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Comparison of monoblock and twinblock mandibular advancement devices in patiens with obstructive sleep apnea and temporomandibular disorder: effects on airway volume, polysomnography parameters, and sleepiness scale scores

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Abstract

Purpose This study aimed to compare the effects of two different mandibular advancement devices on the upper airway volume, polysomnographic parameters, and sleepiness scale scores in patients with obstructive sleep apnea and Temporomandibular disorders (TMD).

Materials and methods Monoblock and twinblock mandibular advancement devices were applied to patients with obstructive sleep apnea syndrome for 3 months separated by a wash-out period of 2 weeks. Research Diagnostic Criteria for TMD (RDC/TMD), Polysomnographic parameters and cone-beam computed tomography findings were recorded before and after the use of the mandibular advancement devices. A three-dimensional analysis of the airway was then performed.

Results The use of the monoblock device significantly increased the upper airway volume compared with the use of the twinblock device ($p = 0.032$). The polysomnographic parameters similarly improved with the use of the twin-block and monoblock devices. The significant reduction in TMD symptoms was observed.

Conclusion The use of the monoblock device increased the retropalatal airway volume. This volume increase may be attributed to the fact that the design of the monoblock device allows less mandibular movement than does that of the twinblock device. Indicates the potential benefits of MAD_S treatment in alleviating TMD-related issues.

Clinical significance Monoblock MADs have improved effects on respiratory parameters and upper airway dimensions in patients with OSA and mild to moderate TMD.

Keywords Obstructive sleep apnea/Hypopnea syndrome, Cone-beam computed tomography, Oral appliance, Mandibular advancement device

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Background

Obstructive sleep apnea syndrome (OSAS) is the most common sleep-related breathing disorder. Frequent partial or complete upper airway closure during sleep causes excessive daytime sleepiness. Snoring, oxygen saturation, neurocognitive dysfunction, and adverse effects significantly impact the quality of life. [1] Additionally, In children, mouth breathing has been reported to be associated with adenotonsillar hypertrophy and dental malocclusions [2]. Although continuous positive airway pressure (CPAP) is the criterion standard of treatment, it often yields suboptimal results because of variable patient adherence. [1] The American Academy of Sleep Medicine and the American Academy of Dental Sleep Medicine recommend mandibular advancement device (MAD) application for patients with mild-to-moderate and more severe OSAS who cannot tolerate CPAP and refuse surgery [3].

Surgically assisted rapid palatal expansion (SARPE) showed increased nasal cavity volume and functional improvement in breathing. Skeletal expansion could be achieved in determined young adults without osteotomies. This procedure is described as the Mini-implant Assisted Rapid Palatal Expansion (MARPE) [4]. However, the underlying mechanisms of oral appliance treatment are poorly understood, and facial anatomy should be carefully examined to observe treatment effects. [5]

Generally, pharyngeal muscle tone loss occurs during sleep; however, in patients with obstructive sleep apnea (OSA), narrow airways can result in respiratory arrest. [6] Additionally, patients with OSAS are thought to have a larger tongue that creates an anatomic imbalance of the upper airway. [7–9] A more caudal and larger tongue is also correlated with increased lower facial dimension, significantly longer mandibular plane to hyoid bone distance, and excessive soft tissue. [8]

Several studies have attempted to better understand airway collapse dynamics and possible structural propositions during OSA events. [10–14] Most studies have used cephalometry [10, 11] or other two-dimensional (2D) imaging techniques; however, their results could not show transverse or volumetric changes.

