Computed Tomographic Evaluation of the Effects of Mandibular Advancement Devices on Pharyngeal Dimension Changes in Patients with Obstructive Sleep Apnea

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Purpose: The aims of this study were to evaluate the effect of a mandibular advancement device on oropharyngeal dimension in patients with obstructive sleep apnea (OSA) and reveal the predominate site of changes produced by mandibular advancement using computed tomography (CT). ***Materials and Methods:*** CT scans of 20 patients diagnosed with OSA were taken with and without the appliance. Three-dimensional changes in pharyngeal shape measured on cross-sectional CT images during two respiratory cycles after oral appliance insertion were estimated at five vertical levels using three variables: *(1)* lateral dimension, *(2)* anteroposterior dimension, and *(3)* cross-sectional area. Various parameters related to severity of OSA such as snoring volume, frequency, duration, and episodes; breathing pauses; oxygen saturation; Epworth Sleepiness Scale (ESS) score; and Apnea Hypopnea Index (AHI) score underwent comparative evaluation subjectively and objectively. Data were analyzed using the Student *t* test for parametric analysis. ***Results:*** A significant increase in the lateral and anteroposterior dimension of the pharyngeal lumen was observed at all five levels, but the mean change was greatest at the retroglossal level and smallest at the hypopharyngral level in both the lateral and anteroposterior dimensions. The cross-sectional area at all levels appeared to increase significantly, and apnea indices improved significantly. A significant decrease in snoring volume, snoring frequency, breathing pauses, snoring duration, snoring episodes, ESS score, and AHI score and a significant increase in oxygen saturation were found after treatment with the mandibular advancement device. ***Conclusion:*** Within the limitations of this study, CT was shown to be useful in evaluating treatment efficacy in subjects with OSA. *Int J Prosthodont 2012;25:497–505.*

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Obstructive sleep apnea (OSA) is a chronic condition characterized by repetitive episodes of upper airway collapse during sleep leading to sleep fragmentation. It adversely affects quality of life and is a risk factor for hypertension and cardiovascular diseases such as ischemic heart disease and stroke.[1] It is a common disease affecting 5% to 10% and 2.3% to 7% of middle-aged men and women, respectively.[2] Patients with OSA have a greater central chemoreceptor response to hypoxia with both direct and reflex effects on peripheral vasculature, causing greater arteriolar vasodilatation, hypoxic peripheral chemoreceptor stimulation, and changes in heart rate and peripheral sympathetic outflow.[3,4] During sleep, critical narrowing of the airway results in a condition in which inspiratory pressure exceeds the forces maintaining airway patency; thus, snoring is a common symptom of this obstruction.[5] Any anatomical or physiologic abnormality that compromises the respiratory system in wakefulness can predispose a person to significant breathing disorders during sleep. Such abnormalities include an anatomically small upper airspace that increases the reliance on the pharyngeal muscles to maintain adequate airflow and prevent OSA. Patients with restrictive lung diseases or neuromuscular weakness rely, to varying degrees, on the activation of nondiaphragmatic respiratory muscles to help maintain adequate ventilation in wakefulness, but this compensation can be reduced or absent in sleep, leading to severe hypoventilation causing sleep apnea.[6]

Upper airway sensory impairment in patients with OSA was initially characterized as impaired thermal sensitivity,[7] but subsequent work has demonstrated impaired mechanosensitivity at the level of the oropharynx,[8,9] which has shown a relationship with OSA severity.[9,10] For subjects with abnormal laryngeal sensation, there was a close correlation between the severity of laryngeal afferent impairment and the Apnea Hypopnea Index (AHI) score.[11] These findings point to the presence of an upper airway neuropathy in patients with OSA, which has been proposed to be the result of mechanical trauma associated with snoring and apneas, oxidative stress related to hypoxia/reoxygenation, and inflammation resulting from both of these insults.[8,11,12]

