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Original Research Paper

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CONE BEAM COMPUTED TOMOGRAPHY (CBCT) ANALYSIS OF OROPHARYNGEAL AIRWAY IN ANGLES CLASS II DIVISION I MALOCCLUSION FOLLOWING FUNCTIONAL APPLIANCE THERAPY

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ABSTRACT **Objectives:** To evaluate and compare the alterations taking place in the oro-pharyngeal airway space with functional appliance between class I & treated class II division 1 subjects. **Methods:** The study comprised of forty five participants. Of these, thirty subjects were divided into two groups (Group 1 & 2) who had Angles Class II Division I malocclusion. Subjects with Angles Class I malocclusion formed the control group (Group 3) with 15 subjects. Group 1 received standard twin block therapy and Group 2 received fixed functional appliance. The control group received fixed mechanotherapy. A full skull CBCT scan was taken pre and post treatment in the two study groups and the control group to check for changes that occurred in the oro-pharyngeal volume. The volume of the oro-pharyngeal airway space was analyzed by student's t test and Tukey's post hoc tests using SPSS Version 22.0. (For Windows) **Results:** Group 2 and group 3 exhibited a statistically significant increase in the mean oropharyngeal space volume ($p < 0.01$) during the post treatment period when compared to the pretreatment. volumes. **Conclusion:** Increased oro-pharyngeal space was seen in twin block therapy since it brings about both skeletal and dento-alveolar changes while fixed functional appliance showed comparatively less changes in the oropharyngeal space.

KEYWORDS : cone beam computed tomography; functional appliance; upper airway; malocclusion

INTRODUCTION:

The airway consists of the space superior to the plica vocalis up until the nasal and oral orifices. It is responsible for regulation of movement of air into and out of the lungs. (1) Normal airway is vital for the development of facial assemblies and is formed by the hard and soft tissue components of the oro and nasopharynx. (1,2) The air pathway, which is crucial for the development of the craniofacial structures and occlusion, may be obstructed due to various physiologic or pathologic causes, which is further implicated in the development of malocclusion.(1,2,3)

Some researchers also believe that there is a direct relationship between airway obstruction and development of certain types of malocclusion and parafunctional habits such as mouth breathing. (2) It is also stated that Edward Angle was the first to propose such a correlation. (2) Restricted or reduced airway volume and higher mandibular plane angles was found to be associated with class II malocclusion. (4)

In the past, calculation of air-way space was seldom carried out as it was done on cephalometric images. With the advent of 3D imaging, the airway volume is calculated with increased accuracy. (2,5) Cone Beam Computed Tomography (CBCT) is now widely used for the assessment of air pathways especially in subjects with malocclusion. CBCT has merits such as identification of stable landmarks on the cranial base and repeatable reconstructions and measurements, before and after treatment. (6)

Class II malocclusion is a commonly encountered condition in the clinical setup and the subjects either have advanced maxilla or retrognathic mandible and at times, both. (3,7,) Clark WJ originally proposed the Twin block therapy for the management of developing Class II malocclusion and ever since, has been popular for its management. (7) Previous studies have revealed compromised pharyngeal airway spaces in children with class II malocclusions when compared with the other two types of malocclusion and also improvement in the same following Twin block therapy. (7)

The objective of the current research was to evaluate the oropharyngeal airway volume in subjects with Class II division 1 malocclusion before and after correction of malocclusion using twin block therapy and compare the volumes with class I malocclusion as well as with class II division 1 subjects receiving fixed orthodontic therapy.

MATERIALS AND METHODS:

The study consisted of 45 participants in the age group of 11-24 years of both sexes. Fifteen participants with ideal Angles class I malocclusion formed the control group; Group 3, whereas the participants with Angles class II division 1 formed the test group. The test group was further divided into two groups; group 1 consisting of 15 participants in the age group of 11-14 years and Group 2 consisting 15 subjects in the age 16-24 years.

Inclusion criteria for the study group was as follows: Angles class II division 1 malocclusion, horizontal to average growth pattern, orthognathic maxilla, retrognathic mandible, increased overjet and deep bite. Exclusions were gross facial asymmetry and deformity, repaired or unrepaired cleft lip or palate, previous orthodontic treatment, maxillofacial trauma or surgeries.

