define reference planes from which hyoid bone position was measured. These cranial

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**Figure 1:** (a) Facial divergence angle, cephalometric landmarks, and planes. (b) Measurements used in the study
reference planes are relatively far from the hyoid bone, thus a small variation in the position or inclination of the reference plane would result in much greater apparent variation in hyoid bone, whether the hyoid bone position changed to that extent or not. However, in this study, a new method was used to evaluate hyoid bone position with the use of reference planes which are relatively nearer to the hyoid bone. Landmarks, planes, and measurements used in the study are shown in Figure 1 and Table 2.

Measurements analyzed were related to horizontal and vertical change in hyoid bone position. Measurements used to determine the horizontal change in hyoid bone position were Hy–B, Hy–Me, and Hy–CL, out of which Hy–B and Hy–Me represent the movement of hyoid bone with respect to mandible. Positive values of these two mean movement of mandible in forward direction was more than that of the hyoid bone. Hy–CL represents the movement of hyoid bone with respect to cervical vertebrae.

Vertical changes in the hyoid bone position were determined by Hy–CHL and Hy–GoMe. Negative value of these measurements means the hyoid bone has moved superiorly. Width of upper pharynx and width of lower pharynx were used to determine the changes in pharynx. ANB shows the position of maxilla in relation to mandible.

Table 1: Mean and standard deviation for measurements in group I, group II, and group III

| Variables                  | Group I (hypodivergent) | Group II (normodivergent) | Group III (hyperdivergent) |
|----------------------------|-------------------------|---------------------------|----------------------------|
|                            | SN-MP: <31° (27°–30°)   | SN-MP: 31°–34°            | SN-MP: >34° (35°–38°)      |
|                            | n=15                    | n=15                      | n=10                       |
|                            | Pre Mean±SD             | Post Mean±SD              | Pre Mean±SD                |
| Hy–B                      | 44.73±5.6               | 47.47±4.3                 | 46.27±5.3                  |
| Hy–Me                     | 36.00±5.7               | 39.70±5.1                 | 38.40±4.8                  |
| Hy–CL                     | 46.00±3.2               | 48.99±3.7                 | 46.33±4.0                  |
| Hy–GoMe                   | 11.67±5.2               | 7.77±5.2                  | 13.87±6.7                  |
| Hy–CHL                    | 49.80±8.9               | 48.07±9.2                 | 45.07±7.7                  |
| Width of upper pharynx    | 12.40±2.4               | 13.67±2.3                 | 12.11±3.5                  |
| Width of lower pharynx    | 10.77±3.4               | 11.57±4.5                 | 10.60±2.6                  |
| ANB                       | 6.40±1.6                | 3.87±1.1                  | 6.67±1.5                  |

Table 2: Description of landmarks, planes, and measurements used in the study

| Landmarks                  | Description                                                                 |
|----------------------------|-----------------------------------------------------------------------------|
| Sella (S)                  | The midpoint of the hypophyseal fossa                                        |
| Nasion (N)                 | The most anterior point of frontonasal suture in the median plane            |
| Sub–spinale (point A)      | The deepest midline point on the premaxilla between anterior nasal spine and prosthion |
| Supramentale (point B)     | The deepest midline point on the mandible between infradentale and pogion    |
| Menton (Me)                | Most caudal point in the outline of the mandible. It is regarded as the lowest point of the mandible |
| Hyoidale (Hy)              | The most antero-superior point on the body of hyoid bone                     |
| Gonion (Go)                | The most posterior point of the odontoid process of second cervical vertebra |
| Od                         | The most posterior–inferior point of the fourth cervical vertebra             |
| C4p                        | The plane extending from sella to nasion                                       |
| Sella–nasion plane (S–N plane) | Perpendicular line from Od to cervical line                           |
| Cervical horizontal line (CHL) | Line connecting Od and C4p                                                 |
| Mandibular plane (Go-Me)   | The plane extending from gonion to menton                                    |
| Hyoidale–supramentale (Hy–B) | Distance from hyoidale to supramentale                                     |
| Hyoidale–menton (Hy–Me)    | Distance from hyoidale to menton                                             |
| Hyoidale–cervical line (Hy–CL) | Perpendicular distance from hyoidale to cervical line                  |
| Hyoidale–mandibular plane (Hy–GoMe) | Perpendicular distance from hyoidale to mandibular plane               |
| Hyoidale–cervical horizontal line (Hy–CHL) | Perpendicular distance from hyoidale to cervical horizontal line |
| Width of upper pharynx     | Measured from a point on the posterior outline of the soft palate to the closest point on the posterior pharyngeal wall. This measurement is taken on the upper half of soft palate outline |
| Width of lower pharynx     | Measured from the intersection of posterior border of tongue and inferior border of the mandible to the closest point on the posterior pharyngeal wall |
| ANB                        | Angle between point A, nasion, and point B                                    |
Statistical Analysis