The main morphologic feature of OSA is upper airway narrowing during sleep, which is associated with snoring and excessive daytime sleepiness.[13] Treatment is generally advised on medical grounds to preclude cardiac disability and hypertension and to improve quality of life.[1,5] It may involve conservative, medical, surgical, or mechanical measures. Conservative methods encompass lifestyle changes such as weight loss, reduction in smoking, and sleep position modification, while medical management includes the use of drugs to reduce nasal congestion or alter sleep architecture. Surgical techniques include palatoplasty, tonsillectomy, and mandibular or maxillomandibular osteotomies.[14] Mechanical alternatives, which include continuous positive airway pressure (CPAP) and oral appliances, are considered effective in treating mild to moderate OSA.[15]

Treatment efficacy may be assessed objectively by nocturnal polysomnography or imaging techniques and subjectively by the patient and his or her spouse.[16] Cine computed tomography (CT) was used in this study since it offers many advantages, such as providing three-dimensional multiple images with a lower radiation exposure than standard CT. “Cine” is a time sequence of axial images where the x-ray is delivered at a specified interval and duration. In a cine acquisition, the cradle is stationary and the gantry rotates continuously, and CTs can be provided in the supine body position. This may be important because changes in body posture influence the size of the upper airway. Most importantly, this technique can capture images during the entire breathing cycle.[17] Hence, this prospective study sought to investigate the mechanism of how the appliance may alleviate OSA by using the cine CT technique to monitor three-dimensional pharyngeal changes of size and shape after the placement of an appliance in the mouth of apneic patients.

Materials and Methods

The study was conducted jointly in the Departments of Prosthodontics, Pulmonary Medicine, Otorhinolaryngology, and Radiodiagnosis of the Chhatrapati Shahuji Maharaj Medical University, Lucknow, Uttar Pradesh, India, after receiving approval from the university ethics committee. This pilot study was a pre- and posttrial comparison study of patients with OSA who were unwilling to wear a nasal CPAP device because of discomfort but who agreed to wear an oral appliance. The study comprised a convenience sample of 20 selected patients who volunteered and provided written informed consent.

Patients were diagnosed with mild to moderate OSA in the Departments of Otorhinolaryngology and Pulmonary Medicine using polysomnography. The diagnosis of OSA was also based on subjective symptoms according to the Epworth Sleepiness Scale (ESS) and the Berlin Sleep Quality Questionnaire.[18,19] Subject selection was based on study inclusion and exclusion criteria. The inclusion criteria consisted of adequate nasal airflow capacity, as determined by the otorhinolaryngologist, and at least 7 mm of protrusion from the position of maximum intercuspation.[11] Exclusion criteria comprised serious nasal passage obstruction or allergies; more than one missing tooth per quadrant (excluding the third molar); substantial evidence of temporomandibular joint disorder, restricted mouth opening, or sites of masticatory muscle tenderness; and a highly cariogenic or periodontally compromised status.[20]

All subjects filled out questionnaires to determine their age, sex, history of smoking, and presence or absence of hypertension.[21,22] Hypertension reported by the patients was based on physician diagnosis. The Body Mass Index (BMI), neck circumference (calculated using a measuring tape just below the prominence of the thyroid cartilage), and Mallampati score (classification system initially designed to predict ease of intubation) were also recorded.[23]

After collecting and analyzing the previously indicated data for mean values, CT images were obtained in the supine position during daytime and at the same time of the day for all patients. It was assured that the patients remained awake during the procedure. Postappliance data were collected after patients were told to quit alcohol, drugs, and smoking since they cause loss of muscle tone, loss of fine motor coordination, and lower respiration rate, resulting in decreased reflex responses. Essential drugs such as antihypertensives were continued. Patients adjusted their pillows to find the most comfortable neutral head position close to their habitual sleep position without having their heads excessively flexed or extended. They were instructed to breath normally through the nose. At the initiation of scanning, they were instructed not to move the head until completion of two respiratory cycles. Seven-millimeter-thick slices were obtained at five different levels: retropalatal high (level 1), retropalatal low (level 2), retroglossal (level 3), epiglottic (level 4), and hypopharynx (level 5).

CT images were taken using a single-detector row CT scanner (GE). CT scans (120 kb and 80 mAs) were performed at the aforementioned levels extending from the retropalatal high to hypopharynx regions. Seven-millimeter-thick slices with a 2-mm intraslice gap were obtained during approximately two quiet respiratory cycles per patient. The matrix was 512 × 512 with a field of view of 26.8 cm.

