

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

Geeta Verma, Pradeep Tandon<sup>1</sup>, Amit Nagar<sup>1</sup>, Gyan P. Singh<sup>1</sup> and Alka Singh<sup>1</sup>

## 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 in to three groups: group I (hypodivergent, SN-MP:  $<31^\circ$  ( $27^\circ$ - $30^\circ$ ),  $n=15$ ), group II (normodivergent, SN-MP:  $31^\circ$ - $34^\circ$ ,  $n=15$ ), and group III (hyperdivergent, SN-MP:  $>34^\circ$  ( $35^\circ$ - $38^\circ$ ),  $n=10$ ). 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.<sup>[1]</sup> 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.<sup>[1]</sup> 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,<sup>[2,3]</sup> while others have correlated the posture of hyoid with mandibular morphology<sup>[4,5]</sup>

and its position in various skeletal types.<sup>[6-9]</sup> Studies have also compared pharyngeal size in different growth patterns and diverse malocclusions.<sup>[10,11]</sup> Effects of orthodontic and orthognathic surgical procedures on hyoid bone position have also been reported.<sup>[12]</sup>

However, very few studies have evaluated change in hyoid bone position after treatment with functional appliance.<sup>[13]</sup> 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

Department of Orthodontics and Dentofacial Orthopedics, Babu Banarasi Das College of Dental Sciences, <sup>1</sup>Faculty of Dental Sciences, CSMMU (Upgraded KGMC), Lucknow, Uttar Pradesh, India

**Address for correspondence:** Dr. Geeta Verma, Department of Orthodontics and Dentofacial Orthopedics, Babu Banarasi Das College of Dental Sciences, Lucknow, Uttar Pradesh, India. E-mail: geetaortho@gmail.com

Access this article online	
Quick Response Code:	Website: www.jorthodsci.org
	DOI: 10.4103/2278-0203.103863

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  $11.39 \pm 1.07$  years for girls and  $13.01 \pm 0.30$  years for boys) with Angle's Class II division 1 malocclusion, ANB angle greater than  $4^\circ$  with deficient mandibular body length ( $<S-N + 3$  mm).<sup>[14]</sup> 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.

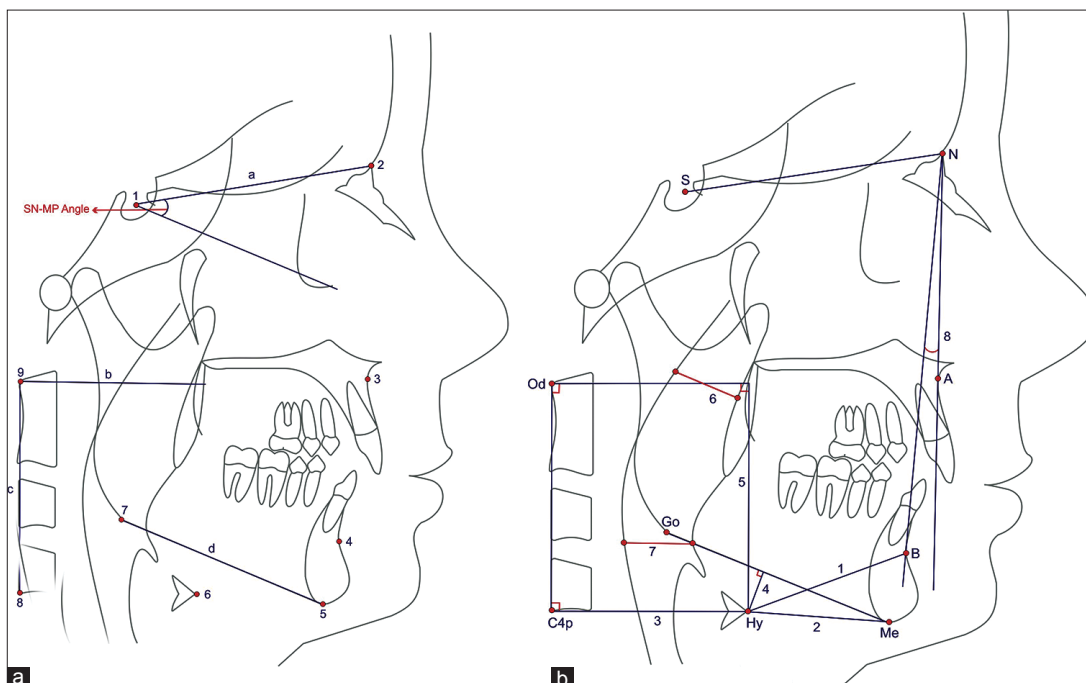
Lateral radiographs were taken before and after the treatment with Instrumentarium Cephalometer (Rotograph plus, Bologna, Italy). All subjects were positioned in the cephalostat with the sagittal plane at a right angle to the path of the X-rays, Frankfort plane parallel to the horizontal plane, teeth 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 ( $8'' \times 10''$ ) 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  $0.5 \mu\text{m}$  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  $0.5^\circ$ , 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<sup>[15]</sup> (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.<sup>[1,16]</sup> 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