Recently, the upper airway has been imaged in three-dimensional (3D) images using advanced imaging methods, such as magnetic resonance imaging (MRI), computed tomography (CT), and cone-beam computed tomography (CBCT). [12–14] MRI provides information on the airway and surrounding soft tissues without producing ionized radiation. However, it is not always accessible to dentists. CBCT has become well accepted in orofacial diagnosis and treatment planning because of its 10 times lower effective radiation dose, shorter acquisition time, easier access, and lower cost than CT. Therefore, CBCT is an ideal diagnostic aid in studying the airway in 3D. [12–14]

During OSA treatment, evaluation of anatomic airway changes may offer explanations on the treatment mechanisms and disease-related factors. [8, 15, 16] The oropharynx has been shown to have a significantly smaller minimal cross-sectional area (CSA) in patients with OSA than in those without. [8, 15, 16]

CBCT efficiently measures the bone volume in orofacial volumetric skeletal measurements. [9] Patients with OSA have been shown to have a narrower maxilla–palatine core volume when analyses were adjusted for age, sex, height, and body mass index (BMI). A 1.1 ± 0.2 cm [3] (15 ± 6%) increase in the airway volume has been reported after MAD application for 7 months. [17, 18] However, these measurements were not clinically validated because OSA status changes were not measured. Similarly, an increase in the airway volume has been reported . [16] The largest changes occurred in the lateral rather than in the anteroposterior (AP) dimension, particularly at the C2 level, and the airway had an elliptical cross-sectional shape. Such airway volume increase has been shown to correspond with SaO_2 level increases. [12]

Most studies have examined the volumetric airway changes in patients with OSA but have not clinically validated such or evaluated the clinical OSA status with a limited number of parameters. Additionally, no study has evaluated the effects of two different devices on the airway volume using 3D measurements and polysomnographic (PSG) parameters. [11, 12, 14]

This study aimed to analyze and compare the effects of monoblock and twinblock MADs on airway volume changes at the obstruction site and AP and transverse upper airway changes in patients with OSAS using CBCT. The airway volume changes were evaluated using PSG parameters, the Epworth Sleepiness Scale (ESS) score, and the Research Diagnostic Criteria for TMD (RDC/TMD). This study hypothesizes that the upper airway volume would significantly increase with monoblock device application compared with twinblock device application. Depending on this increase, the apnea–hypopnea index (AHI), oxygen desaturation index (ODI), and ESS score would improve.

Materials and methods

Ethical considerations

This prospective randomized clinical test of patients with OSAS referred for oral appliance treatment was conducted in Ondokuz Mayis University Medical Center (2018/482), and all patients provided informed consent, and ethical approval was obtained from this institutional review board. All procedures performed in studies involving human participants were by the ethical

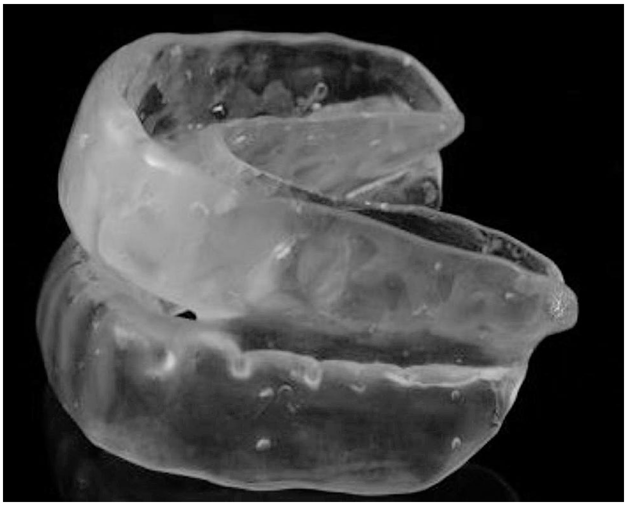

Fig. 1 Monoblock appliance

standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration comparable ethical standards.

According to Cohen's guidelines, [18] an effect size d, which quantifies the standardized difference in the means of an outcome variable between two groups is considered small at 0.20. A difference of 0.50 is regarded as medium, while a difference of 0.80 is considered large. In this investigation, we anticipated a substantial effect size (i.e., a notable distinction between both groups) based on clinical expertise. To identify an effect size d of 0.8 between two MAD groups with 80% statistical power and a significance level of 5%, we calculated that a sample size of approximately 14 patients per group would be necessary. Hence, this plan entails randomizing 14 patients into each group.

