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Effect of Twin Block Therapy Versus Fixed Functional Appliances on Pharyngeal Airway Space in Skeletal Class II Patients: A Prospective Cephalometric Study

R. Kaur[1], A.K. Garg[2], D.K. Gupta[3], L. Singla[4], K. Aggarwal[5]

[1]Consultant Orthodontist and Former PG Resident, Department of Orthodontics and Dentofacial Orthopedics, Panjab University Chandigarh, India; [2]Associate Professor, Department of Orthodontics and Dentofacial Orthopedics, Panjab University Chandigarh, India; [3]Professor, Department of Orthodontics and Dentofacial Orthopedics, Panjab University Chandigarh, India; [4]Senior Lecturer, Department of Orthodontics and Dentofacial Orthopedics, Panjab University Chandigarh, India; [5]Consultant Orthodontist and Former PG Resident, Department of Orthodontics and Dentofacial Orthopedics, Panjab University Chandigarh, India

Abstract

Background. Class II malocclusion is one of the most common malocclusion with varied prevalence. Functional therapy with appliances like Twin Block or Fixed functional appliances forms the mainstay of treatment in growing Class II patients. These patients might demonstrate narrow airway due to the retrognathic position of the mandible. This study investigated the effects of twin block and fixed functional appliance therapy (Forsus™ FRD) on the pharyngeal airway space in skeletal Class II patients.

Methods. Forty patients with Class II malocclusion were selected and divided into two equal groups of 20 patients each for both Twin block and Forsus group. Lateral cephalograms were obtained before and after the functional appliance therapy. Evaluation was done for changes in hyoid bone position, pharyngeal airway dimensions and tongue position.

Results. The variables of the study showed better hyoid position in both the groups. In Twin Block group, an increase in hy-apw2 and hy-PoFH suggested anterior positioning of hyoid and a decrease in H-MP and hy-ML indicated superior positioning. In Forsus group an increase in H-H', hy-FH, hy-ML, hy-NL, hy-NSL and hy-OL suggested inferior positioning of hyoid, while an increase in hy-apw2, hy-CVT, hy-PoFH, hy-RL and hy'-tgo indicated anterior positioning of hyoid bone after functional therapy.

Conclusion. Both the twin block and Forsus™ FRD improved the position of the hyoid bone after the functional appliance therapy however the changes were not statistically significant. Twin block and Forsus™ had similar effect on the hyoid bone position, pharyngeal dimensions and the tongue position. ***Clin Ter 2022; 173 (4):306-315-doi: 10.7417/CT.2022.2439***

Key Words: *Hyoid bone, pharyngeal airway space, tongue position, Class II malocclusion, functional appliances, mandibular retrognathism*

Introduction

Class II malocclusion is one of the most common malocclusion encountered in orthodontic practice with its prevalence varying from 1.9 – 14.6 % in Indian Sub-continent and with a wide geographical variation associated with it (1). As stated by McNamara, the Class II malocclusion presents with a wide array of clinical presentations owing to the prospects of various combinations of skeletal and dental components (2). Among these various possibilities, Class II malocclusion with retrognathic mandible, is the most frequently observed (3,4). The presence of retrognathic mandible predisposes the patients to a set of problems including unbalanced facial profile, retruded chin, lip incompetency, lip trap, reduced self-confidence, associated breathing difficulties etc. Such problems are rectified under the aegis of dentofacial orthopedics with an aim to achieve functional stability of the dentofacial complex. The correction of such malocclusion during the circumpubertal growth period eliminates the need for orthognathic surgical procedure later in life of an individual.

The treatment of skeletal Class II patients during the circumpubertal growth period can be accomplished either as single phase therapy involving Class II correction with fixed functional appliances in combination with fixed mechanotherapy (eg. Herbst appliance, Mandibular Anterior Repositioning Device (MARA), Jasper Jumper, Mandibular Protraction Appliance (MPA), Churro Jumper and Forsus Fatigue Resistant Device) or as two phase therapy that includes Class II correction using a removable appliance (for eg. activator, bionator, twin block and Frankel functional regulator) which is followed by the comprehensive fixed mechanotherapy aimed at fine-tuning the occlusion for long term stability. The correction achieved with fixed functional

Correspondance: Dr. Arun K. Garg, MDS (Orthodontics); FICD (USA), Associate Professor, Department of Orthodontics and Dentofacial Orthopedics, Panjab University Chandigarh, India. https://orcid.org/0000-0001-5589-2868. E mail id: drarunkgarg@gmail.com Contact number: Tel. +91-9814406789

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appliances is mainly dentoalveolar in nature with a smaller component of skeletal correction in contrast to the effect of twin block in which the major correction achieved is skeletal in nature with a small dentoalveolar component. But both treatment modalities produce clinically acceptable outcomes improving the facial imbalance particularly in the lower third of the face, overjet reduction, correction of molar relationship and improvement in lip incompetency.

In addition to the effects produced on craniofacial structures, various skeletal and dental malocclusions have been associated with significant effects on the pharyngeal airway. Mandibular retrognathism in skeletal class II patients is thought to have an adverse effect on pharyngeal airway by causing a reduction in posterior airway space (PAS). Short mandibular body and downward and backward rotation of mandible also contributes to the same. This narrowing of PAS may contribute to difficulty in breathing; which predisposes the patient to the development of Obstructive Sleep Apnoea Syndrome (OSAS). Computed Tomography guided evaluation along with Magnetic Resonance Imaging (MRI) has directly correlated the severity of OSAS with the pharyngeal airway dimensions (4).