**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	
	Mean±SD		Mean±SD		Mean±SD	
	Pre	Post	Pre	Post	Pre	Post
Hy-B	44.73±5.6	47.47±4.3	46.27±5.3	47.40±4.9	46.50±4.7	47.20±4.8
Hy-Me	36.00±5.7	39.70±5.1	38.40±4.8	40.20±3.8	36.70±5.3	37.70±5.3
Hy-CL	46.00±3.2	48.99±3.7	46.33±4.0	49.20±3.3	45.10±3.1	48.09±5.36
Hy-GoMe	11.67±5.2	7.77±5.2	13.87±6.7	12.60±5.1	14.60±4.74	15.40±4.7
Hy-CHL	49.80±8.9	48.07±9.2	45.07±7.7	43.97±5.2	50.50±4.9	51.30±6.3
Upper pharynx	12.40±2.4	13.67±2.3	12.11±3.5	13.23±3.0	10.58±1.43	12.00±1.83
Lower pharynx	10.77±3.4	11.57±4.5	10.60±2.6	11.60±3.1	9.70±2.5	10.90±2.5
ANB	6.40±1.6	3.87±1.1	6.67±1.5	3.73±1.4	7.70±4.50	4.50±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 pogonion
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)	
Od	The most posterior point of the odontoid process of second cervical vertebra
C4p	The most posterior-inferior point of the fourth cervical vertebra
Planes	
Sella-nasion plane (S-N plane)	The plane extending from sella to nasion
Cervical horizontal line (CHL)	Perpendicular line from Od to cervical line
Cervical line (CL)	Line connecting Od and C4p
Mandibular plane (Go-Me)	The plane extending from gonion to menton
Measurements	
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 highly significant in all groups. The results for all cephalometric measurements are shown in Tables 1, 3, and Figure 2.

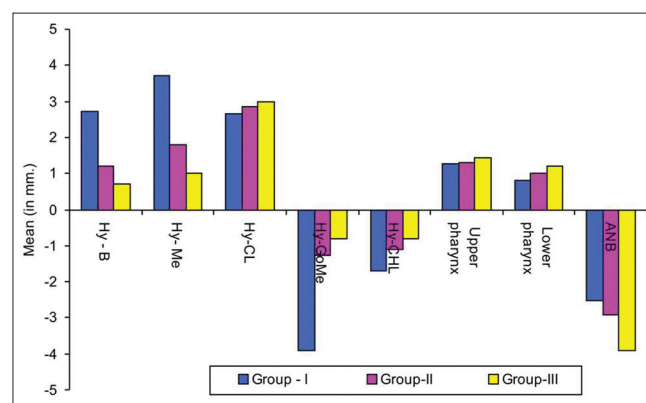
## DISCUSSION

From normal position (occupies a constant position opposite the third and fourth cervical vertebrae<sup>[3]</sup>), 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.<sup>[17]</sup> 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.<sup>[18]</sup> 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

**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 <i>P</i> value	Bonferroni <i>post hoc</i> test " <i>P</i> "		
	Mean±SD	<i>P</i> value	Mean±SD	<i>P</i> value	Mean±SD	<i>P</i> value		I vs. II	I vs. III	II vs. III
Hy–B	2.73±4.4	0.0310*	1.13±4.7	0.7047	0.70±4.9	0.6650	0.177	0.468	0.217	0.904
Hy–Me	3.70±3.5	0.0010**	1.80±4.5	0.1429	1.00±5.3	0.5617	0.280	0.562	0.359	0.959
Hy–CL	2.67±2.9	0.0086**	2.87±2.7	0.0066**	2.99±4.2	0.0026**	0.439	0.970	0.911	0.994
Hy–GoMe	-3.90±3.4	0.0004***	-0.27±4.9	0.8372	-0.80±2.2	0.2694	0.0079**	0.039*	0.014*	0.874
Hy–CHL	-1.70±2.1	0.0068**	-1.10±5.2	0.4226	-0.80±4.4	0.5787	0.309	0.965	0.352	0.593
Upper pharynx	1.27±2.3	0.0468*	1.30±1.3	0.0051**	1.42±0.9	0.0008***	0.906	0.993	0.994	0.961
Lower pharynx	0.80±3.6	0.4017	1.00±2.8	0.394	1.20±2.5	0.402	0.950	0.997	0.985	0.998
ANB	-2.53±0.7	0.0001***	-2.93±1.2	0.0001***	-3.92±10.0	0.0001***	0.248	0.620	0.289	0.885

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,<sup>[18]</sup> 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<sup>[13]</sup> 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 suprahyoid and infrahyoid 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<sup>[13]</sup> and Bettagel *et al.*<sup>[19]</sup> 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.*<sup>[18]</sup> Bonham also reported a mean increase of 2.76 mm in the superior airway space after modified functional appliance therapy.<sup>[20]</sup>

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<sup>[21]</sup> 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.