The study recruited 60 individuals presenting with excessive daytime sleepiness from the Ear, Nose, and Throat Department of 19 Mayıs University. Following initial diagnostic assessments, patients diagnosed with obstructive sleep apnea syndrome (OSAS) were included in the study. Exclusion criteria were applied to individuals who missed appointments or could not tolerate Mandibular Advancement Devices (MADs). Consequently, 25 patients remained eligible for further analysis. The final sample included 14 patients (10 men and 4 women) in the main study group, while the remaining 11 patients (8 men and 3 women) were allocated to a preliminary study. The ages of the patients ranged from 24 to 68 years. Inclusion criteria were: 1. Symptomatic mild or moderate OSA ($5 \leq$ apnea-hypopnea index (AHI) < 30 events/hour) and temporomandibular disorders identified through functional examination of the masticatory system. Before treatment was initiated, one dental clinician examined all patients, applied the RDC/TMD, and recorded the occlusal characteristics.

Fig. 2 Twinblock appliance

MAD application

Dental records were used for both devices. The protrusion and opening of the bite were adjusted individually. The MADs were designed to hold the mandible to 75% of the maximal protrusion based on the construction bite in the sagittal plane and approximately 6 mm based on that in the vertical plane [20, 21] to ensure device retention. Both devices were custom-made and made of thermal acrylic material. Both devices were custom-made from thermal acrylic material and were manufactured by conventional methods (Figs. 1 and 2).

The twinblock MAD was a two-piece resin-made activator device retained by two clasps on the first premolars and first molars of the four quadrants. (Fig. 2) Vertical and sagittal activations were performed with a ramp prepared for the premolar tooth area. Each patient underwent a subjective sleep assessment using the initial ESS score and an objective assessment using PSG and CBCT images, and the results were recorded as T0 data.

After T0 data collection, the monoblock MAD was applied for 3 months. Thereafter, the patients underwent PSG to assess the treatment efficacy; the ESS score was evaluated, and CBCT images were obtained. The results were recorded as T1 data, and the monoblock device was removed.

After a 2-week wash-out period wherein the devices were not used to avoid any possible effect of the first device, the twinblock MAD was applied for 3 months. At the end of treatment, the patients underwent a final PSG for conclusive assessment, and data collection was concluded (T2).

CBCT images

Galileos Comfort Plus (Sirona Dental Systems Inc., Bensheim, Germany) was used to obtain the CBCT images. The scanning protocol was as follows: 98 kV, 3–6 mA, field of view: 15×15 cm, voxel: 0.25 mm, and scanning time: 14 s. The patients were instructed to avoid tongue movement and swallowing during CBCT. The volumetric datasets were imported into DICOM files in Sirona SIDEXIS XG; this software reconstructs 3D images, facilitates measurement, and provides 12-bit gray-scale imaging with a voxel size of 0.25 mm [3] (Radi-Force MX270W 27 inch 3.7 MP color LCD monitored, EIZO Corp., Ishikawa, Japan).

Three-dimensional airway analysis

Three-dimensional image sections obtained from the upper airway were examined, and the upper airway volumes were measured for each segment with and without the devices. The reference planes were marked to determine the standardization of the T1 and T2 data and in which segment the airway volume increase was significant. The skull images were oriented parallel to the Frankfurt horizontal plane in the sagittal view, similar to the method of Suleiman et al. [22]

All CBCT images were oriented perpendicular to the floor of the skeletal midline (nasion to the anterior nasal spine) in the frontal view and perpendicular to the midsagittal line (midpoint between the maxillary incisors and posterior nasal spine) in the axial view. In patients with asymmetry, the orientation was made as close as possible to the guidelines. Because the nasal cavity contains multiple connected air spaces and turbines, clear segmentation is not possible; therefore, it was excluded from this measurement. The upper airway was divided into three segments according to the selected airway percentage using a method adapted from Guijarro-Martinez and Swennen [15] with airway sensitivity.

The upper airway volume was defined as the airway volume between two planes. The first plane was the superior plane (P plane), which was defined on the midsagittal image as the horizontal line connecting the posterior nasal spine to the basion (because these anatomic points are closest to the upper airway and clearly shown on the sagittal plane of the CBCT image). The second plane was the inferior plane (C_4 plane), which was defined as the horizontal line passing through the most superior point of the fourth cervical vertebra.