The computer-stored images were displayed on a monitor, and a mouse was used to digitize the lumen of the pharynx. A clear outline was first observed. Irregularities found on the margin that were difficult to define and 0.5 mm^2 or less in size were ignored. The cross-sectional area of the lumen diameters in the lateral and sagittal planes at the aforementioned levels and the thickness of the retropharyngeal tissues were measured using the automatic edge-detection capabilities of the image-processing software. The same investigator performed all measurements to avoid interexaminer errors.

Subjects (n = 20) received a mandibular advancement device (MAD) as the treatment modality. The MAD selected was a Twin Block appliance. The Twin Block device effectively combines inclined planes with maxillomandibular and extraoral traction. The appliance consists of an upper and lower plate with occlusally inclined bite planes that induce favorably directed occlusal forces by causing functional mandibular displacement. The MAD was fabricated with the mandible in an advanced position: 75% of the patient's maximum protrusive ability or at least 7 mm of advancement. Subjects were instructed to use the appliance every night. The device was adjusted in an anteroposterior direction until acceptable symptomatic improvement was achieved while controlling the temporomandibular joint and tooth sensitivity. After 4 to 6 weeks, another CT scan was performed and analyzed. The data were then computed to record changes in pre- and posttreatment CT readings using statistical software (SPSS version 13.0, IBM). The tests involved parametric analysis, for which the Student *t* test was used.

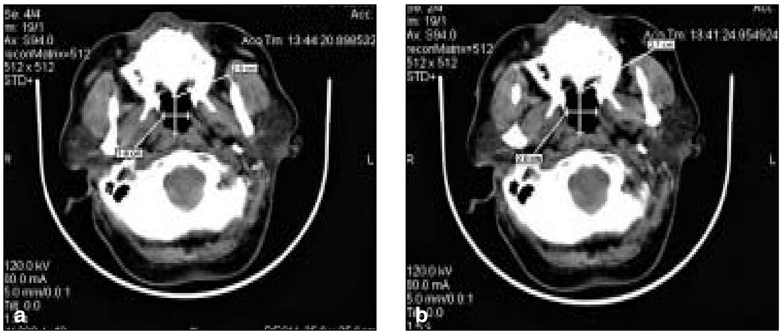
Statistical Analysis

This study was of a crossover comparative design, allowing each subject to act as his or her own control, which reduced the effect of systemic error on the outcome. The change in pharyngeal dimension was checked for normality, and a two-tailed paired *t* test was carried out to determine whether there was a statistically significant difference in pharyngeal dimension ($P < .05$) following MAD insertion. Validity was evaluated by imaging. In addition, the reliability of the digitization and measurement techniques was estimated by additional measuring of the images of 10 randomly chosen subjects. The limits of agreement for each measurement (ie, the mean difference ± 2 × the standard error of the mean difference) were then calculated.

