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A Study to Evaluate the Changes in Upper Airway Volume and Sleep Parameters in Edentulous Class II OSA Patients Treated with Mandibular Advancement Splint Fabricated at Different Jaw Positions

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Abstract

Purpose: To evaluate the changes in upper airway volume and sleep parameters in edentulous class II OSA (Obstructive Sleep Apnea) patients treated with mandibular advancement splint (MAS) fabricated at different jaw positions.

Materials and Methods: Thirty five patients were selected based on inclusion ans exclusion criteria and were randomly divided into two groups i.e. Group I and Group II. For patients in Group I, mandibular advancement splint (MAS) was fabricated at 60 % of mandibular protrusion and for patients in Group II, MAS was fabricated at 70 % of mandibular protrusion. Four variables were assessed at baseline and 6 months after wearing MAS. These variables were: AHI, oxygen desaturation events/hr, mean O2 saturation and total upper pharyngeal volume.

Results: All the subjects showed an increase in pharyngeal volume at both level of mandibular advancement. There was a drastic improvement in AHI values from 21.76 to 15.82 at 60 % of mandibular advancement and 17.76 at 70 % of mandibular advancement. On evaluating the percentage change in pharyngeal volume at various levels of mandibular advancement using regression analysis, the following equation was derived: Percentage change in volume (Y) = 0.347*X +57.55. Where percentage change in volume is dependent (Y) and percentage of mandibular advancement (X) is independent.

Conclusion: Present studied showed that mandibular advancement splint is effective in increasing the upper airway volume and reducing the severity of OSA. Also the percentage change in posterior pharyngeal volume is directly proportional to mandibular advancement up to certain limit.

INTRODUCTION

Edentulism or complete loss of teeth potentiates several morbidities and, can even be life-threatening [1,2]. The causal relationship between edentulism and obstructive sleep apnea (OSA) has been enunciated [3-5]. Prevalence of OSA in elderly edentulous population has been found to be 40.94% (males: 32.03%, females:8.91%) [6]. Diverse opinions have been expressed on nocturnal wear of complete dentures to treat OSA in edentulous patients [7-11]. Mandibular advancement induced by oral appliances is an accepted and beneficial therapeutic modality to treat OSA in dentate patients [12,13]. An innovation in use of dentures as a mandibular advancement device (MAD) during sleep at night was tested and found to effectively bridle OSA in edentulous patients with normal (class I) skeletal maxillomandibular relationship [14].

Retrognathia is a heritable craniofacial skeletal anomaly [15] characterised by a disproportionately smaller and retruded mandible, inferior and posteriorly placed hyoid bone with reduced horizontal tongue space. The tongue is thus placed posteriorly and superiorly, thereby occluding the pharyngeal space especially in the retropalatal and retroglossal region [16,17]. This becomes more pronounced in supine position, when the mandible [18,19] and the tongue drop backward under gravity. Since the tongue is ventral to the soft palate, it can push the latter dorsally, changing the pharyngeal space [20] Pharyngeal narrowing or occlusion consequent to posterior displacement of soft palate especially during sleep can precipitate obstructive sleep apnea (OSA) [21]. The head posture also profoundly affects the size of the pharyngeal air space and must be considered [22]. Retrognathia, compounded by the collapse of the vertical dimension of the oral cavity and upper airway due to complete loss of teeth may predispose the patient to moderate to severe levels of OSA. OSA continues to be a poorly diagnosed and largely untreated silently progressive morbidity in elderly edentulous patients [23,24]. Apnea induced persistent hypoxaemia is the progenitor of serious, often life threatening cardiorespiratory, neurological and renal conditions. Early detection and interception of OSA is therefore vital.

Previous studies investigated the effect of mandibular position on upper airway size in adult patients and discovered that the upper airway showed a significant expansion after mandibular advancement treatment [25-27]. Studies have been conducted to evaluate the effect of the Harvold activator [28], headgear [29], bionator [30], herbst appliance [31], rapid maxillary expansion [32], and twin block appliance [33] on posterior airway passage in class II patients. All these appliances were given on dentate patients and studies on class II edentulous patients are still deficient hence, the present study was done to evaluate the changes in upper airway volume and sleep parameters in edentulous class II OSA (Obstructive Sleep Apnea) patients treated with mandibular advancement splint (MAS) fabricated at different jaw positions. Our null hypothesis was that MAS will not any effect on upper airway volume and sleep parameters in edentulous class II OSA patients.

