EGYPTIAN
DENTAL JOURNAL
www.eda-egypt.org

VOL. 68, 2035:2041, JULY, 2022

PRINT ISSN 0070-9484 • ONLINE ISSN 2090-2360

ORTHODONTICS, PEDIATRIC AND PREVENTIVE DENTISTRY

Submit Date : 21-03-2022 • Accept Date : 03-06-2022 • Available online: 30-06-2022 • DOI : 10.21608/edj.2022.128651.2033

PHARYNGEAL AIRWAY VOLUME CHANGES FOLLOWING TREATMENT OF SKELETAL CLASS II PATIENTS USING A MINIPLATE-SUPPORTED BUCCALLY ACTING DISTALIZER: A RETROSPECTIVE 3-DIMENSIONAL CBCT STUDY

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ABSTRACT

Objective: To evaluate pharyngeal airway volume changes following treatment of skeletal class II patients using miniplate supported buccally acting distalizer; Zyogoma Anchorage System (ZAS) using cone beam computed tomography (CBCT).

Materials and Methods: Ten class II patients (8 females and 2 males), with a mean age, 13.44 ± 1.08 years were treated by ZAS. ZAS consists of two zygomatic miniplates, a heavy arch wire, and a closed Nickel Titanium (NiTi) coil spring attached between a power hook on 0.018 × 0.025-inch stainless steel arch wire stepped on the six anterior teeth mesial to the maxillary 1st premolar and the hook of a miniplate supported to zygomatic buttress of each side. The spring delivered 450 gm continuous force. The volumetric air way changes concomitant to maxillary buccal segments distalization and the sagittal skeletal parameters before and after distalization were analyzed based on CBCT images.

Results: Paired sample t-test showed a statistically highly significant ($p \leq 0.01$) increase (3.16 cm^3, 0.78 cm^3) in both total airway and nasopharyngeal airway volumes respectively with treatment, whereas retropalatal airway volume showed statistically significant ($p \leq 0.05$) increase (0.96 cm^3) after treatment with the skeletally anchored distalizing appliance. But retroglossal airway volume showed statistically non-significant ($p > 0.05$) increase (0.81 cm^3) with treatment. Moreover, an improvement in class II correction was evident as demonstrated by a statistically highly significant ($p \leq 0.01$) increase (4.38 mm, -3.94 mm) in MBCU6- Nv and MBCU6- ptv respectively.

Conclusions: Pharyngeal airway volume considerably enhanced subsequent to skeletal class II correction through the miniplate supported distalizer appliance which could be a helpful treatment opportunity for skeletal class II patients who have breathing disorders.

KEYWORDS: Skeletal class II; Pharyngeal airway; maxillary distalization; (CBCT)

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INTRODUCTION

For treatment of class II patients there are two possible approaches, extraction in cases of severe crowding and non-extraction in cases of mild crowding. In non-extraction therapy treatment approaches may include enamel reapproximation of teeth, skeletal or dental expansion, correction of tilted teeth by uprighting, derotation of posterior rotated teeth, and/or molar distalization. [1]. Successful clinical results could be achieved by using skeletal anchorage systems for treatment and correction of class II malocclusion [2]. Skeletal anchorage enables us to overcome the traditional anchorage drawback [3-5].

Zygomatic process had been utilized by Nur *et al*. and Sugawara as a skeletal anchorage [6,7]. ZAS consists of two mini-plates with three integrated Mini-Implants (MI) fixed on the lower contour of zygomatic buttress surgically. The zygomatic buttress enables us to generate higher distalizing forces [8]. There is controversy regarding the effects of different treatment approaches on the airway space, many studies have showed that the air way space could be affected by not only abnormal growth pattern of craniofacial structures but also abnormal position of teeth [9,10]. Also, several studies have showed that the size of airway space may be decreased by extraction treatment [11-13]. On the other hand, a study has showed that the airway space was not significantly affected by either extraction or nonextraction treatment of adults [14]. And also, another CBCT study has showed that there were no negative 3-dimensional (3D) long-term effects on airway space after total maxillary arch distalization using modified C-palatal plates in adolescents [15].

However, no 3-dimensional (3D) evaluations of the effects on airway space after maxillary arch distalization using miniplate-supported buccally acting (ZAS) in adolescent patients with Class II malocclusion using a distalizing force of 450 gm per side have been reported. Therefore, the objectives of this study were to evaluate the effects on the air way space after total maxillary arch distalization using miniplate-supported buccally acting (ZAS) appliance in adolescent patients using cone-beam computed tomography (CBCT) images.