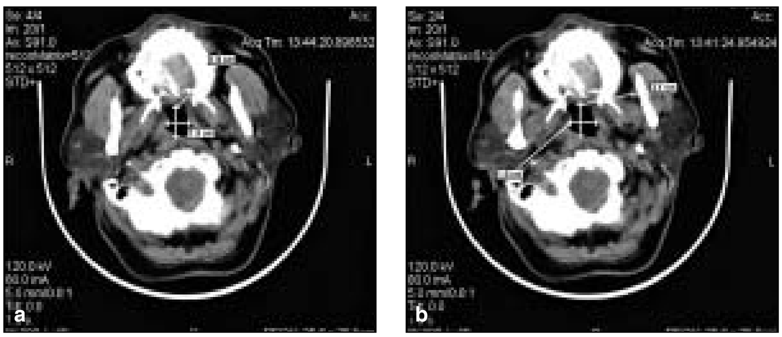
Results

The mean age of the study sample was 55.25 ± 6.88 years, of which 60% were men and 40% were women. All subjects who participated in the study were of the same racial origin (Indian). The mean BMI of patients was 32.17 ± 5.85 kg/m^2. While 15% of subjects were of normal weight (BMI < 25 kg/m^2), 20% were overweight (BMI 25 to 28 kg/m^2), and 65% were obese (BMI > 28 kg/m^2). The mean neck circumference of the subjects was 17.15 ± 1.27 inches; those for men and women were 17.5 ±1.31 and 16.6 ± 1.06 inches, respectively. Hypertension was present in 85% of subjects, and diabetes was present in 40% of subjects; 10% of subjects were smokers. A Class II jaw relationship was noted in 70% of subjects. The majority of patients had Mallampatti grade 2 (65%); there were two (10%) subjects with Mallampatti grade 1 and three (15%) subjects with Mallampatti grade 3.

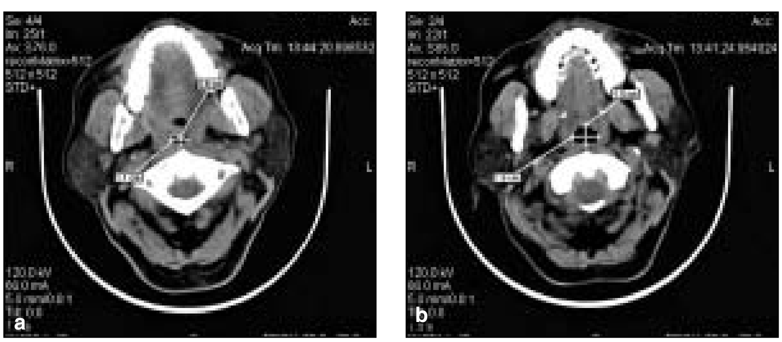
A statistically significant increase at the retropalatal high, retropalatal low, retroglossal, epiglottic, and hypopharynx regions was seen in all the three dimensions (sagittal, lateral, and cross-sectional area) following treatment ($P < .001$) (Figs 1 to 6). The percent change observed at these levels in the anteroposterior (sagittal) dimension was 6.17% ± 2.66%, 14.75% ± 8.78%, 47.84% ± 26.14%, 10.98% ± 8.09, and 5.79% ± 3.47%, respectively, as shown in Table 1.



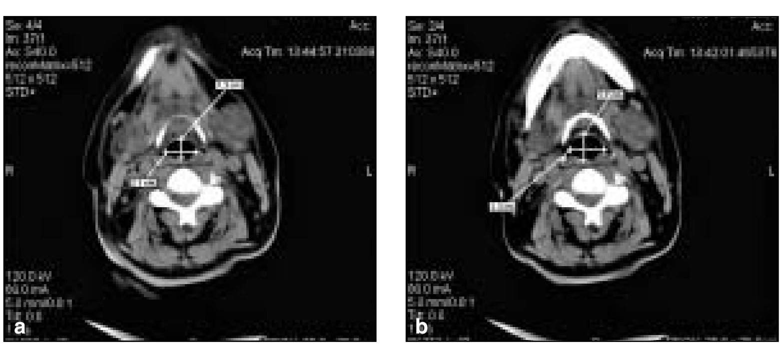
Figs 1a and 1b CT cross section at the retropalatal high level **(a)** without and **(b)** with the oral appliance.



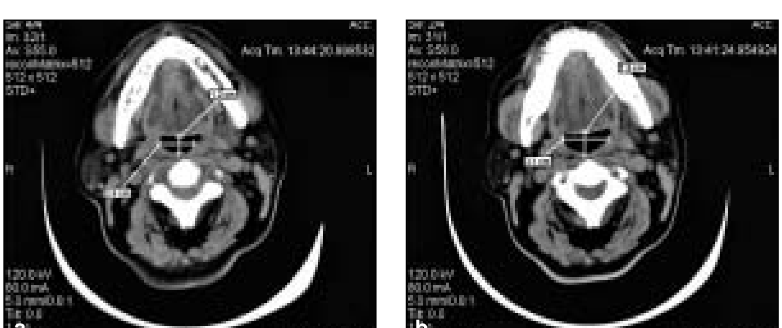
Figs 2a and 2b CT cross section at the retropalatal low level **(a)** without and **(b)** with the oral appliance.