The study of airway is incomplete without the analysis of hyoid bone. Hyoid bone is unique when it comes to its anatomic relationship because of lack any bony articulations but still is suspended by attachments of muscles, ligaments and fascia of the pharynx, mandible and cranium (6). Another peculiar feature of hyoid is its movement with different oral functions such as deglutition and respiration, also its close association with tongue because of muscular attachments of genioglossus and geniohyoid to it. Pae *et al* reported partial occlusion of oropharynx heterogeneity in hyoid position and genioglossus's electromyography (EMG) (7). The lateral cephalogram obtained as a routine diagnostic radiograph for orthodontic cases serve as valuable tool for airway assessment. An evaluation of lateral cephalogram imaging for recording the reproducibility of the upper airway, tongue and other related structures has shown that the measurements are highly reproducible in natural head position (NHP), provided the greatest possible attention is paid to head positioning (8). Moreover the literature is supportive of the fact that the lateral cephalograms are accurate tool for diagnosis and treatment planning in orthodontics pertaining to the hyoid bone and airway assessment (9-13).

The effect of malocclusion as such and the various treatment modalities on airway space has been a matter of concern in the era of evidence based orthodontics. An endeavour to explore the possible consequences of orthognathic surgical treatment of patients with Class III skeletal deformities have been made by various researchers (15-18). Both the effect of bimaxillary surgical treatment and mandibular setback alone has been researched on such patients. But there exist conflicting evidences regarding the two procedures. Furthermore, the evidence in regard to the effect of the removable and fixed functional appliance on airway dimensions in growing patients is lacking. Hence, the aim of the current study is to evaluate the effects of both removable and fixed functional appliances on the possible changes in the pharyngeal airway dimensions, the hyoid position and the change in the position of the tongue.

Methods

This prospective, single-center clinical study was carried out on the patients reporting for orthodontic treatment in the Department of Orthodontics and Dentofacial Orthopedics at Dr. Harvansh Singh Judge Institute of Dental Sciences and Hospital, Panjab University, Chandigarh. The study design was approved by the ethical committee of Panjab University, Chandigarh (PUIEC/2016/29/1-A/20/05). The study sample comprised of a total of 40 patients with a chief complaint of either forwardly placed upper front teeth or a backwardly placed chin or both. All the patients had skeletal Class II malocclusion with retrognathic mandible, an overjet > 5mm and an ANB angle $>4^0$. The age criteria for the inclusion of patients was selected to be 10-15 years for females and 12-17 years for males as the treatment modalities are generally used before the cessation of growth. All the patients were checked for presence of any kind of pharyngeal pathology. The patients with a history of enlarged tonsils, previous orthodontic treatment and those with a history of adenoidectomy or tonsillectomy were excluded from the study. Patient reporting with any systemic disease or any syndrome affecting the head and neck region were also excluded from the study.

Pre-treatment records were obtained for all the patients and a bench of experienced orthodontists selected the patients for enrollment into the study and formulated an individualized treatment plan for the patients. Lateral cephalograms of the patients were obtained with help of Carestream CS 9000 X-Ray unit system as per standardized procedure to allow for the reproducibility of the measurements. The cephalograms were recorded with the patient in standing position with the Frankfurt horizontal plane parallel to the floor. The patients were asked to occlude in centric occlusion and the cephalograms were exposed at the end of expiration phase of the respiration. The patients were instructed not to move their head and tongue during the exposure. On the basis of treatment plan, the patients were enrolled into two equal groups (comprising of 20 patients each), as follows:

- **Group 1:** Twin block group (It included those patients who were indicated to be best suited for Twin Block functional appliance for the correction of Class II malocclusion)
- **Group 2:** Forsus group (It included those patients who were indicated to be best suited for Forsus Fatigue Resistant Device for the correction of Class II malocclusion after a phase of initial leveling and alignment)

The patients in group 1 were treated with twin block appliance and a single-step mandibular advancement was carried out (Fig.1). Labial bow was provided in all the appliances; however, it was not activated until class I buccal segment relationship was achieved. Lower incisor capping was wherever necessary in order to prevent further proclination of incisors. The patients were instructed to wear the appliance 24 hours a day (including mealtimes and night-time wear). All the patients were followed at 4 week intervals till class I molar relation was achieved. Necessary adjustments were done in the appliance as per the requirements of the subjects.

Fig.1. Intra-oral photographs of patient with Twin-Block Appliance; A. Frontal View ; B. Right Buccal View and C. Left Buccal View

The patients in group 2 were treated with 0.022-inch slot pre-adjusted edgewise appliance (PEA) brackets with MBT prescription (3M Unitek, Monrovia, California, USA). Maxillary molars were banded and they carried headgear tubes on them. Prior to installation of fixed functional appliance, both arches were prepared up to 0.019-inches X 0.025-inches stainless steel archwires. Maxillary and mandibular archwires were tightly cinched back distal to the molars. L-pin spring module of Forsus™ FRD (3M Unitek, Corp., Monrovia, Calif) was used for the correction of Class II malocclusion (Fig. 2). Negative root torque was incorporated in mandibular incisor region wherever indicated. Activation with split crimps was done, if needed. Each patient was followed up at 4 week intervals. Patients were instructed to report immediately in case of any breakages of the appliance. Appropriate home care instructions were reinforced at every visit in both the groups.