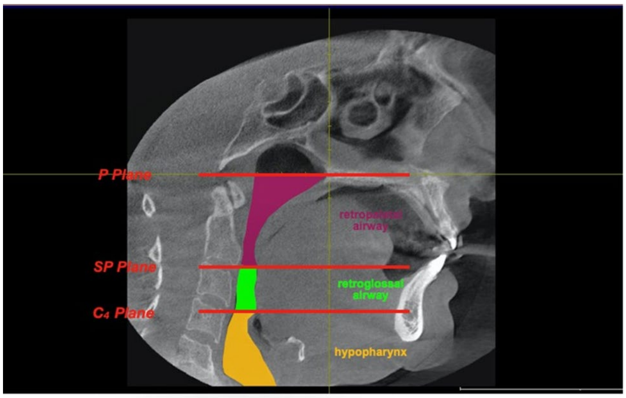

Fig. 3 Airway segments: retropalatal airway (pink), retroglossal airway (green) and hypopharynx (yellow). Image rendered with the use of Sirona Sidexis XG software

The upper airway was then divided into two segments to further evaluate the specific effects of the MADs. The upper segment or retropalatal airway was limited superiorly by the P plane and inferiorly by a horizontal plane crossing the most posteroinferior point of the soft palate (SP plane) (Fig. 3), [23, 24].

Once the posterior nasal spine and basion points were selected in the midsagittal view, the P plane was reoriented so that it became parallel to the floor, and the subsequent planes (SP and C_4) were traced parallel to the P plane to increase the measurement accuracy.

The inferior segment or retroglossal airway was limited superiorly by the SP plane and inferiorly by the C_4 plane (Fig. 3). After determining the reference planes on the sagittal sections, we recorded the axial images of the passage to be measured in 1-mm slices using Sirona SIDEXIS XG (Fig. 3).

All measurements were performed by an author who was trained in histology (M.E.O). The volume calculations of the CBCT images were performed at the Department of Histology and Embryology of this institution.

The volume calculations were performed using the Cavalieri method, which is a neutral stereological method between reference planes on CBCT images. The point-counting grids and point density used were determined by considering an acceptable error coefficient (EC) after the pilot study. A 0.5-cm grid was used for the areas to be measured. The EC was <0.05 at acceptable intervals. The relevant area volume was determined using the following formula: $\text{volume} = t \times a/\ p \times \Sigma p$, where “t” is the section thickness; “a/p,” each field in the grid area; and “Σp,” total number of points in the area. [23] The measured airway and axial CSAs are shown in Figs. 4 and 5.

Statistical analysis

The data were analyzed using IBM SPSS Statistics for Windows, Version 23.0. (IBM Corp. Armonk, NY). The Shapiro–Wilk test was used to evaluate the variable distribution. The data were analyzed using repeated variance analysis tests in the groups with normally distributed data and the Friedman test in those with non-normally distributed data. The results were presented as means, standard deviations, medians, minimum values, and maximum values for the quantitative variables. Statistical significance was set at $p<0.05$.

Results

The median retropalatal volume was 1788.04 mm [3] without the devices, 2238.91 mm [3] with the monoblock device, and 1747.56 mm [3] with the twinblock device. Monoblock device application significantly increased