Figs 3a and 3b CT cross section at the retroglossal level **(a)** without and **(b)** with the oral appliance.



Figs 4a and 4b CT cross section at the epiglottic level **(a)** without and **(b)** with the oral appliance.



Figs 5a and 5b CT cross section at the hypopharynx level **(a)** without and **(b)** with the oral appliance.

Figs 6a and 6b CT cross section at the level of the saggital reconstruction **(a)** without and **(b)** with the oral appliance.

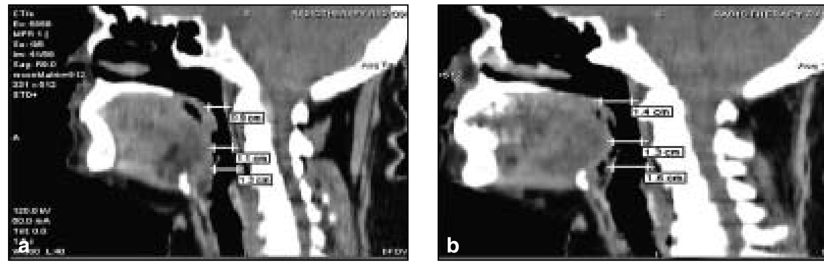


Table 1 Assessment of Changes in the Sagittal Dimension (mm) of the Upper Airway

	Before treatment		After treatment		% change		Statistical significance	
	Mean	SD	Mean	SD	Mean	SD	z	*P*
Retropalatal high	20.40	3.91	21.60	3.89	6.17	2.66	4.179	< .001
Retropalatal low	12.00	4.50	13.60	4.68	14.75	8.78	4.018	< .001
Retroglossal	8.10	4.12	11.40	3.97	47.84	26.14	3.944	< .001
Epiglottic	13.00	4.81	14.15	4.33	10.98	8.09	3.624	< .001
Hypopharynx	16.00	5.06	16.80	4.88	5.79	3.47	4.000	< .001

SD = standard deviation.

Table 2 Assessment of Changes in the Lateral Dimension (mm) of the Upper Airway

	Before treatment		After treatment		% change		Statistical significance	
	Mean	SD	Mean	SD	Mean	SD	z	*P*
Retropalatal high	19.05	2.96	21.60	3.89	23.49	11.41	3.941	< .001
Retropalatal low	14.65	3.70	18.95	3.85	31.62	19.42	3.937	< .001
Retroglossal	13.45	2.76	20.05	2.63	53.39	30.45	3.939	< .001
Epiglottic	22.05	5.89	24.20	6.07	10.54	4.09	4.058	< .001
Hypopharynx	22.35	2.83	23.95	2.78	7.39	4.58	4.058	< .001

SD = standard deviation.

Table 3 Assessment of Changes in the Cross-Sectional Area (mm^2) of the Upper Airway

	Before treatment		After treatment		% change		Statistical significance	
	Mean	SD	Mean	SD	Mean	SD	z	*P*
Retropalatal high	394.85	119.37	508.40	123.14	31.11	12.32	3.925	< .001
Retropalatal low	188.20	116.26	264.70	137.86	46.49	24.65	3.922	< .001
Retroglossal	116.10	88.56	227.75	89.07	126.61	53.54	3.925	< .001
Epiglottic	300.50	164.13	353.95	167.14	22.90	12.89	3.933	< .001
Hypopharynx	364.40	144.54	408.05	146.81	13.60	5.97	3.927	< .001

SD = standard deviation.

The percent change observed at these levels in the lateral dimension was 23.49% ± 11.41%, 31.62% ± 19.42%, 53.39% ± 30.45%, 10.54% ± 4.09%, and 7.39% ± 4.58%, respectively, as shown in Table 2. The percent change in the cross-sectional area at these levels was 31.11% ± 12.32%, 46.49% ± 24.65%, 26.61% ± 53.54%, 22.90% ± 12.89%, and 13.60% ± 5.97%, respectively, as shown in Table 3.