The data obtained were subjected to the statistical analysis using statistical package program STATA version 9.2. Descriptive statistics, including the mean and standard deviation values, were calculated for all the measurements in each group [Table 1]. Student’s t-test was used to determine the significant differences between the pre- and post-treatment values of various measurements in the three groups. Mean difference of pre- and post-treatment values of all measurements in each group was subjected to analysis of variance (ANOVA) test to determine if any significant difference was present between the three groups. Bonferroni post hoc test was then used to find out significant differences between the three groups [Table 3]. Reliability of measurements was tested by doing double determinations of 12 radiographs randomly selected at 15 days interval from the collected sample by the same operator and comparison was drawn between first and second determinations by Student’s t-test. No significant differences in initial and repeat readings of measurements were found. Hence, good reliability can be laid on the observations made.

RESULTS

The values of Hy–Me and Hy–B increased significantly in group I and increase in Hy–CL was significant in all three groups, but highest in group III. The value of Hy–GoMe and Hy–CHL decreased in all three groups, but was significant only in group I. Width of upper pharynx increased in all three groups, but increase in group III was highly significant, in group II was moderately significant, and in group I was just significant. There was no significant change in the width of the lower pharynx although it was highest in group III and lowest in group I. Value of ANB decreased in all three groups after treatment, which was highest in group III and lowest in group I. The data obtained were subjected to the statistical analysis (Table 1). Reliability of measurements was tested by doing double determinations of 12 radiographs randomly selected at 15 days interval from the collected sample by the same operator and comparison was drawn between first and second determinations by Student’s t-test. No significant differences in initial and repeat readings of measurements were found. Hence, good reliability can be laid on the observations made.

DISCUSSION

From normal position (occupies a constant position opposite the third and fourth cervical vertebrae[3]), the hyoid bone is displaced quite superiorly and posteriorly in Class I and Class II malocclusions and the degree of displacement is more in the latter.[7] Today the concept of dentofacial orthopedics to stimulate the mandibular growth in skeletal Class II cases with mandibular deficiency is widely used due to the fact that the functional orthopedic treatment in such patients leads to increase in oral airway dimensions, thereby reducing the risk of respiratory problems in future.[8] Twin block given by William Clark is the most common functional appliance for treatment of Angle’s Class II division 1 subjects, which effectively modifies the occlusal inclined plane to induce favorably directed occlusal forces by causing functional mandibular displacement. As the hyoid bone is attached to the mandible through the muscles, change in mandible position also changes the position of hyoid bone. As there is a tendency of compromised oropharyngeal airway in Angle’s Class II malocclusion, with hyoid bone being the anterior boundary of this airway, there is a need to define its position in this type of malocclusion before and after the treatment.

The age group of 10–14 years was considered in this study because this age group represented a period of active growth and development of craniofacial complex, which is a foremost requirement for the Twin block therapy.

Anteroposterior movement of the hyoid bone with respect to

![Figure 2: Comparison of mean differences and standard deviation of measurements among three groups](image)

### Table 3: Student’s t-test for each group, statistical comparisons (ANOVA) of measurements among different groups, and inter-group comparison (Bonferroni post hoc test)

| Variables | Group I (n=15) | Group II (n=15) | Group III (n=10) | ANOVA P value | Bonferroni post hoc test P value |
|-----------|---------------|----------------|-----------------|---------------|-------------------------------|
|           | Mean±SD      | P value        | Mean±SD         | P value       | I vs. II | I vs. III | II vs. III |
| Hy–B      | 2.73±4.4     | 0.0310*       | 1.13±4.7        | 0.7047        | 0.070±4.9 | 0.6650    | 0.177     |
| Hy–Me     | 3.70±3.5     | 0.0010**      | 1.80±4.5        | 0.1429        | 1.00±5.3 | 0.5617    | 0.280     |
| Hy–CL     | 2.67±2.9     | 0.0086**      | 2.87±2.7        | 0.0066**      | 2.99±4.2 | 0.0026**  | 0.439     |
| Hy–GoMe   | -3.90±3.4    | 0.0004***     | -0.27±4.9       | 0.8372        | -0.80±2.2 | 0.2694    | 0.009**   |
| Hy–CHL    | -1.70±2.1    | 0.0068**      | -1.10±5.2       | 0.4226        | -0.80±4.4 | 0.5787    | 0.309     |
| Upper pharynx | 1.27±2.3 | 0.0468*       | 1.30±1.3        | 0.0051**      | 1.42±0.9 | 0.0008*** | 0.906     |
| Lower pharynx | 0.80±3.6 | 0.4017         | 1.00±2.8        | 0.394         | 1.20±2.5 | 0.402     | 0.950     |
| ANB       | -2.53±0.7    | 0.0001***     | -2.93±1.2       | 0.0001***     | -3.92±10.0 | 0.0001*** | 0.248     |