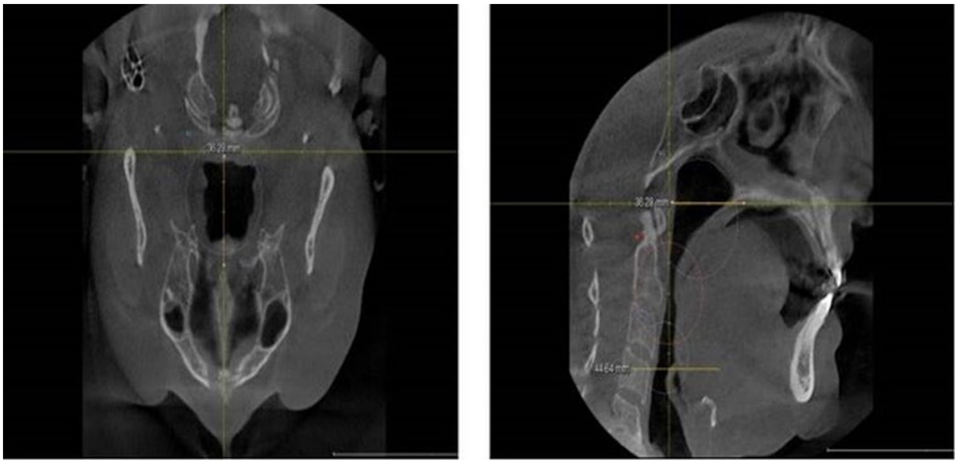

Fig. 4 Determination of boundaries of upper airway

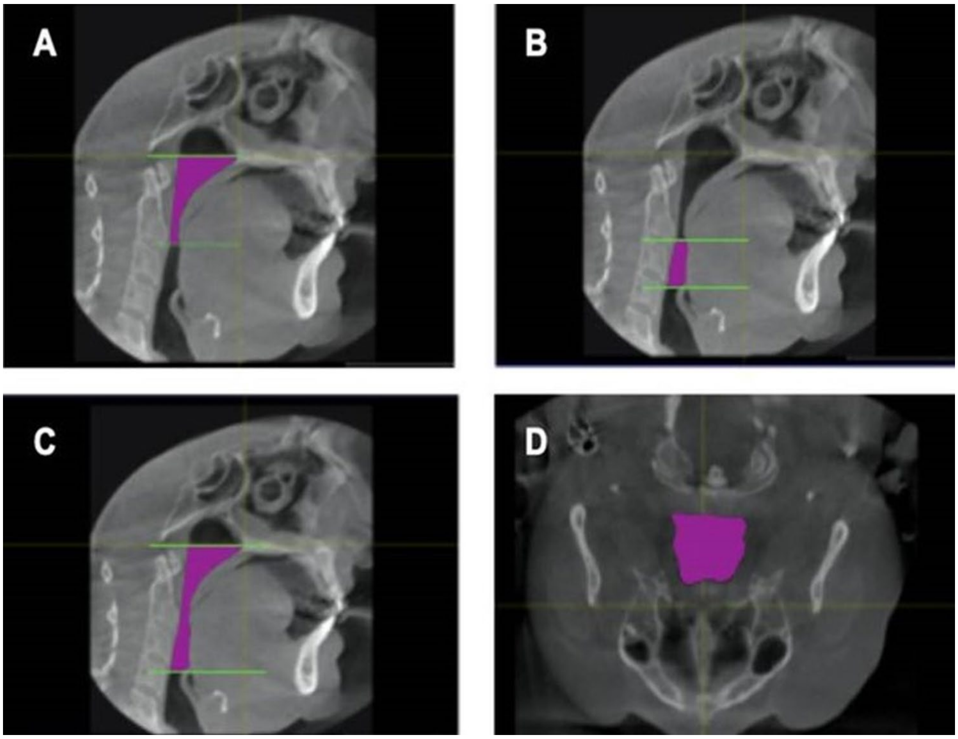

Fig. 5 Segmentations of the airway: **A**, retropalatal airway; **B**, retroglossal airway; **C**, total upper airway; **D**, P plane cross-sectional airway

the volume compared with twin-block device application ($p=0.032$). Although monoblock device application increased the retroglossal and total volumes, this increase was not significant ($p>0.05$) (Table 1).

The P and C_4 planes increased after monoblock device application but decreased after twinblock device application compared with those pre-treatment; however, no significant difference was found. In the SP plane, an increase was observed after both device applications compared with that pre-treatment; however, the difference was not significant ($p>0.05$).

The AHI pre- and post-treatment significantly differed in both groups ($p=0.001$) (Table 2).

Before treatment, the median AHI was 13.4; monoblock and twinblock device applications decreased the value to 5.1 and 5.4, respectively. However, no significant difference was found between them ($p>0.05$).