A significant decrease in snoring volume (3.55 ± 0.60 to 1.65 ± 0.59), snoring frequency (3.70 ± 0.47 to 2.00 ± 0.46), number of breathing pauses (3.70 ± 0.47 to 2.10 ± 0.55), snoring duration (38.99 ± 5.81 minutes to 11.79 ± 4.39 minutes), number of snoring episodes (134.45 ± 62.39 to 38.65 ± 15.84), ESS score (14.65 ± 1.90 to 6.75 ± 1.71), and AHI score (43.83 ± 30.00 to 20.31 ± 14.58) was found after treatment,

Table 4 Assessment of Parameters Related to Sleep and Its Associated Disorders

	Before treatment		After treatment		% change		Statistical significance	
Parameter	Mean	SD	Mean	SD	Mean	SD	z	*P*
Snoring volume (grade)	3.55	0.60	1.65	0.59	–52.92	16.06	3.944	< .001
Snoring frequency (no.)	3.70	0.47	2.00	0.46	–45.83	11.63	4.099	< .001
Breathing pauses (no.)	3.70	0.47	2.10	0.55	–43.33	13.13	4.053	< .001
Snoring duration (min)	38.99	5.81	11.79	4.39	–70.21	9.21	3.922	< .001
Snoring episodes (no.)	134.45	62.39	38.65	15.84	–69.88	10.50	3.922	< .001
Oxygen saturation (%)	77.45	8.73	88.30	6.45	14.77	8.26	3.925	< .001
ESS (score)	14.65	1.90	6.75	1.71	–54.00	9.53	3.946	< .001
AHI (score)	43.83	30.00	20.31	14.58	–53.39	5.93	3.932	< .001

SD = standard deviation.

as shown in Table 4. A significant increase in oxygen saturation was recorded after treatment (77.45% ± 8.73% to 88.30% ± 6.45%).

Discussion

Statistical analysis of the data supported rejection of the null hypothesis. Interpretation of the data confirmed that CT may be successfully used in the evaluation of treatment results in patients with OSA. The reason for setting the upper age limit of 65 years for the study population was the higher chance of central sleep apnea in patients over this age, which could have provided false results. Although obstructive sleep-disordered breathing is common in children, the etiology, clinical presentation, and treatment differ in such patients.[21,24] Polysomnography is the standard modality to evaluate treatment efficacy and diagnosis of patients with OSA.

Basic knowledge of radiation risk is useful in counseling patients who express concern about this issue. In most cases, the benefits of indicated medical imaging will outweigh the relatively small excess cancer risk, and patient management should not be altered on the basis of radiation risk. However, for certain subsets of patients, radiation risk should be of greater concern to the clinician.[25] With cone beam CT scanning, the patient is subjected to far less radiation because it uses a focused beam with a physically larger sensor to capture all the axial slices covering the face and jaws in one scan. Hence, there is no redundant overlap of slices, resulting in a significant reduction of radiation. The radiation exposure to a patient from a conventional CT is approximately 100 to 300 microsieverts (μSv) for the maxilla and 200 to 500 μSv for the mandible.[25] The radiation exposure for both the mandible and maxilla from a cone beam CT is between 34 and 102 μSv depending on the time and resolution of the scan.[26] CT offers several advantages, including providing three-dimensional images[27,28] and allowing the image to be obtained in the supine body position. This may be important because body posture change influences the size of the upper airway.[29] Moreover, the technique can capture images during the entire breathing cycle[17]; the size of the pharyngeal lumen fluctuates continually with the phases of respiration.

The mode of action of an MAD is related to the mechanical influence of mandibular advancement on pharyngeal patency. Because the tongue is attached to the mandible, the forward displacement of the mandible improves airway patency by reducing folds and compression in the upper airway.[30] Limitations associated with the use of an MAD include temporomandibular disorder, tooth sensitivity, and possible tooth movement.[20] Isono et al[27] hypothesized that the lateral wall of the soft palate anatomically connects to the base of the tongue through the palatoglossal arch, and therefore mandibular advancement stretches the soft palate, thus stiffening the velopharyngeal segment. Various types of MADs are available. Twin Block appliances were used in this study since they offer certain advantages, including being simple to construct and readily adjustable. This allows the mandible to be advanced gradually to a position of maximum comfortable protrusion, which is associated with optimal reduction of OSA symptoms. They also offer the potential for a more robust and cost-effective appliance.[31] The appliance was fabricated at 75% maximum protrusion. Studies have shown that the appliance set at 75% reduced the AHI to < 10 in 52% of patients, whereas the MAD set at 50% reduced the AHI to < 10 in 31% of patients.[32]