MATERIALS AND METHODS

A retrospective CBCT study was carried out on ten Egyptian subjects. (8 females and 2 males) each required molar distalization as part of their comprehensive orthodontic treatment with bilateral class II molar relationship, Overjet ≥ 5 mm, ANB angle > 5º, with an average or reduced vertical face height and with an age ranged from 11-15 years. Collected and treated at Orthodontic Out-patient Clinics, Faculty of Dental Medicine (Boys), Al-Azhar University, Cairo, Egypt. An approval was obtained by ethical committee (Quality Education Assurance Unit, Al-Azhar Faculty of Medicine, Nasr City, Cairo, Egypt), with a registration number 0000006. In accordance with previous study, [16] sample size calculation was undertaken with G*power statistical software (version 3.1, Universität Dusseldorf, Dusseldorf, Germany) based on the following pre-established parameters: an 80% power, significance level (alpha) =0.05 (two-tailed) and an effect size of 1.012. The estimated minimum sample needed to have adequate power to detect difference would be nine patients. It was decided to increase the number of patients to ten to compensate for any possible drop out during the course of the study

The age ranged between 11.9 to 14.11 years with a mean age of 13.44 ± 1.08 years. The research objectives were full discussed to the patients and/or guardians and informed consents were obtained before commencing the study.

Each patient was fitted with Roth's prescription preadjusted edgewise brackets (Ormco Mini 2000, Ormco Corporation, Glendora, California, USA). The first and second premolars were bracketed while the first molars were banded.

Surgical procedures

The miniplates were fixed to the zygomatico-maxillary buttress [8] under local anesthesia, and they were adjusted to fit the contour of the lower face of each zygomatic process. After reflecting a vertical flap in that area to expose the zygomatic process, the miniplates were fixed by three self-drilling titanium bone screws (length, 5.0 mm; diameter, 2.0 mm). The full thickness mucoperiosteal flap then repositioned by single interrupted sutures with 4-0 polypropylene sutures. Patients were instructed to rinse twice daily for 2 minutes starting 24h after surgery, for 2 weeks, using 0.12% chlorhexidine gluconate (Hexitol mouthwash). Systemic antibiotic (Hibiotic 1 gm), antiedematous drug (Alphinterin) were prescribed for 7 days after the surgery. Analgesic (Cataflam 50 mm gm) was given to the patient orally when needed during the first 7 days. The patients were recalled after 7 days for suture removal.

Orthodontic mechanics

All the patients were treated by bilateral distalization of the maxillary buccal segments using NiTi closed coil spring attached between a power hook on 0.018 × 0.025-inch stainless steel arch wire stepped on the six anterior teeth mesial to the maxillary 1st premolar and the hook of a miniplate supported to Zygomatic buttress of each side. The spring delivered 450 gm continuous force as measured by correx tension gauge being an identical force to that used for distalization in a previous study [17].

As the force level during distalization may fall below 450 gm, the springs were regularly reactivated by 0.01-inch stainless steel ligature wire every three weeks, the force was checked and calibrated with a gram-force gauge during the initial activation and at 3-weeks intervals. In the present study the miniplates` hook was placed approximately at the upper first molar bifurcation (by measuring the distance from the occlusal surface of each upper 1st molar to the bifurcation of its buccal roots on the CBCT), this placed the hook at approximately the center of resistance of molars, thus supposed to provide bodily distal movement of molars. Distalization was started at least two weeks after surgical insertion of the miniplates to allow an enough time for healing. After super Class I relationship was achieved, fixed appliances were bonded to the anterior teeth for the second phase of the orthodontic treatment. All anchor plates were used for anchorage control during the retraction of anterior teeth if required, and then they were surgically removed after debonding.