SD denotes standard deviation, *just significant, P<0.05; **moderately significant, P<0.01; *** highly significant, P<0.001
the mandible is represented by Hy–Me and Hy–B and with respect to cervical vertebrae by Hy–CL. Increased values of Hy–Me and Hy–B measurement means the mandible is moving anteriorly from the hyoid bone. In this study, in group I, Hy–Me and Hy–B were significantly increased because the relative anterior movement of mandible was more than that of the hyoid bone after functional appliance therapy, though the hyoid bone also moved anteriorly with respect to the pharyngeal airways, which was shown by increase in Hy–CL. This was supported by Bettagel,\textsuperscript{[18]} who found hyoid became farther from point B and point Me in obstructive sleep apnea patient after using mandibular protrusion appliance. Increase in Hy–CL was the highest in group III, which signified the greatest anterior movement of hyoid bone with respect to cervical vertebrae, leading to increase in airway. But there was no significant difference between the three groups with respect to hyoid bone position alteration in horizontal dimension. Yassaei and Soroush\textsuperscript{[13]} did a similar study in horizontal, normal, and vertical growth patterns and found that the forward movement of hyoid bone in horizontal and normal growth directions was moderately significant and in vertical growth direction was highly significant.

Values of Hy–CHL and Hy–GoMe decreased in all three groups. This may be explained by the fact that as the hyoid bone is attached to the mandible by geniohyoid, mylohyoid, and the anterior belly of digastric muscles which are responsible for downward movement of the mandible, treatment with functional appliance results in hyperactivity of these muscles. Therefore, the balance between the suprahypoid and infrahypoid muscles is disturbed, resulting in upward movement of hyoid bone, while forward mandibular displacement occurs with functional appliance therapy. The decrease in these values was significant in group I and least in group III. This may be explained by the fact that as we move from group I to III, the hyoid bone is positioned more posteriorly and superiorly, which encroaches the airway and the pharyngeal size and has the least amount of displacement in the upward direction. This is also least damaging to the pharyngeal space. Similar results were reported by Yassaei and Soroush\textsuperscript{[13]} and Bettagel et al.\textsuperscript{[19]} in their studies.

In all three groups, the value of width of upper pharynx was increased, but no significant changes were found in lower pharynx. However, treatment with Twin block appliance was associated with mandibular advancement and forward posturing of tongue which relieved the pressure on the soft palate, thus leading to an increase in oropharyngeal dimension and improved airway permeability. The large increment in group III might be explained by the fact that in this group the airway was more compromised and narrower than in the other two groups. Hence, more compensation takes place in the soft palate with the advancement of mandible. This finding was supported by Murat Ozbek and Bettagel et al.\textsuperscript{[18]} Bonham also reported a mean increase of 2.76 mm in the superior airway space after modified functional appliance therapy.\textsuperscript{[20]}

Reduction in ANB value was highly significant in all three groups. Probably this reduction was because the advancement of mandible with Twin block decreased the overjet and increased the value of SNB. Trenouth\textsuperscript{[21]} also observed decrease in overjet and increase in SNB.

Hence, functional appliances such as twin block are used in developing Class II division 1 malocclusion not only to improve facial esthetics but also to increase the pharyngeal airway space along with a favorable hyoid bone position. This in turn may significantly reduce the chances of obstructive sleep apnea in future.

**CONCLUSION**

The following conclusions were drawn on the basis of the findings of this study:

- There was no significant difference between the three groups with respect to hyoid bone position alteration in horizontal dimension, but was the highest in hyperdivergent group
- Upward hyoid bone displacement in relation to mandibular plane was found to be highly significant in hypodivergent group as compared to the other groups, following treatment with Twin block appliance
- Width of upper pharynx measured from a point on the posterior outline of the soft palate (upper half) to the closest point on the posterior pharyngeal wall was found to be significantly increased in all three groups after treatment
- There was no significant change in the width of the lower pharynx although it was the highest in group III
- ANB was found to be significantly decreased in all three groups after treatment.

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How to cite this article: Verma G, Tandon P, Nagar A, Singh GP, Singh A. Cephalometric evaluation of hyoid bone position and pharyngeal spaces following treatment with Twin block appliance. J Orthodont Sci 2012;1:77-82.

Source of Support: Nil, Conflict of Interest: None declared.