The study population consisted of 60% men and 40% women. Young et al[13] reported that OSA was three to four times more prevalent in men than women, which may be related to differences in sex hormones and preferential fat distribution in women in the subcutaneous tissue of the hips and thighs, with less deposition in the neck compared to men. Guilleminault et al[33] found that middle-aged individuals with low BMIs constituted most of the subjects who snored in their study, whereas O'Sullivan et al[34] reported that most subjects who snored were overweight, with a BMI of 29.63 kg/m^2. The mean BMI of patients in this study was 32.17 kg/m^2, which showed obesity as a risk factor for OSA. Fat deposited in the upper airway physically causes obstruction, while thickening of the soft palate and posterior pharyngeal wall also plays a minor role. The tendency for airway passage closure is exaggerated in obese individuals and in patients with airway pathology.[23] Increased neck size has been demonstrated to be a predictor of sleep apnea.[23] In this study, men had a mean neck circumference of 17.5 inches (a normal circumference is 17 inches), while women had a circumference of 16.6 inches (a normal circumference is 15 inches). Flemons and Remmers[19] also reported greater neck circumference to be a significant risk factor for sleep apnea.

Eighty-five percent of the study sample suffered from hypertension. It has been reported previously that a significant association exists between OSA and hypertension, probably as a result of repetitive intermittent hypoxia increasing the arterial pressure because of the effect of chemoreceptors on sympathetic activation.[1] Approximately 10% of the study sample were smokers, although previous studies do not report on whether nicotine has an effect on upper airway obstruction in rapid eye movement sleep.[22,35]

Seventy percent of subjects in this study had a Class II jaw relationship. Subjects with a skeletal Class II pattern, reduced mandible, and a corresponding increase in overbite are at greater risk of developing OSA.[36] In this study, most subjects had a grade II (65%) Mallampati classification. The Mallampati score was an independent predictor of both the presence and severity of OSA. On average, for every 1-point increase in the Mallampati score, the odds of having OSA increased more than twofold.[37] It was shown that with or without the appliance, the retroglossal region is the narrowest area along the pharynx.

The most common site of obstruction detected by various studies was at the level of the oropharynx, with extension to the laryngopharynx commonly observed.[38] Lowe et al[39] found that most airway constrictions occurred in the oropharynx, and subjects with more severe OSA tended to have larger tongues and smaller airway volumes. A statistically significant increase ($P < .001$) in all the three dimensions (sagittal, lateral, and cross-sectional area) of the retropalatal high, retropalatal low, retroglossal, epiglottic, and hypopharyngeal levels was seen following treatment with an MAD. MADs lower the tongue position, reduce the mandibular plane to hyoid distance, advance the mandible, and widen the upper oropharynx (retropalatal and retroglossal) in some subjects.[40]

The retroglossal (oropharynx) area increased by 47.84% ± 26.14% when an MAD was inserted. Similarly, Johnson et al[41] reported that posterior airway space increased by 56% in patients with OSA on forward mandibular positioning.

When changes of the lumen were evaluated by measuring the lateral and sagittal dimensions, the lateral dimension increased at the retropalatal high (23.49% ± 11.41%), retropalatal low (31.62% ± 19.42%), and retroglossal (53.39% ± 30.45%) levels, while the change in the sagittal dimension was statistically significant at the retroglossal level only (47.84% ± 26.14%), as shown in Tables 1 and 2. This suggests that an oral appliance widens the pharyngeal lumen more laterally compared to sagittally in patients with OSA. This observation was underpinned by the results of the comparison between the changes in lateral and sagittal directions. At the retroglossal level, the lateral dimension showed a significant increase from 13.45 to 20.05 mm and the sagittal dimension increased from 8.10 to 11.40 mm. A previous report[31] showed an increase in the sagittal dimension of the soft palate but not in the tongue base area. Some studies have reported that oral appliances increase the posterior airway space at the velopharyngeal level (the retropalatal low level in this study),[42] whereas others reported change at the oropharyngeal level (the retroglossal level in this study).[43] No significant differences below the epiglottis were found, but the retroglossal or more rostral levels were most affected by the appliance.