Study Measurements

A pre-operative CBCT scan was obtained using i-CAT CBCT scanner (Imaging Sciences International, Hatfield, PA, USA). After treatment CBCT scan was obtained using the same parameters: 20.1x17.3x 10.2-cm field of view, 90kVp, 12.5 MA,15-second scan time, and 0.2 mm voxel size. (Planmeca ProMax® 3D Mid Imaging Unit, USA) It should be noted that during CBCT imaging, the patient was asked to hold her breath at the end of expiration, without swallowing. After acquisition, all data were exported and transferred in Digital Imaging and Communication in Medicine (DICOM) format via a CD to a personal computer for airway volume and sagittal skeletal evaluation. The DICOM-data before treatment was imported into In vivo Dental Application v.5.3.1 (Anatomage. Inc. San Jose, CA). From the “Superimposition” tab, the “Import New Volume” option was selected, and the DICOM files data after treatment was selected. Using the “Point Registration” option, by selecting reference points on the midface and skull base, followed by the “Automatic Volume Based Registration” option, the two data sets were superimposed perfectly. The superimposition accuracy was then checked on the axial, coronal, sagittal slices and the 3D volume.

Pharyngeal airway assessment

The pharyngeal airway volume was recognized as it was located between superior and inferior planes; the superior plane (P plane) defined on the midsagittal image as the horizontal line connecting the posterior nasal spine to basion, and the inferior one, called the "EP plane," defined as the horizontal line passing through the most superior point of the epiglottis. The upper airway was divided into two segments to evaluate the effects of buccal segments distalization. The upper segment called (retropalatal airway) limited superiorly by the P plane and inferiorly by a horizontal plane crossing the most posteroinferior point of the soft palate, called the "SP plane." [19] After selection of the posterior nasal spine and basion points in the midsagittal view, the P plane was reoriented to be parallel to the floor, and the other planes (SP and EP) were traced parallel to that plane. The inferior segment (retroglossal airway) was demarcated by the SP plane superiorly and by the EP plane inferiorly. Once each airway segment had been recognized and demarcated, the Anatomage software then allowed the airway to be selected by defining a threshold range of CT units that characterized each air space of the pharyngeal airway.

Sagittal skeletal assessment

Lateral cephalometric images were reconstructed from the CBCT records for assessment of the sagittal changes based on SNA, SNB, ANB, A-Nv, B-Nv, MBCU6-Nv and MBCU6-Ptv angles using cephalometric reference lines and planes [16].

Statistical analysis

All data were collected and statistically analyzed by Statistical Package for Social Science software for Windows (SPSS, version 20, Inc., IBM Company, Chicago, III, USA). Descriptive statistics were displayed as means, standard deviations, and standard errors. The data were checked for normality by using Shapiro-Wilk test. It was found that all data were normally distributed; so, parametric tests were used for statistical analyses. The statistical significance was set at $p \leq 0.05$.

RESULTS

Drop out and loses

A male patient was dropped out from the study due to failure in miniplate in the left side, therefore the statistical analyses were performed on only nine patients (8 females and a male)

The data in this present study were collected from before and after treatment CBCT measurements of the patients. Due to the little number of males in this study so, no gender difference was made.

Analysis of error and reliability

The all measurements were repeated for randomly selected four patients (nearly 40 % of the sample) by the same examiner after four weeks and compared to the first measurements taken from the total sample using Interclass Correlation Coefficient. A very high correlation between 1st and 2nd measurements was found which indicate a low error of CBCT measurements. Table 1 and figure 1 show that Paired sample t-test showed a statistically highly significant ($p \leq 0.01$) increase (3.16 cm^3, 0.78 cm^3) in both total airway and nasopharyngeal airway volumes respectively with treatment, whereas retropalatal airway volume showed statistically significant ($p \leq 0.05$) increase (0.96 cm^3) after treatment with the skeletally anchored distalizing appliance. But retroglossal airway volume showed statistically non-significant ($p>0.05$) increase (0.81 cm^3) with treatment. Moreover, an improvement in class II correction was evident as demonstrated by a statistically highly significant ($p \leq 0.01$) increase (4.38 mm, -3.94 mm) in MBCU6- Nv and MBCU6-ptv respectively.

TABLE (1) Descriptive statistics and comparison of pharyngeal airway volumes and sagittal skeletal parameters Pre and Post treatment using paired sample t-test, (N=9).