Institutional Ethics committee approval was obtained before the initiation of the study. Informed consent was obtained from the participants and informed assent when the participants were aged less than 18 years of age.

After a preliminary clinical examination, all the subjects underwent a full skull Cone Beam Computed Tomographic (CBCT) examination to assess the airway volume. CBCT scans were obtained using KODAK 9000 3D Extraoral Imaging System (Carestream Health, Rochester, New York) with a field of view (FOV) of 14 X 19 cm. The images were obtained with the participants in standing position. CBCT datasets were acquired by the software with reconstruction slice thickness of 0.300 mm and 728 X 728 matrix. A single 270-degree rotation of 20-second duration scan was made with isotropic voxel size set at 0.300mm. The data were exported as Digital Imaging and Communications in Medicine (DICOM) images to the Anatomage Software.

Following pre treatment CBCT scan, Group 1 subjects received standard twin block to achieve class I occlusion, while group 2 received fixed functional appliance. Group 3 served as the control. Group 1 participants were instructed to wear the appliance 24 hours a day and maintain good oral hygiene, while group 2, the appliance was fixed to the mandibular and maxillary arches for a period of 8 months.

Group 1 participants were reviewed 15 days of insertion, and subsequently once every 4 weeks for a period of 7-9 months. The monthly appointments included adjustment of clasps, assessment and correction of any discomfort and motivation. Trimming of maxillary blocks was done once pterygoid reflex was achieved. Trimming was carried out on both sides of the maxillary bite block (1 mm each side per month) to encourage eruption of lower molars leaving a wedge shaped inclined plane in the premolar region. Trimming was carried on until the lower first molars completely erupted into occlusion.

In group 2, after the insertion of the appliance, the participants were recalled for review 15 days following insertion of the appliance and subsequently recalled once every 4 weeks for a period of 7-9 months The monthly appointments included adjustment of clasps, assessment and correction of any discomfort and motivation. After observing the desirable changes, the appliance was deactivated.

Following treatment, all subjects underwent repeat CBCT for assessment of pharyngeal airway volume. Oropharygeal volume was reconstructed as follows: a line from the palatal plane i.e. the superior ANS-PNS line to the inferior limit of the oro-pharayngeal volume i.e. from the most antero-inferior point of the second cervical vertebrae. (Figures 1 to 3)

The airway volume thus obtained from the CBCT scans were statistically analyzed using Statistical Package for Social Sciences [SPSS] for Windows, Version 22.0 and One-way ANOVA followed by Tukey's HSD Post HOC analysis were applied to compare the mean oro-pharyngeal space volumes between the different groups. Students paired t test was used to compare the mean oro-pharyngeal space (in mm^3) between pre and post treatment periods in each group. The level of significance [p -value] was set at $p < 0.05$.

RESULTS:

This study consisted of 30 participants in the age group of 11-24 years.

The mean pre-treatment oropharyngeal airway volumes of the three groups is summarized in Table 1. Accordingly, the group 1 participants had a mean volume of 2867.36 mm^3, group 2 of 3314.82 mm^3 whereas the control group (group 3) had a mean volume of 2689.83 mm^3. One-way ANOVA showed no statistically significant difference between the mean oropharyngeal volumes in three study groups. ($p = 0.07$)

The mean post-treatment oropharyngeal airway volumes of the three groups has been summarized in Table 2. Accordingly, the group 1 participants had a mean volume of 6172.31 mm^3, group 2 5150.17 mm^3 whereas the control group (group 3) had a mean volume of 2744.11 mm^3. The one-way ANOVA showed statistically significant difference between the mean oropharyngeal volumes in three study groups. ($p = 0.0001$)

The multiple comparison using Tukey's HSD post hoc analysis revealed that the group 1 (control group) demonstrated a statistically significant difference with group 2 ($p < 0.001$) and a significant difference was also observed between group 2 and group 3 ($p = 0.03$).