The percent change at the cross-sectional area was greatest at the retroglossal level (126.61% ± 53.54%) and smallest at the hypopharynx (13.60% ± 5.97%), as shown in Table 3. Kato et al[44] suggested that closing pressure at the velopharynx and oropharynx significantly decreased with mandibular advancement under general anesthesia in a dose-dependent fashion. They also demonstrated that mandibular advancement normalized the pressure cross-sectional area in relation to the oropharynx in both obese and nonobese patients with OSA.[45] Therefore, if the appliance prevents the initial obstruction by moving the tongue base forward, it could prevent the obstruction further downstream in the pharynx and provide a mechanism whereby the oral appliance improves OSA.

A significant decrease in snoring volume, snoring frequency, number of breathing pauses, snoring duration, number of snoring episodes, ESS score, and AHI score was found after treatment with an MAD, as shown in Table 4. Gao et al[46] stated that through oral appliance therapy, the AHI score decreased significantly from 44.6 ± 21.5 to 9.6 ± 6.3 and the lowest oxygen desaturation rose from 71.4% ± 15.0% to 82.0% ± 7.7%. Meanwhile, the upper airway increased at most levels, especially at the oropharynx. MAD therapy improves a range of symptoms associated with OSA, such as ESS score, oxygen saturation, and snoring frequency.[47] A significant increase in oxygen saturation was recorded posttreatment (77.45% ± 8.73% to 88.30% ± 6.45%).

The limitations of the current pilot study include the limited time and restricted sample size, which could be unduly influenced by a peculiarity in the sample. Further long-term follow-up studies on larger patient populations are required to evaluate the success, efficacy, and compliance of the MAD in comparison to other differently designed oral appliances.

Conclusions

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

- The MAD enlarges and stabilizes the oropharyngeal and hypopharyngeal airway space by advancing the mandible and stretching the attached soft tissue, particularly the tongue.
- Posttreatment CT scans revealed an increase in the volume of airway passages at most levels, especially at the oropharynx (retroglossal region), resulting from a significant increase in the pharyngeal area.
- Increase in both lateral and sagittal dimensions at the retroglossal level resulted in an increase of cross-sectional area, hence improving the symptoms of OSA.
- The MAD significantly improved sleep and its associated disorders, such as snoring volume, snoring frequency, breathing pauses, snoring duration, snoring episodes, oxygen saturation, ESS, and AHI.

This study shows that airway enlargement in the lateral dimension may play a role in the mechanism of the oral appliance and thus reduce symptoms of OSA. This also suggests that a mandibular advancement appliance widens the pharyngeal lumen more laterally than sagittally in patients with OSA.

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Literature Abstract

Increasing predoctoral dental students' motivations to specialize in prosthodontics

This study surveyed recently matriculated dental students to investigate the factors that influence their preferred choice of dental specialty. It also elaborated the changes to the prosthodontic program aimed at increasing students' interest in the field. An email survey was sent to 176 students, of which 167 responded (94.9% response rate). Statistics were analyzed using Pearson chi-square analysis. Lecture and faculty/mentoring were found to be very significant ($P < .006$) in their impact on the students' introductory experience with prosthodontics. Forty-four percent of students cited "enjoyment of providing the specialty service" as the top reason for choosing a specialty. For the students interested in prosthodontics, four significant factors were cited: enjoyment of providing the specialty service ($P < .037$, $P < .057$), faculty influence ($P < .0002$, $P < .0001$), length of program ($P < .039$, $P < .006$), and cost of program ($P < .023$, $P < .004$). When asked to rank the nine American Dental Association–recognized specialties regarding their perceptions of future salary and impact on the dental profession, prosthodontics was ranked fourth for future salary and fifth for impact on the profession. Significant changes to the prosthodontic graduate program were made when the study was conducted, and the changes seemed to have a favorable effect on students' choices of prosthodontics as a specialty.

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