Both device applications significantly decreased the median supine AHI after treatment ($p=0.004$) (Table 1). Before treatment, the median supine AHI was 54.5. Monoblock and twinblock device applications reduced this value to 8 and 14.5, respectively. The device type did not affect the results ($p>0.05$).

Table 1 Effect of monobloc and twinbloc MADs on objective PSG parameters and ESS

		Baseline (T0)	Monobloc (T1)	Twinbloc (T2)	Test statistics value	p	p^1	p^2	p^3
ESS	Mean	13,2	3,6	4,2	X^2=21,571	**< 0,001***	**0,001***	**0,001***	0,274
	SD	3,9	2,4	2,2					
	Median	12,0	3,5	4,0					
	Range	9–24	0–8	1–10					
AHI (even-ts/h)	Mean	13,5	6,2	6,0	X^2=13,286	**0,001***	**0,002***	**0,014***	1,000
	SD	4,4	5,2	5,6					
	Median	13,4	5,1	5,4					
	Range	5,5–19,5	1–19,1	0,8–24					
Supine AHI(even-ts/h)	Mean	52,8	15,6	17,3	X^2=11,286	**0,004***	**0,004***	**0,042***	1,000
	SD	31,4	15,1	14,4					
	Median	54,5	8,0	14,5					
	Range	0-102	0–42	2–60					
ODI% (events/h)	Mean	16,5	10,9	10,5	X^2=9,000	**0,011***	**0,028***	**0,010***	0,778
	SD	7,3	9,7	6,8					
	Median	13,3	7,4	8,8					
	Range	7–31	1–37	2–25					

F: Variance analysis, X^2=Friedman analysis, p1: T0-T1, p2: T0-T2, p3: T1-T2, symbol of * significant difference between groups $p<0.05$

SD: standard deviation, ESS: Epworth Sleepiness Scale, AHI: apnoea-hypopnoea index, ODI4%: oxygen desaturation index>4%

Table 2 Comparison of area measurements of reference planes

		Baseline (T0)	Monobloc (T1)	Twinbloc (T2)	Test statistics value	p
P Plane (mm^2)	Mean	889,60	974,88	852,21	F = 0,948	0,401
	SD	566,16	638,56	382,88		
	Median	936,81	919,82	845,78		
	Min.	119,01	118,84	103,28		
	Max.	1652,48	2052,28	1395,96		
SP Plane (mm^2)	Mean	445,54	460,40	370,78	X^2=5,286	0,071
	SD	398,45	276,15	279,44		
	Median	292,39	340,52	259,91		
	Min.	15,59	118,48	117,50		
	Max.	1161,34	1086,95	966,52		
C_4 Plane (mm^2])	Mean	738,95	780,82	508,25	X^2=3,000	0,223
	SD	399,05	391,80	297,62		
	Median	683,25	668,53	430,62		
	Min.	165,19	320,90	107,19		
	Max.	1383,91	1857,02	1176,68		

F: Variance analysis, X^2=Friedman analysis*$p<0.05$ SD: standard deviation

The pre-and post-treatment ESS scores significantly differed in both groups ($p<0.001$) (Table 1). Before treatment, the median ESS score was 12. Monoblock and twinblock device applications decreased the score to 3.5 and 4, respectively. Both device applications decreased the ESS score ($p<0.05$); however, no significant difference was found between them ($p>0.05$).

The pre-and post-treatment median ODI of >4% (ODI4%) significantly differed ($p=0.001$) (Table 3). Before treatment, the median ODI4% was 13.3. While monoblock and twinblock device applications reduced this value to 7.4 and 8.8, respectively, no difference was found between them ($p>0.05$).

In this presented study a significant reduction in TMD symptoms was observed. indicates the potential benefits of MAD treatment in alleviating TMD-related issues (Table 4).

Discussion

Because the volume of the upper airway using the monobloc device compared to the use of the twin block device was found to be significant, and depending on this increase, the apnea-hypopnea index (AHI), the oxygen saturation index (ODI) and the ESS score was Improved. The hypothesis is accepted.