Table 3 summarizes the results of Student paired t test, which compares the mean oropharyngeal space dimension (in mm^3) between pre-treatment and post treatment oro-pharyngeal volume in each group. Summary of the pre and post-treatment oropharyngeal airway volume is depicted in graph 1.

DISCUSSION:

Snoring and sleep apnea-hypopnea syndrome are the clinical indicators of childhood respiratory sleep disorders and has an overall prevalence of 2 % in the general population. The above disorder is considered as a manifestation of obstruction of oropharyngeal air pathways and is of special interest to orthodontists. (8,9) The structure and function of the air pathways is related directly to the development of orofacial structures and to malocclusion.(8) Compromised pharyngeal airway spaces have also been implicated in the development of respiratory and cardiac pathologies. (3,10) When the air pathways are in a state of balance, they preserve the processes of respiration and deglutition. (10)

Correction of mandibular retrognathism using functional appliances is an established treatment option and is further found to have an effect on increasing the airway volume. Skeletal class II malocclusion is quite common among Indians and the prevalence is suggested to be around 15-20 %. (3,11) Normal oro-pharyngeal airway volume is about 2030mm^3. (12) Twin block therapy is a prevalent treatment option for the correction of class II malocclusion of skeletal type.(8) Functional appliances are in use since long for the correction of class II malocclusion and this includes Activator, Bionator, Monobloc, Frankel and the Twin-Block (TB) appliance. (3,13) A conducive situation is created by the twin block for the correction of skeletal abnormalities and further brings about favorable alterations in the function of the airway (3,13)

Kochhar AS et al analyzed 120 CBCTs of healthy individuals with a mean age of 15 years, for multiple parameters including the airway. The subjects were grouped based on the Point A-Nasion-Point B (ANB) angle as those with <4 and those with >4. The superior, middle and inferior airways were reduced in the second group (class II malocclusion) when compared with the first and they concluded that retrognathic mandible is associated with compromised airway. (14)

Liang Li and co-workers recruited 60 subjects with class II malocclusion, 30 of which underwent twin block treatment for correction of malocclusion and the remaining 30 did not receive twin block and functioned as controls. Pre and post treatment CBCT scans were analyzed for mandibular advancement, hyoid bone position and upper airway changes. In the twin block group, the hyoid bone was more anteriorly placed; the hypo and oro-pharynx were much more distended than the pre-treatment period. The mean naso-pharyngeal volume improved from 3086.42 mm^3 to 3662.40 mm while the oropharyngeal volume improved from 5348.98 mm^3 to 7075.06 mm^3. They concluded that Twin block significantly improves airway volume. (15) The results of the present research is consistent with the results of the above, as this research too observed a statistically significant increase in the air way volume in the participants treated with twin block.

Literature suggests that the reason for improvement in airway volume following functional therapy is due to the tongue and soft palate taking an anterior position along with the mandible compared to the pre-treatment. Anterior placement of hyoid bone also is a contributing factor for increased airway volume. (15) In the present study, the hyoid bone position was not assessed.

Ghodke et al studied the effect of twin block on improvement of airway dimensions in subjects with mandibular retrognathia. They used cephalometric radiographs of 18 test and 20 control subjects, taken 6 months apart and found statistically significant increase ($p < 0.001$) in the depth of the oropharynx and hypopharynx in the test group. Although the above research was done using cephalometric radiographs, it nevertheless shows that twin block improves airway dimensions, which is similar to the results obtained in the this study. Further, the researchers indicate that twin block retracts the tongue more anteriorly thereby providing more airway space.(16) Similar results were reported by Vinoth et al who found significant improvement following twin block therapy in 25 of their study subjects. (17)

A research measured the airway volume using CBCT in 120 individuals with class I and class II malocclusion. Overall reduction of glossopharyngeal airway was found in the subjects with class II malocclusion (4991.89 ± 2021.08 mm^3) when compared with class I (6969.56 ± 3855.92 mm^3) The researchers further detected that subjects with class III malocclusion had higher oropharyngeal airway, owing to forward placement of the mandible.