## REFERENCES

1. Bibby RE, Preston CB. The hyoid triangle. *Am J Orthod* 1981;80:92-7.
2. King EW. A roentgenographic study of pharyngeal growth. *Angle Orthod* 1952;22:23-37.
3. Durzo CA, Brodie AG. Growth behaviour of the hyoid bone. *Angle Orthod* 1962;32:193-204.
4. Cuozzo GS, Bowman DC. Hyoid positioning during deglutition following forced positioning of the tongue. *Am J Orthod* 1975;68:564-70.
5. Gobeille DM, Bowma DC. Hyoid and muscle changes following distal repositioning of the tongue. *Am J Orthod* 1976;70:282-9.
6. Ingervall B, Carlsson GE, Helkimo M. Change in location of hyoid bone with mandibular positions. *Acta Odontol Scand* 1970;28:337-61.
7. Kuroda T, Nunota E, Hanada K, Ito G, Shibasaki Y. A roentgenocephalometric study of the position of hyoid bone. *Bull Tokyo Med Dent Univ* 1966;13:227-43.
8. Kuroda T, Nunota E, Hanada K, Ito G, Shimizu K, Nakamura S, *et al.* [A roentgenocephalometric study of the position of hyoid bone]. *Nihon Kyosei Shika Gakkai Zasshi* 1966;25:31-8.
9. Sloan RF, Bench RW, Mulick JF, Ricketts RM, Brummett SW, Westover JL. The application of cephalometrics to cinefluorography: Comparative analysis of hyoid movement patterns during deglutition in class I and class II orthodontic patients. *Angle Orthod* 1976;37:26-34.
10. Mergen DC, Jacobs MR. The size of nasopharynx associated with normal occlusion and class II malocclusion. *Angle Orthod* 1970;40:342-6.
11. de Freitas MR, Alcazar NM, Janson G, de Freitas KM, Henriques JF.



- Upper and lower pharyngeal airways in subjects with class I and class II malocclusions and different growth patterns. *Am J Orthod Dentofacial Orthop* 2006;130:742-5.
12. Graber LW. Hyoid changes following orthopedic treatment of mandibular prognathism. *Angle Orthod* 1978;48:33-8.
  13. Yassaei S, Soroush M. Changes in hyoid position following treatment of class II division 1 malocclusion with a functional appliance. *J Clin Pediatr Dent* 2008;33:81-4.
  14. Graber, Rakosi, Petrovic. *Dentofacial orthopedics with functional appliances*. 2nd ed. St. Louis Mosby; 1997.p. 118.
  15. Schudy FF. Vertical growth versus anteroposterior growth as related to functional and treatment. *Angle Orthod* 1964;34:75-93.34.
  16. Erdinc AM, Dincer B, Sabah ME. Evaluation of the position of hyoid bone in relation to vertical facial development. *J Clin Pediatr Dent* 2003;27:347-52.
  17. Galvao Carlos Augusto Aranha N. Hyoid bones cephalometric positional study in normal occlusion and in malocclusion patients. *Rev Odont UNESP, Sao Paulo* 1983;12(1/2):143-52.
  18. Ozbek MM, Memikoglu TU, Gögen H, Lowe AA, Baspinar E. Oropharyngeal airway dimensions and functional-orthopedic treatment in skeletal class II cases. *Angle Orthod* 1998;68:327-36.
  19. Battagel JM, Johal A, L'Estrange PR, Croft CB, Kotecha B. Changes in airway and hyoid position in response to mandibular protrusion in subjects with (OSA). *Eur J Orthod* 1999;21:363-76.
  20. Bonham PE, Currier GF, Orr WC, Othman J, Nanda RS. The effect of a modified functional appliances on obstructive sleep apnea. *Am J Orthod* 1988;94:384-92.
  21. Trenouth MJ. Proportional changes in cephalometric distance during twinblock appliance therapy. *Eur J Orthod* 2002;24:485-91.

**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.

## Staying in touch with the journal

### 1) Table of Contents (TOC) email alert

Receive an email alert containing the TOC when a new complete issue of the journal is made available online. To register for TOC alerts go to [www.jorthodsci.org/signup.asp](http://www.jorthodsci.org/signup.asp).

### 2) RSS feeds

Really Simple Syndication (RSS) helps you to get alerts on new publication right on your desktop without going to the journal's website. You need a software (e.g. RSSReader, Feed Demon, FeedReader, My Yahoo!, NewsGator and NewzCrawler) to get advantage of this tool. RSS feeds can also be read through FireFox or Microsoft Outlook 2007. Once any of these small (and mostly free) software is installed, add [www.jorthodsci.org/rssfeed.asp](http://www.jorthodsci.org/rssfeed.asp) as one of the feeds.