Parameter	Pre-treatment			Post-treatment			Difference			p-value	Sig
	Mean	**SD**	**SE**	**Mean**	**SD**	**SE**	**Mean**	**SD**	**SE**		
Total volume (cm³)	14.25	3.44	1.15	17.40	4.35	1.45	3.16	1.69	0.56	0.001	HS
Naso pharynx (cm³)	3.60	1.47	0.49	4.39	1.55	0.52	0.78	0.48	0.16	0.001	HS
Retro palatal (cm³)	6.73	1.71	0.57	7.69	1.65	0.55	0.96	1.04	0.35	0.024	S
Retro glossal (cm³)	5.29	2.63	0.88	6.10	2.62	0.87	0.81	1.28	0.43	0.094	NS
SNA (°)	82.51	3.04	1.01	82.81	3.52	1.17	0.30	0.63	0.21	0.190	NS
SNB (°)	76.13	2.71	0.90	75.49	3.62	1.21	-0.64	1.27	0.42	0.166	NS
ANB (°)	6.24	1.38	0.46	7.22	1.95	0.65	0.98	1.09	0.36	0.027	S
A-Nv (mm)	3.34	1.76	0.59	3.50	1.89	0.63	0.16	0.78	0.26	0.568	NS
B-Nv (mm)	4.81	2.61	0.87	6.70	2.64	0.88	1.89	1.25	0.42	0.002	HS
MBCU6- Nv (mm)	19.48	2.90	0.97	23.86	1.79	0.60	4.38	2.23	0.74	<0.001	HS
MBCU6- ptv (mm)	26.76	2.70	0.90	22.81	3.06	1.02	-3.94	2.89	0.96	0.003	HS

N=Number, SD= Standard deviation, SE= Standard error, p=probability level, T1= Before treatment, T2= After Herbst treatment, SD= Standard deviation, Sig= significance, NS= non-significant p>0.05, S= significant p≤0.05, HS= highly significant p≤0.01.

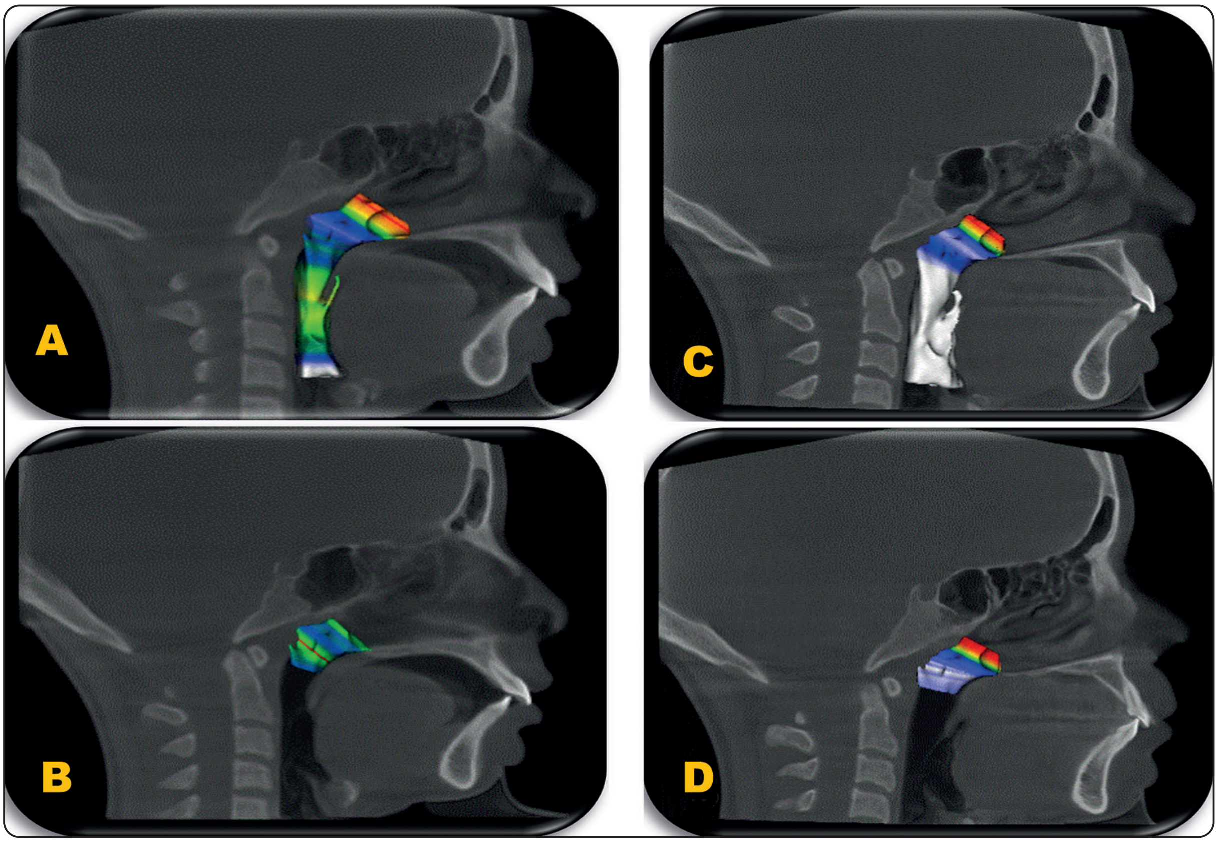

Fig. (1) A, B Preoperative scan. C, D Postoperative scan showing the effect of treatment on the pharyngeal airway