The results of this study also was similar, with class II malocclusion subjects having lower airway volume. (2) Analogous results are also reported by another study, where class III subjects had higher airway when compared to class II. Interestingly, the researchers also found a higher oropharyngeal volume in girls than boys. They opine that enlargement of airway after growth spurt is faster in girls than boys, with this being the reason for this variation. (1) No comparison between male and female subjects was carried out in this study.

Yildrim and Karacay assessed airway volume in 30 subjects with class II malocclusion treated with twin block appliance. The pre-treatment superior and inferior airway volumes were 11,639.84 mm^3 and 9958.84 mm^3 whereas the post-treatment volumes were 14404.41 mm^3 and 14858.57 mm^3 respectively.

This clearly shows the effectiveness of twin block in improving the airway volume, which is in tandem with the results of this research. (18) Akin to the above results, another study which used Forsus Fixed Functional appliance in treating 30 subjects with class II division 1 found statistically significant increase in hypo-pharyngeal and oro-pharyngeal volumes following treatment.(10) These studies reiterate that functional orthodontics definitely brings improvement in air pathways.(19)

Likewise, literature suggests that fixed orthodontic treatment also brings in positive improvement in airspaces by altering the hyoid bone position and increasing the tongue space. (11) Contradictory results showing no improvement in airway dimensions were obtained by another researcher who compared the airway spaces pre and post fixed orthodontic therapy in class I,II and III subjects. (20) In the present research, although there was not substantial improvement in the oropharyngeal airway, nevertheless fixed orthodontic therapy brought in some increase in airway volume.

CONCLUSION:

Airway space compromise has been extensively evaluated in orthodontic population and numerous studies have assessed diverse orthodontic therapies to help improve the same.

The present research was successful in demonstrating the enhancement of oropharyngeal air pathways in class II malocclusion, treated with twin block as well as fixed orthodontic therapy in the population studied. Owing to the advantages twin block has to offer, it can be recommended as a treatment option for management of class II malocclusion with airway deficiency.

Conflicts of interest:
The authors declare no conflicts of interest.

Table 1: One way ANOVA test was conducted to compare the mean oropharyngeal space dimension in mm3 between three groups during the pre-treatment period

Comparison of Mean Oro-pharyngeal space dimension (in mm^3) between 03 groups during pre-treatment period using one-way ANOVA test								
Groups	N	Mean	SD	Std. Error	Min	Max	F	P-Value
Control	15	2689.831	1009.885	260.751	1179.14	4197.69	2.839	0.07
Twin Block	15	2867.364	613.022	158.282	2017	4197.77		
Fixed Functional	15	3314.828	498.598	128.737	2344.11	4567.89		

Table 2: One way ANOVA test was conducted to compare the mean oropharyngeal space dimension in mm3 between three groups during the post-treatment period.

Comparison of Mean Oro-pharyngeal space dimension (in mm^3) between 03 groups during Post-treatment period using one-way ANOVA test followed by Tukey's HSD post hoc Analysis								
Groups	N	Mean	SD	Std. Error	Min	Max	F	P-Value
Control	15	2744.512	1002.531	258.852	1189.71	4220.69	41.471	<0.001*
Twin Block	15	6172.311	901.801	232.844	4598.24	7444.37		
Fixed Functional	15	5150.171	1241.859	320.647	3671.49	7100.90		

Table 3: Student's T test

Comparison of mean oro-pharyngeal space dimension (in mm^3) between pre and post treatment periods in each group using Student Paired t test								
Group	Time	N	Mean	SD	S.E.M	Mean Diff	t	P-Value
Control	Pre Rx	15	2689.831	1009.885	260.751	-54.681	-3.331	0.005*
	Post Rx	15	2744.512	1002.531	258.852			
Twin Block	Pre Rx	15	2867.364	613.022	158.282	-3304.947	-17.041	<0.001*
	Post Rx	15	6172.311	901.801	232.844			
Fixed Functional	Pre Rx	15	3314.828	498.598	128.737	-1835.343	-6.484	<0.001*
	Post Rx	15	5150.171	1241.859	320.647			