The analysis of the pharyngeal airway dimensions, the hyoid position and the position of the tongue was done by comparing serial cephalograms. For Group 1 the cephalograms were obtained before the initiation of the functional appliance therapy and at the completion. In group 2 the lateral cephalograms were obtained before installation of the Forsus™ FRD and at the completion of the treatment with Forsus™ FRD. A descriptive analysis of the pre and post treatment cephalograms was done using landmarks and planes as defined (Table 1-4).

All the measurements were made by two independent in randomly selected 11 coded cephalograms to check the inter-examiner variability. Both the operators were blinded to the grouping of the cephalograms.

The data obtained was statistically analysed to test the significance of the findings. The inter-examiner variability was analysed using intra-class correlation coefficient. The intra-group comparison for both the groups were done using paired t test and mean differences were calculated. For inter-group comparison unpaired t-test was used for the comparison of mean of pre-treatment, post-treatment

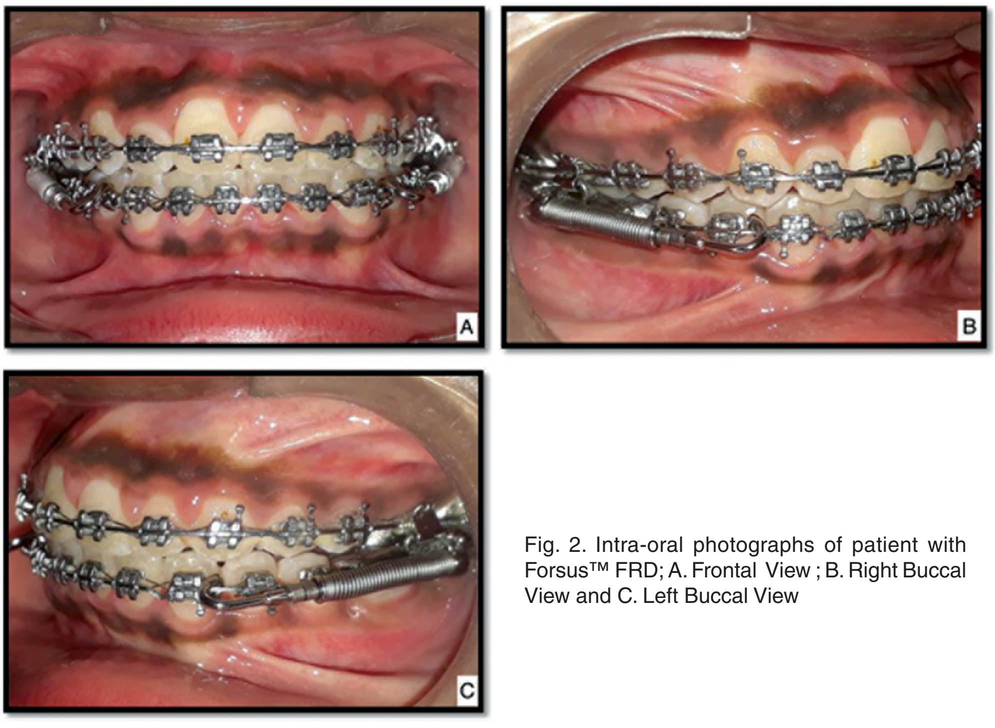

Fig. 2. Intra-oral photographs of patient with Forsus™ FRD; A. Frontal View ; B. Right Buccal View and C. Left Buccal View

Table 1. Description of cephalometric landmarks and reference planes (19)