Traditionally, lateral cephalometric radiography has performed upper airway and associated dentofacial structure imaging. Characteristic skeletal, oral, and pharyngeal differences have been identified between patients with OSA and their peers. Cephalometry is informative

Table 3 Comparison of 3-dimensional changes of designated segments of the airway

		Baseline (T0)	Monobloc (T1)	Twinbloc (T2)	Test statistics value	*p*
Retropalatal airway(mm [3])	Mean	2064,79	3440,81	1906,65	X^2=6,873	**0,032****
	SD	1186,40	3665,33	878,54		
	Median	1788,04	2238,91	1747,56		
	Min.	564,34	1075,47	752,53		
	Max.	4155,55	15322,96	3438,89		
Retroglossal airway(mm [3])	Mean	1656,65	1843,71	1303,98	X^2=5,345	0,069
	SD	1173,81	1081,70	806,60		
	Median	1069,95	1805,10	977,86		
	Min.	379,17	441,13	349,30		
	Max.	3609,56	4799,84	2532,94		
Total airway(mm [3])	Mean	3572,31	5284,52	3210,64	X^2=5,571	0,062
	SD	2166,47	4208,32	1478,97		
	Median	2928,93	4010,62	2546,05		
	Min.	944,81	1516,60	1465,63		
	Max.	7765,11	17760,61	5713,66		

F: Variance analysis, X^2=Friedman analysis *$p<0.05$

SD: standard deviation

Table 4 Number of patients using monoblock MAD$_s$ reporting improvement in TMD for each diagnosis Group according to RDC/TMD at each checkup

	Users 1 checkup	Users 2 ckeckup	Users 3 checkup
TMD improvment monobloce	9(%64)	1O(%71)	**12(%85)***
TMD improvment twinbloce	5 (%35)	7(%50)	9(%64)

Symbol of * significant difference between groups $p<0.05$; concerning the three checkup values (Wilcoxon test) for each group of patients

and readily available; however, any 2D radiographic procedure has limitations, such as magnification, overlapping of surrounding structures, and inability to visualize changes in the mediolateral dimension. [26–28]

The upper airway extends from the nose tip to the superior tracheal direction and can be visualized using advanced imaging methods, such as MRI, CT, and CBCT. MRI is the most desirable method because it does not produce ionizing radiation. It also provides information on the airway and surrounding soft tissues. However, MRI is not easily accessible to dentists, and static image sequences take a long time to complete. [13, 14, 29] Although CT offers high-resolution hard and soft tissue images owing to its fan-shaped beam, thin collimation exposes patients to high radiation amounts (approximately 860 µSv for a 12-cm-high field of view). [29] Similarly, CT is not accessible to dentists. Meanwhile, CBCT is readily available to dentists and provides 10 times less ionizing radiation than CT owing to its large, cone-shaped X-ray beam. [29, 31] Additionally, it was found to be more effective than CT in measuring the volume of an air space surrounded by soft tissue and obtaining precise measurements owing to the small isotropic pixels. [32, 33]

Since 2D imaging is insufficient for diagnosing OSAS and observing recovery post-treatment, 3D imaging should be performed, and the airways should be evaluated using the segmentation technique . [18, 29, 30]

The segmentation technique is essential in depicting cross-sections and volumes in 3D analysis. Segmentation involves the extraction of structural information of special interest from surrounding images for visualization or characterization of anatomy or pathology via 3D reconstruction. This process can be performed manually, automatically, or semiautomatically. Manual segmentation requires the operator to manually monitor boundaries or adjust the pixel gray threshold in the respective area. [18] Although it is a long process, it ensures the correct creation of the airway in 3D. Automatic segmentation is usually offered by commercial software products and saves time, but it is not as accurate as manual segmentation because such software products tend to "combine" rather than customize the gray threshold levels of the entire area of interest . [18] Accordingly, a manual segmentation technique was preferred to determine the airway boundaries and reference planes in this study.

Herein, the airway volume significantly increased from 2064.79±1186.40 mm^3 to 3440.81±3665.33 mm [3] with monoblock device application (p=0.032). Haskell et al. [18] (2792±4380 mm3) reported a similar airway volume increase, but it was not significant. Airway volume increases to increase airway flow, which could improve the ESS score and oxygen saturation level.