DISCUSSION

Evaluation of pharyngeal airways' dimensions is very important to the orthodontist due to the increased prevalence of OSA in patients with narrowed and constricted upper airway [20]. this study aimed to evaluate the possible volumetric pharyngeal airway changes following treatment with skeletally anchored distalizer in the adolescent skeletal class II patients. Although a small sample size could be drawback of this study, a power analysis was used to determine the minimum desirable size. In this study statistical significance was achieved which means the treatment effects were large enough to be detected in the sample. [18]

The current results showed that the nasopharyngeal airway volume increased by 0.78 cm^3 this change was statistically highly significant ($p \leq 0.01$). This is in agreement with Schutz et al [20] who reported a significant increase in the nasopharyngeal airway volume following Herbst treatment in his MRI study. In contrast, Amuk et al [21] reported non-significant increase in his cephalometric evaluation study of nasopharynx after Herbst therapy in late adolescent and young adult patients. In the present study, a control group of untreated individuals could not be used as suggested by others. [22] to avoid leaving a group of skeletal Class II patients untreated for ethical concerns in addition to the needless exposure of patients to radiation. So, treatment effects were compared with the baseline values.

Currently, distalizing appliance treatment produced statistically non-significant ($p>0.05$) increase (0.81 cm^3) in retroglossal airway volume with treatment. These findings were in contrast to those of Isidor et al [23], who reported a significant increase in retroglossal airway volume (1167 mm^3) in his retrospective CBCT study. In this study, CBCT was utilized to overcome the limitations of the cephalograms which cannot enable us to recognize the soft tissue contour of the pharyngeal airway in the third dimension. [23,24]

Regarding the total pharyngeal airway volume, the current study resulted in a statistically highly significant increase (3.16 cm^3) with treatment. These results concur with Isidor et al [23] who used monoblock and Twin-Block removable functional appliances and reported a significant increase of 2500 mm^3 in the total pharyngeal airway. Likewise, these finding are in harmony with those of other studies [25,26] who utilized somewhat different distalizing appliances and accomplished enhancement in the pharyngeal airway volume via CBCT.

CONCLUSIONS

Pharyngeal airway volume considerably enhanced subsequent to skeletal class II correction through the miniplate supported distalizer appliance which could be a helpful treatment opportunity for skeletal class II patients who have breathing disorders.

REFERENCES

1. Oberti G, Villegas C, Ealo M, Palacio J, Baccetti T. Maxillary molar distalization with the dual-force distalizer supported by mini-implants: a clinical study. Am J Orthod Dentofac Orthop.2009; 135: 282–3.
2. Kyung S. Distalization of the entire maxillary arch in an adult. Am J Orthod Dentofac Orthop.2009; 135:123–32.
3. Polat-Ozsoy O. The use of intraosseous screw for upper molar distalization: a case report. Eur. J. Dent.2008; 2: 115–21.
4. Cope J. Temporary anchorage devices in orthodontics: A paradigm shift. Sem Orthod. 2005;11: 3–9.
5. Levin L, Vasiliauskas A, Armalaite J, Kubiliute K. Comparison of skeletal anchorage distalizers effect in maxillary buccal segment: A systematic review. Stomatologija, Baltic Dental and Maxillofacial Journal: 2018; 20, (3).66-72.
6. Sugawara J, Kanzaki R, Takahashi I, Nagasaka H, Nanda R. Distal movement of maxillary molars in nongrowing patients with the skeletal anchorage system. Am J Orthod Dentofac Orthop 2006; 129:723-33.

7. Nur M, Bayram M, Pampu A. Zygoma-gear appliance for intraoral upper molar distalization. Korean J Orthod 2010; 40:195-206.

8. Nur M, Bayram M, Celikoglu M, Kilkis D, Pampu A. Effects of maxillary molar distalization with Zygoma-Gear Appliance. Angle Orthod.2012; 82: 596–602.