LANDMARK	DESCRIPTION
AA	The most anterior point on the atlas vertebrae
ANS (sp)	Spinal point - the apex of the anterior nasal spine
Ap	Point on the posterior wall of nasopharynx
apw2	The anterior pharyngeal wall along the line intersecting cv2ia and hy
apw4	The anterior pharyngeal wall along the line intersecting cv4ia and hy
at 1	The most anterior part of the adenoid mass
at2	The intersection point between a line from the pterygomaxillary point (Ptm) to the midpoint of a line joining basion (Ba) and the centre of sella turcica (S), and the anterior contour of the adenoid soft tissue shadow
atp 1	The intersection point between a line from the pterygomaxillary point (Ptm) to the midpoint of a line joining basion (Ba) and the centre of sella turcica (S), and the posterior contour of the adenoid soft tissue shadow
Ba – basion	The most postero-inferior point on the anterior margin of the foramen magnum
C3	The most inferior anterior point on the third cervical vertebrae
cv2ia	The most anteroinferior point on the corpus of the second cervical vertebrae
cv4ia	The most anteroinferior point on the corpus of the fourth cervical vertebrae
cv4ip	The most posterior and inferior point of the fourth cervical vertebrae
E	The most inferior and anterior point of the epiglottis
Gnpost- retrognathion	The most inferior posterior point on the mandibular symphysis
Go	The most posterior and inferior point of the mandible
H'	The intersection point between the perpendicular from H to the line connecting the point C3 and retrognathion
hy (H)	The most superior and anterior point on the body of the hyoid bone
hy' - hyoid prime	The perpendicular point from hy along the mandibular plane
hya	The most anterior point of the hyoid
Hyp	The most posterior point of the greater horn of the hyoid
ii	The incisal tip of the most prominent mandibular incisor
Lp	Point on the anterior wall of oropharynx
Mp	Point on the posterior wall of oropharynx
m	The most posterior point on the mandibular symphysis
Mc	Point on cervical, distal third of the last permanent erupted molar
N - nasion	The most anterior point of the frontonasal Suture
O	The middle of the linear distance U-ii on the Mc-ii line
Or – orbitale	The most inferior point of the orbit
PNS	The tip of the posterior nasal spine – the most posterior point at the sagittal plane on the bony hard palate
Po – porion	The most superior point of the external auditory meatus
ppw2	The posterior pharyngeal wall along the line intersecting cv2ia and hy
ppw4	The posterior pharyngeal wall along the line intersecting cv4ia and hy
Ptm (pm)	Pterygomaxillary point - the intersection between the nasal floor and the posterior contour of the maxilla
PTR	The intersection point between the Frankfort horizontal line (FH) and the posterior border of pterygomaxillary fissure (PTR)
S- sella	The centre of sella turcica
TT	The tip of the tongue
tgo – gonion	The intersection point of mandibular and ramus planes
U	The tip of the uvula or its projection on the Mc-ii line
Ba-N	Line connecting the points basion (Ba) and nasion (N)
C3-Gnpost	Line connecting the most inferior anterior point on the third cervical vertebrae (C3) and the most inferior posterior point on the mandibular symphysis (retrognathion)
CVT	The cervical vertebrae tangent- the posterior tangent to the odontoid process through cv4ip‖
FH	Frankfort horizontal plane
ML (MP)	Mandibular line (plane) - tangent line to the lower border of the mandible through gnathion (gn)
NL (PP) - nasal line (palatal plane)	Line connecting the anterior nasal spine (ans or sp) and pterygomaxillare (Ptm or pm)
NSL (SN) - the anterior cranial base	Line connecting the centre of sella turcica (s) and nasion (n)
OL (OP) -occlusal line (plane)	The line connecting the distobuccal cusp tip of the upper first permanent molar (mc) and the incisal tip of the most prominent maxillary incisor (is)
Po⊥FH	Vertical line drawn on Frankfort horizontal plane at porion (Po)
PTR⊥FH	Vertical line drawn on Frankfort horizontal plane at the posterior border of pterygomaxillary fissure (PTR)
RL - the ramus line (plane)	Tangent line on the posterior contour of ramus ascentens

Table 2. Description of cephalometric variables for hyoid bone assessment (19)

VARIABLE	DESCRIPTION
VERTICAL POSITION (mm)	
H-H'	Linear distance between H and a perpendicular to the C3-retrognathion line
H-MP	Distance between H- MP
hy-FH	Linear distance along a perpendicular from hy to the Frankfort horizontal line.
hy-ML (hy-MP)	Linear distance along a perpendicular from hy to the mandibular plane (ML) on the intersection point
hy-NL (hy-PP)	Linear distance along a perpendicular from hy to the maxillary plane (NL)
hy-NSL (hy-SN)	Linear distance along a perpendicular from hy to the anterior cranial base (NSL)
hy-OL (hy-OP)	Linear distance along a perpendicular from hy to the occlusal plane
ANTEROPOSTERIOR POSITION (mm)	
hy-CVT	Linear distance along a perpendicular from hy to the cervical vertebrae tangent (CVT)
hy—m	Linear distance between point hy and point m on the mandibular symphysis
C3-H	Linear distance between C3 and H
hy-RL	Linear distance along a perpendicular from hy to the ramus plane (RL)
hy-Gnpost	Linear distance between point hy and point Gn post
hy-Po⊥LFH	Linear distance along a perpendicular from hy to the line Po⊥FH
hy-PPW	Linear distance between point hy and point PPW
hy-PTR⊥FH	Linear distance along a perpendicular from hy to the line PTR⊥FH
AXIAL INCLINATION OF HYOID BONE (0)	
hy axis-BaN	Angular measurement between the long axis of the hyoid bone and the basion-nasion line
hyaxis—ML	Angular measurement between the long axis of the hyoid bone and the mandibular plane
hyaxis-NL	Angular measurement between the long axis of the hyoid bone and palatal plane
OTHER LINEAR DISTANCE (mm)	
hy'-tgo	Linear distance between point hy' and point tgo
hy-apw2	Linear distance between point hy and the anterior pharyngeal wall on point apw2
hy-apw4	Linear distance between point hy and the anterior pharyngeal wall on point apw4

Table 3. Description of cephalometric variables for pharyngeal airway assessment (19)