In a similar CBCT study, [32] MAD applications increased the retropalatal airway volume and significantly decreased the AHI. Other studies with volumetric imaging found that MAD application increased the pharyngeal airway volume. [27–33]

The reference plane areas were evaluated separately herein. With monoblock device application, an increase was observed in all planes; however, no such effect was observed with twinblock device application ($p > 0.05$). Accordingly, the field measurements were found to be compatible with the volume measurements. The failure to achieve the desired airway expansion with the twinblock device can be explained as follows: As the device allows mouth opening, the tongue and soft palate collapse backward, and the oropharyngeal area decreases. [33, 35]

In studies examining the effect of MAD-type intraoral appliances on the retropalatal and retroglossal airways using MRI, the greatest increase was found at the retropalatal segment. This result was significantly compatible with the AHI. [5–36]

Herein, the AHI ($p = 0.001$), supine AHI ($p = 0.004$), and ESS score ($p < 0.001$) significantly improved post-treatment. Although the PSG parameter improvements were greater after monoblock device application than after twinblock device application, no significant difference was found between them ($p > 0.050$). These findings are similar to previous reports. [3, 37, 38] Additionally, the ODI4% decreased from 13.3±7.3% to 8.8±6.8% and 7.4±9.7% after twinblock and monoblock device applications, respectively, also similar to previous reports . [2, 39, 40]

MAD application has been reported to improve the EES score and reduce daytime sleepiness and the AHI, similar to this findings. [10, 41–43] Additionally, monoblock device application increased the retropalatal airway size compared with twinblock device application with elastic support [44]. Although the AHI after monoblock device application was superior to that after twinblock device application in terms of arousal, desaturation, and snoring indices, the AHI and ESS scores decreased with both devices [44]. However, in early treatments, airway dimensions at the PP, OP, and C3 levels were significantly increased with the use of the twin-block appliance in treating Class II Division I malocclusion [45]

The results of this study indicated that MAD treatment did not alter the prevalence of temporomandibular disorders (TMD) in patients with obstructive sleep apnea (OSA). During the treatment of OSA patients with MADs, a diagnosis of TMD was made according to RDC/TMD criteria. The presence of disk displacement with reduction along with a decrease in temporomandibular joint (TMJ) symptoms suggests that MAD treatment may not be a contraindication, and improvement was also observed in some cases.

Note that on both devices, Patients did not report any intra or extra-oral side effects during 3 months. Note that in both devices, patients reported no intra- or extra-oral side effects over 3 months. On the contrary, the improvement of TMJ disorder was observed in most patients. A limitation of this study is that CBCT scans were taken in an upright position, whereas OSA usually occurs during sleep (supine position). The minimum cross-sectional area is significantly reduced when patients are scanned in the supine position compared to the upright position due to the backward displacement of the tongue base and epiglottis [46]. Additionaly, The present study explored the short-term treatment effects of both MADs. However, to validate this findings and address the study's limitations, a long-term follow-up investigation is warranted.

Conclusion

Within the limitations of this in vivo study, the following conclusions were drawn:

Monoblock device application significantly increases the retropalatal airway volume. This volume increase effectively increases the oxygen saturation level and decreases the AHI. In cases where the upper airway volume is important, monoblock devices should be preferred in terms of increasing the airway volume and stabilizing it overnight, although the ease of use is not as great as that of twinblock devices. The improvement of TMD was observed in most patients after 3 mounth.

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No.

Author contributions

G.O. designed and planned the article.D.S. wrote the main manuscript text. R.S. edits and review manuscript. D.U.review manuscript.

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Data availability

The authors declare that data supporting the findings of this study are available in the article. All the data were used by IBM SPSS 23.0. (IBM Corp., Armonk, NY). images prepared at the Ondokuz Mayis Institute and are available in the article and corresponding author.

Declarations

Ethical approval

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Human ethics and consent to participate

Not applicable.

Consent for publication

No.

Competing interests

The authors declare no competing interests.

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