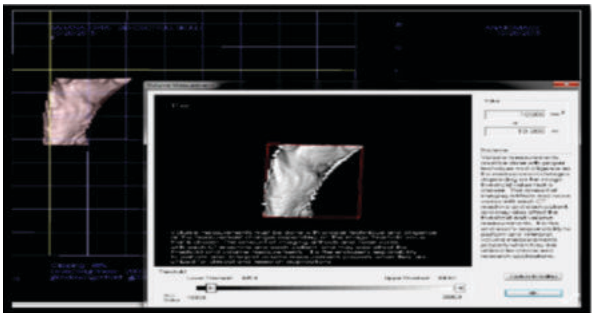


Figure 1: CBCT volumes showing the pre-treatment volume of the oropharynx in group 1 participants

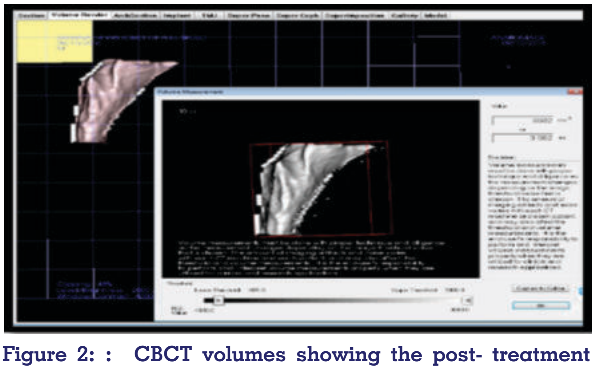


Figure 2: : CBCT volumes showing the post- treatment volume of the oropharynx in group 1 participants

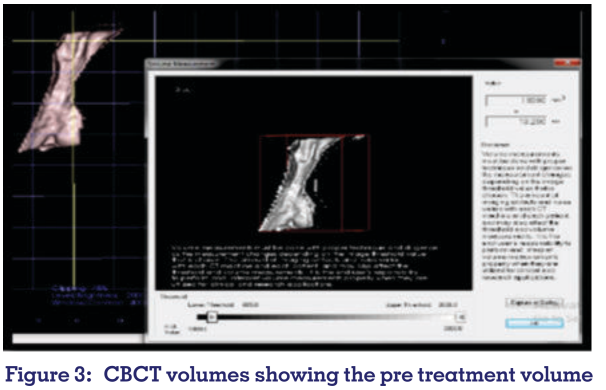


Figure 3: CBCT volumes showing the pre treatment volume of the oropharynx in group 2 participants

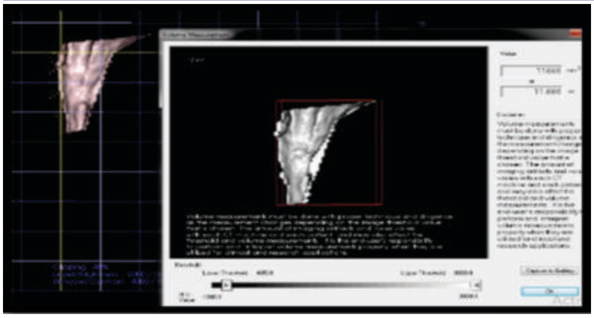
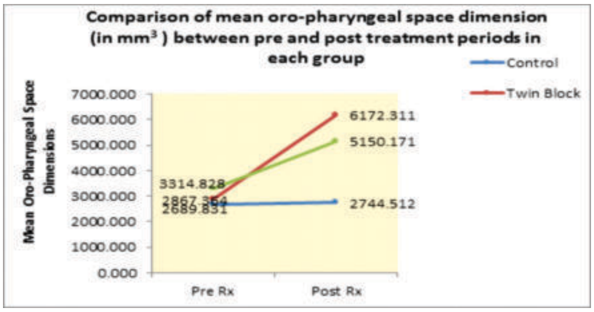


Fig 4: CBCT volumes showing the post-treatment volume of the oropharynx in group 2 participants



Graph 1: Comparison of mean oropharyngeal space dimension in mm3 in three groups; pre-treatment and post-treatment period

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