VARIABLE	DESCRIPTION
PHARYNGEAL DEPTH (mm)	
apw2-ppw2	Linear distance on the line connecting the point hy and the point cv2ia, between the intersection point on the anterior and on the posterior pharyngeal walls (apw2 and ppw2, respectively)
apw4-ppw4	Linear distance on the line connecting the point hy and the point cv4ia, between the intersection point on the anterior and on the posterior pharyngeal walls (apw4 and ppw4, respectively)
Ptm-PPW	Linear distance between the pterygomaxillary point (Ptm) or the point PNS and the intersection point between the palatal plane and the posterior wall of the nasopharynx (PPW)
DIMENSION OF BONY PHARYNX (mm)	
Ba-PNS	Linear distance between point Ba and PNS
SHAPE OF BONY NASOPHARYNGEAL SPACE (0)	
N-S-Ptm	Angle between the lines N-S and S-Ptm
POSTERIOR AIRWAY SPACE (mm)	
Ptm-S-Ba	Angle between the lines Ptm-S and S-Ba
OTHER LINEAR DISTANCES (mm)	
PAS	Linear distance between a point on the base of the tongue (tb) and another point on the posterior pharyngeal wall (ppwb), both determined by an extension of a line from point B through Go
AA-PNS	Linear distance between the most anterior point on the atlas vertebrae and the tip of the posterior nasal spine
Ap-Cp (Ap-Ptm)	The greatest distance between the pterygomaxillary point (Cp or Ptm) and the posterior wall of nasopharynx (Ap)
Mp-Lp	The smallest distance between the anterior wall (Lp) and the posterior wall (Mp) of oropharynx
T1	The soft tissue shadow (atl-atp 1) on a line from the pterygomaxillary point (Ptm) to the midpoint of a line joining basion (Ba) and the centre of sella turcica (S)
T2	The soft tissue shadow (at2-Ba) on a line from the pterygomaxillary point (Ptm) to basion (Ba).

Table 4. Description of cephalometric variables for tongue position assessment (19)

VARIABLE	DESCRIPTION
PARTIAL LENGTH OF TONGUE	
tg1	Line through the O and ii. tgl measures the length of the tongue in the posterior portion (root) of the tongue
tg2	Line constructed on O at 30° Mc-ii line. tg2 indicates the partial length of the tongue in the posterior region of the dorsum
tg3	Line constructed on O at 60° Mc-ii line. tg3 indicates the partial length of the middle part of the dorsum of the tongue
tg4	Line constructed on O at 90° Mc-ii line. tg4 indicates the partial length of the tongue in the middle of the dorsum of tongue
tg5	Line constructed on O at 120° Mc-ii line
tg6	Line constructed on O at 150° Mc-ii line. tg6 indicates the partial length of the tongue in the anterior region of the tongue
tg7	Line constructed on O at 180° Mc-ii line. tg7 indicates the partial length of the tongue in the tip region
TONGUE HEIGHT	
TGH	This is perpendicular to the mid of E-TT line (line between the most antero-inferior point of epiglottis and tongue tip). It measures the height of the tongue during the rest and centric occlusion
TONGUE LENGTH	
TGL	This is measured by distance between tongue tip (TT) and epiglottis (E) point

and mean of pre and post-treatment measurements. All the statistical analysis was performed on SPSS software for Windows (Ver.19, SPSS, Chicago, Ill).

Results

The present study sample included 40 patients. The mean age and gender distribution of all patients along with the intergroup differences are listed in Table 5. The correlation coefficient ranged from 0.968 to 0.999 for hyoid bone measurements, from 0.884 to 0.996 for pharyngeal measurements and from 0.870 to 0.986 for tongue position measurements. The comparison of the measurements recorded for inter-operator variability show a very high correlation between the readings of two examiners.

The comparison of the hyoid bone measurements in Group 1 revealed an improvement in the antero-posterior and vertical position but only few measurements were found to be statistically significant. Mean hy-apw2 and hy-PoFH increased suggesting anterior positioning of hyoid bone. The mean H-MP and hy-ML decreased significantly indicating further superior positioning of hyoid bone. In group 2 increase in mean values of H-H', hy-FH, hy-ML, hy-NL, hy-NSL and hy-OL suggests inferior positioning of hyoid. The mean hy-apw2, hy-CVT, hy-PoFH, hy-RL and hy'-tgo increase is indicative of anterior positioning of hyoid bone after functional therapy. A significant decrease in the mean H-MP points to the upward movement of hyoid bone (Table 6).

Table 5. Age and gender distribution of study sample

Groups	Number of participants	Mean Age	Sex distribution
Group 1 (Twin Block)	20	12.47 ± 1.8	Male: 11
			Female: 9
Group 2 (Forsus™ FRD)	20	14.60 ± 1.3	Male: 12
			Female: 8

The comparison of mean of variables for pharyngeal measurements in group 1 show improvement as indicated by increase in AA-PNS and Ba-PNS but it lacked any statistical significance. The results of Group 2 also showed no significant change in the pharyngeal measurements (Table 7).

The results of the tongue space measurements showed an increase in mean tg7 and TGH measurements was observed to be statistically significant indicating increase in anterior tongue space following functional mandibular repositioning with twin block appliance. In Forsus group the measurements for the mean tg3 and tg4 showed a decrease from pre to post treatment measurements indicating a decrease in the partial length of the tongue. A statistically significant increase in the measurements for tg7 was suggestive of increase in anterior space for the tongue (Table 8).

The values of mean of difference between pre and post-treatment measurements between Twin Block and Forsus™ group shows the values of hy-NSL and hy-OL were more among group 2 suggesting a greater increment of change in position of hyoid in group 2. However, hy-ML showed greater statistical significant change in group 1, thereby suggesting the change in position of hyoid is more with respect to ML in group 1 but if considering distant landmarks such as NSL and OL changes are appreciated more in group 2 (Fig. 3).

The comparison of pharyngeal measurements showed no statistically significant changes, thus both treatment modalities have similar effects on the pharyngeal measurements (Fig. 4).

The evaluation of tongue space measurements also show similar results suggesting that the both the treatment modalities have similar effect on the tongue position after mandibular advancement (Fig. 5).