9. Ali B, Shaikh A, Fida M. Effect of Clark's twin-block appliance (CTB) and non-extraction fixed mechano-therapy on the pharyngeal dimensions of growing children. Dental Press J Orthod 2015; 20:82-8.

10. Baroni M, Ballanti F, Franchi L, Cozza P. Craniofacial features of subjects with adenoid, tonsillar, or adenotonsillar hypertrophy. Prog Orthod 2011; 12:38-44.

11. Wang Q, Jia P, Anderson NK, Wang L, Lin J. Changes of pharyngeal airway size and hyoid bone position following orthodontic treatment of Class I bimaxillary protrusion. Angle Orthod 2012;82: 115-21.

12. Chen Y, Hong L, Wang CL, Zhang SJ, Cao C, Wei F, et al. Effect of large incisor retraction on upper airway morphology in adult bimaxillary protrusion patients. Angle Orthod 2012; 82:964-70.

13. Germec-Cakan D, Taner T, Akan S. Uvulo-glossopharyngeal dimensions in non-extraction, extraction with minimum anchorage, and extraction with maximum anchorage. Eur J Orthod 2011;33: 515-20.

14. Park JH, Kim S, Lee YJ, Bayome M, Kook YA, Hong M, et al. Three-dimensional evaluation of maxillary dentoalveolar changes and airway space after distalization in adults. Angle Orthod 2018;88: 187-94.

15. Kuo AH, Park JH, Shoaib AM, Lee NK, Lim HJ, Abdulwhab AA, et al. Total maxillary arch distalization with modified C-palatal plates in adolescents: A long-term study using cone-beam computed tomography. Am J Orthod Dentofacial Orthop 2021; 159:470-9.

16. Iwasaki T, Takemoto Y, Inada E, Sato H, Saitoh I, Kakuno E, Kanomi R, Yamasaki Y. Three-dimensional cone-beam computed tomography analysis of enlargement of the pharyngeal airway by the Herbst appliance. Am J Orthod Dentofacial Orthop 2014; 146:776-85.

17. Kaya B, Arman A, Uckan S, Yazıcı AC: Comparison of the zygoma anchorage system with cervical headgear in buccal segment distalization. European Journal of Orthodontics 2009 31: 417–24.

18. Elkordy S, Abouelezz A, Fayed M, Aboulfotouh M, Mostafa Y. Evaluation of the miniplate-anchored Forsus Fatigue Resistant Device in skeletal Class II growing subjects: A randomized controlled trial. Angle Orthod 2019; 89:391-403.

19. Lenza MG, De Lenza MM, Dalstra M, Melsen B, Cattaneo PM. An analysis of different approaches to the assessment of upper airway morphology: a CBCT study. Orthod Craniofac Res 2010; 13:96-105.

20. Schutz T, Dominguez G, Hallinan M, Cunha T, Tufik S. Class II correction improves nocturnal breathing in adolescents. Angle Orthod 2011; 81:222-28.

21. Amuk N, Kurt G, Baysal A, Turker G. Changes in pharyngeal airway dimensions following incremental and maximum bite advancement during Herbst-rapid palatal expander appliance therapy in late adolescent and young adult patients: a randomized non-controlled prospective clinical study. Eur J Orthod 2019; 41:1-9.

22. Celikoglu M, Buyuk S, Ekizer A, Unal T. Treatment effects of skeletally anchored Forsus FRD EZ and Herbst appliances: A retrospective clinical study. Angle Orthod 2016; 86:306-14.

23. Isidor S, Carlo G, Cornelis M, Isidor F, Cattaneo P. Threedimensional evaluation of changes in upper airway volume in growing skeletal Class II patients following mandibular advancement treatment with functional orthopedic appliances. Angle Orthod 2018; 88:552-59.

24. Guijarro-Martinez R, Swennen GR. Cone-beam computerized tomography imaging and analysis of the upper airway: a systematic review of the literature. Int J Oral Maxillofac Surg 2011; 40:1227-37.

25. Rizk S, Kulbersh V, Al-Qawasmi R. Changes in the oropharyngeal airway of Class II patients treated with the mandibular anterior repositioning appliance. Angle Orthod 2016; 86:955-61.

26. Erbas B, Kocadereli I. Upper airway changes after Xbow appliance therapy evaluated with cone beam computed tomography. Angle Orthod 2014; 84:693-700.