Table 6. Intragroup comparison of Hyoid measurements

Variable	Group 1			Group 2		
	Pre-Treatment	Post-Treatment	p-value	Pre-Treatment	Post-Treatment	p-value
C3H	33.18 ± 6.2	34.17 ± 3.4	0.511	33.73 ± 5.6	34.88 ± 4.9	0.304
H-H’	4.38 ± 3.5	4.87 ± 4.2	0.560	4.03 ± 3.6	5.98 ± 4.7	0.039*
H-MP	14.80 ± 6.1	12.15 ± 4.2	0.001***	17.33 ± 6.1	16.88 ± 5.5	0.047*
hy-apw2	16.50 ± 6.69	19.93 ± 5.4	0.011**	16.85 ± 5.6	20.88 ± 5.3	0.001***
hy-apw4	16.28 ± 3.2	19.23 ± 8.03	0.191	17.15 ± 3.7	18.30 ± 2.8	0.159
hya-BaN	45.53 ± 9.8	42.43 ± 12.8	0.387	46.75 ± 11.1	46.30 ± 12.1	0.869
hya-ML	8.90 ± 7.6	12.05 ± 8.9	0.122	8.90 ± 4.8	11.85 ± 8.9	0.109
hya-NL	21.63 ± 9.3	21.45 ± 8.6	0.935	25.00 ± 13.3	21.70 ± 10.03	0.131
hy-CVT	45.35	49.15 ± 8.7	0.071	47.70 ± 6.7	50.60 ± 5.6	0.023*
hy-FH	75.85 ± 10.9	76.30 ± 14.5	0.874	77.70 ± 22.2	85.73 ± 15.9	0.043*
hyGnp	36.25 ± 7.2	37.68 ± 5.3	0.443	38.25 ± 7.8	35.40 ± 9.03	0.254
hy-m	35.75 ± 7.3	34.70 ± 9.6	0.744	37.90 ± 7.3	35.83 ± 8.9	0.373
hy-ML	14.38 ± 5.4	12.70 ± 3.8	0.039*	16.88 ± 5.2	17.43 ± 6.2	0.048*
hy-NL	53.00 ± 9.3	58.38 ± 12.8	0.064	54.85 ± 15.1	63.60 ± 10	0.014*
hy-NSL	92.15 ± 14.2	94.75 ± 17.3	0.490	99.15 ± 12.9	105.40 ± 13.5	0.028*
hy-OL	39.23 ± 8.7	38.75 ± 8.1	0.825	40.13 ± 6.7	45.18 ± 8.18	0.002***
hy-PoFH	32.43 ± 8.3	37.78 ± 9.03	0.022*	36.25 ± 8.7	39.33 ± 9.3	0.042*
hy-PPW	26.28 ± 6.2	27.55 ± 5.7	0.268	29.90 ± 7.8	30.85 ± 7.5	0.363
hy-PTRFH	7.80 ± 6.4	7.28 ± 5.2	0.705	6.18 ± 5.1	6.25 ± 5.6	0.943
hy-RL	11.68 ± 5.2	13.50 ± 5.9	0.242	13.25 ± 6.6	16.33 ± 5.4	0.001***
hy’-tgo	25.33 ± 7.9	27.73± 6.4	0.138	27.50 ± 7.2	27.73± 6.4	0.011**
*p value ≤ 0.05 is significant; **p value ≤ 0.01 is significant; ***p value ≤ 0.001 is significant						

Table 7. Intragroup comparison of Pharyngeal measurements

Variable	Group 1			Group 2		
	Pre-Treatment	Post-Treatment	p-value	Pre-Treatment	Post-Treatment	p-value
AA-PNS	31.35 ± 4.1	32.58 ± 4.9	0.260	31.00 ± 3	30.70 ± 4	0.757
Ap-Cp	16.78 ± 4.7	16.85 ± 4	0.936	16.68 ± 3.6	18.28 ± 3.6	0.205
apw2-ppw2	12.88 ± 5.9	11.65 ± 4	0.281	14.95 ± 5.3	12.53 ± 4.6	0.108
apw4-ppw4	14.55 ± 3.7	13.73 ± 3.7	0.354	15.33 ± 4	13.65 ± 3.2	0.080
Ba-PNS	43.28 ± 5.3	44.85 ± 5.2	0.289	42.95 ± 2.9	43.28 ± 3.5	0.746
Mp-Ip	8.80 ± 3.3	8.35 ± 2	0.594	9.58 ± 2.4	9.45 ± 3.4	0.871
NSPtm (°)	69.33 ± 4.6	70.13 ± 3.3	0.459	71.65± 2.9	70.65 ± 3	0.240
PtmSBa (°)	63.30 ± 7.4	63.25 ± 5	0.977	11.13 ± 2.4	10.28 ± 3.4	0.332
PAS	11.33 ± 4.7	10.48 ± 4.5	0.527	21.80 ± 5.4	23.13 ± 4.6	0.375
PtmPPW	22.30 ± 8.9	20.90 ± 6.1	0.567	60.23 ± 4.2	58.83 ± 7.9	0.300
T1	12.43 ± 4.1	13.68 ± 5	0.337	10.98 ± 3.2	12.18 ± 3.7	0.174
T2	32.13 ± 6	33.43 ± 4	0.379	29.98 ± 5.8	31.12 ± 3.4	0.459

Table 8. Intragroup comparison of Tongue space measurements

Variable	Group 1			Group 2		
	Pre-Treatment	Post-Treatment	p-value	Pre-Treatment	Post-Treatment	p-value
tg1	25.05 ± 4.5	26.08 ± 4.7	0.494	25.23 ± 4.9	24.05 ± 4.7	0.273
tg2	16.30 ± 4.6	16.48 ± 3.7	0.896	15.53 ± 6.8	13.95 ± 5.1	0.178
tg3	12.05 ± 2.7	11.45 ± 2.5	0.357	11.73 ± 4	10.18 ± 3.9	0.011**
tg4	11.05 ± 2.8	10.60 ± 2.3	0.401	10.53 ± 3.8	9.50 ± 3.8	0.045*
tg5	12.68 ± 3.2	12.15 ± 2.8	0.481	12.03 ± 4.3	12.05 ± 5.7	0.977
tg6	18.15 ± 4.9	17.98 ± 6.5	0.926	17.75 ± 6.2	17.05 ± 7.6	0.536
tg7	26.18 ± 5.3	29.20 ± 5.1	0.033*	26.60 ± 5.2	29.05 ± 3.6	0.040*
TGH	26.60 ± 3.6	28.83 ± 4	0.027*	28.23 ± 3.3	30.88 ± 3.9	0.010**
TGL	68.33 ± 10.3	70.45 ± 9	0.340	69.95 ± 9.5	72.13 ± 7	0.277
*p value ≤ 0.05 is significant; **p value ≤ 0.01 is significant						

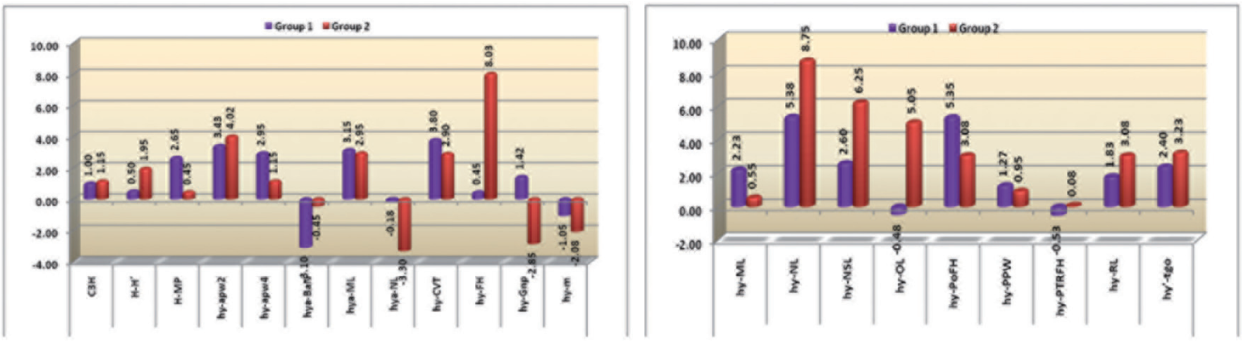

Fig. 3. Intergroup comparison for hyoid bone measurements

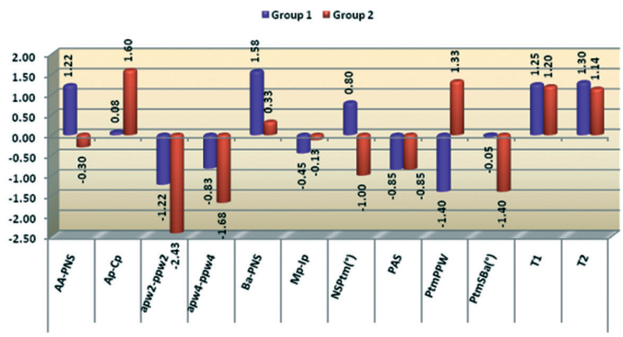

Fig. 4. Intergroup comparison for pharyngeal measurements

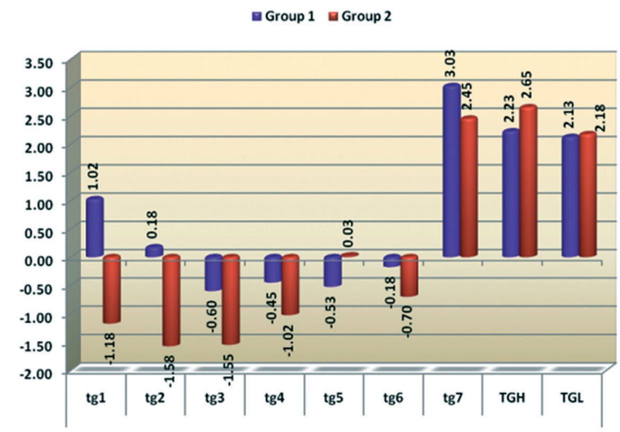

Fig. 5. Intergroup comparison for tongue space measurements

Discussion

Successful treatment of patients with skeletal Class II malocclusion is one of the most common challenges faced by orthodontists since the early years of the speciality. The Class II patients can have varied clinical presentations such as maxillary prognathism, mandibular retrognathism or a combination of both (mandibular retrognathism being the common). A wide range of literature has been dedicated to the discussion of the various modalities of Class II treatment and its outcome/effects on associated skeletal and dentoalveolar structures.

The effect of Class II malocclusion on the dentoalveolar structures has been well documented. Apart from the dentition and the maxillo-mandibular complex, the area of interest has expanded to the influence of various functional appliances on the changes in airway dimensions and associated structures such as changes in hyoid bone position and tongue position following any functional repositioning of mandible with any appliance (20-25). Freitas MR et al have reported that narrow upper pharyngeal airways are seen in Class II malocclusion paients (26). According to Lowe, small and retrognathic mandible along with increased obesity, increased neck size, a lower hyoid position and overall reduction in the dimensions of craniofacial complex are major risk factors for development of Obstructive Sleep Apneoa (OSA) (27). As an orthodontist, among the various treatment modalities available for OSA, two are of special interest: Orthopedic mandibular advancement (OMA) and rapid maxillary expansion (RME). OMA is usually opted for patients with retrognathic mandible and has the potential to improve the airway by redirection of the mandibular growth of posteriorly positioned mandible into a more favourable downward and forward direction. Whereas RME is indicated for patients with narrow maxillary arches whose nasal resistance is improved post-RME (28,29).

In the present study lateral cephalograms were used for the assessment of various measurements of hyoid bone, pharyngeal airways and tongue position. The reliability of the cephalograms for the measurements of nasopharyngeal dimensions has been shown to be high by various authors. Vizzotto et al compared the measurement of upper airway using lateral cephalograms, CBCT-lateral reconstructions and CBCT-axial planes and found statistical similarity between the measurements of the three selected methods (30). Narayanan and Faizal studied the correlation between lateral cephalogram, flexible laryngoscopy (awake endoscopy) and sleep study to evaluate OSA patients. They found a significant correlation between lateral cephalograms and the flexible laryngoscopy with the Apnoea Hypopnoea Index (AHI) in patients with OSA (31). Moreover, lateral cephalograms are routinely obtained for the purpose of orthodontic diagnosis and treatment planning. The validity of lateral cephalogram for airway analysis precludes the patient from additional imaging modalities like CBCT and MRI which predispose to additional radiation exposure and have associated financial insinuations.

The outcomes of the present study showed that in group I (twin block) among the vertical position parameters H-MP and hy-ML showed a significant decrease. An important factor in the improving the airway in OSA patients has been reported to be the positioning of the hyoid bone in close proximity of the mandibular plane, which in turn improves the airflow by indirectly influencing the pharyngeal airways. Similar findings were observed for group II (patients treated with fixed functional appliance) with decrease of H-MP. In both the groups an increase in antero-posterior position measurement from pre to post-treatment values are suggestive of an improvement in the position of hyoid bone in response to the functional appliance therapy. Verma G et al also reported significant increase in the hy-CL (cervical line) measurement post twin block therapy in Class II patients, which supports the finding of increase in hy-CVT in the present study demonstrating an anterior movement of hyoid bone with respect to the cervical vertebrae (21).

The changes in the pharyngeal measurements after the functional appliance therapy in both the groups did not reveal any statistically significant result. In the present study an increase in the value of AA-PNS is seen from its pre-treatment to post-treatment value for both the groups which indicated the improvement of pharyngeal airway at the level of palatal plane, but this improvement lacks significant potential to influence the clinical condition of the patient. The comparison of tongue space variables have shown that there was a significant increase in dimensions of tg7 in both the groups, but greater increase was observed in group II than in group I (2.23mm in group I and 2.65mm in group II) which could have been possible due to larger dentoalveolar effect of Forsus FRD providing more tongue space in the anterior region of oral cavity. This could have a favorable effect on the airways in Class II patients which eventually increase the pharyngeal airway space subsequent to anterior movement of tongue.

The present study had certain limitations in regard to the use of lateral cephalograms for the evaluation purpose which gives 2-dimensionsnal representation of a complex 3-dimensional airway. There is a possibility of superimpositions of structures on a 2-D film which allows evaluation of changes only in vertical and antero-posterior dimensions. Thus any modifications in the medio-lateral or transverse aspect might be got neglected thereby diluting the outcomes. In other words, volumetric data could not be obtained from lateral cephalograms. Furthermore, a long term follow-up is required to substantiate the stability of results achieved.

Conclusion

The findings of the present study concluded that:

1. Twin block appliance and Forsus™ FRD have a positive effect on the hyoid bone, positioning it more favorably in forward direction.
2. Both the appliances did not have a great impact on the pharyngeal dimensions.
3. There was lack of any statistically significant changes in tongue position in response to the two appliances.
4. Functional appliances can't be solely relied upon to improve the restricted airway merely by repositioning the mandible in forward direction and increasing the dimensions of the airway.

Recommendations

1. Lateral cephalograms of all the Class II patients should be carefully screened in order to locate the potential problem of airway obstruction which makes these patients prone to development of sleep-disordered breathing (SDB). The timely evaluation of other parameters increased neck circumference, obesity, snoring, sedentary lifestyle, daytime sleepiness etc during clinical examination and case history will allow the patients to be aware of future airway problems.
2. Functional appliances could be used to improve upon the reduced airways in Class II patients but their use alone might not be sufficient.
3. If any Class II patient is found to have any signs of airway obstruction, interdisciplinary approach should best serve the patient by prompt referral to ear nose throat (ENT) specialist or somnologist, if needed.

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Nil

Conflict of interest

The authors declare no conflict of interest regarding this manuscript.

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