MATERIALS AND METHODS

All the edentulous class II patients enrolled in Dept of Prosthodontics, between the years 2016 to 2017 were recalled by inland postal mail. A total of 72 patients responded to the mail. These patients were screened for the sleep disordered breathing by Epworth sleepiness scale (ESS) and Berlin questionnaire. 22 patients were excluded having ESS score < 10 and negative score in 2 or more categories of Berlin questionnaire. Remaining 50 patients were subjected to overnight polysomnography. 39 patients had AHI (Apnea Hypopnea Index) greater than 5. Among these, the patients having AHI > 30, residual ridge of order>4, TMJ disorders including pain, restricted mouth opening or sites of muscle tenderness in the Masseter or Temporalis region were excluded from the study. Thus the sample size constituted 35 patients (28male, 7 female, average age 61±4 years; BMI, 18±5; AHI 6-30). These patients were randomly divided into two groups i.e. Group I and Group II. For patients in Group I, mandibular advancement splint (MAS) was fabricated at 60 % of mandibular protrusion and for patients in Group II, MAS was fabricated at 70% of mandibular protrusion. Four variables were assessed at baseline and 6 months after wearing MAS. These variables were: AHI, oxygen desaturation events/hr, mean O_2 saturation and total upper pharyngeal volume. Written informed consent was taken from all the patients.

Total upper pharyngeal volume estimation

Computerised tomography (CT) was performed while the patients were awake and in supine position. Three CT scans were done-- without appliance, with appliance at different mandibular advancement (Figure 1). The total pharyngeal volume was calculated at baseline and 6 months after wearing MAD at two different mandibular advancements.

The CT images were imported to On Demand 3D app software (Cybermed Corporation, South Korea) for the estimation of total upper pharyngeal volume. This software enables the evaluation of the shape, contour, volume, sagittal area and the smallest pre-defined cross sectional area in the airway space. After importing the DICOM image file, the area of interest in the airway space is defined using airway tool. The program automatically provides

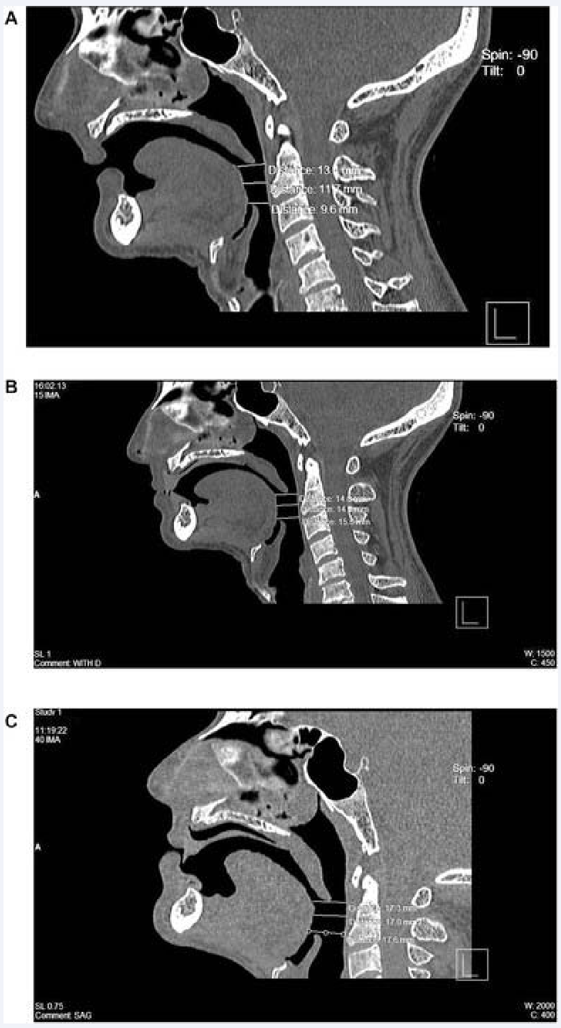

Figure 1 (A)CBCT image of the patient without denture
(B) CBCT image of the patient with denture
(C) CBCT image of the patient with mandibular advancement splint

the volume of any defined region as well as location and dimensions of the most constricted airway space (Figure 2-4).

Polysomnography

Overnight polysomnography sleep study (S-7000, Cogent technologies, EMBLA System Inc) included electroencephalograms (EEG); (C3-A2,C4-A1,O2-A1,O3-A2), bilateral electro-oculogram (ROC,LOC), chin and leg electromyogram (EMG), Nasal airflow, thoracic and abdominal movements, electrocardiogram (ECG), O_2 Saturation measurement by finger Pulse oximeter and body position recorders. Apnea Hypopnea Index (AHI) was calculated with the help of Somnologica Studio software. The apnea episodes were defined as complete cessation of airflow for ≥10 s, and hypopnea was defined as a ≥50% reduction in oronasal airflow accompanied by a reduction of at least 4% oxygen saturation calculated by pulse oximetry. AHI was determined by the frequency of these events per hour during sleep time, based on the results of the overnight polysomnography. Recorded polysomnography data was cross checked manually for scoring of sleep stages, apneas and hypopnea events.

Data was analyzed using Statistical Package for Social Sciences, version 15.0. Data was expressed as means ± the standard deviation (SD). Baseline versus post treatment values at two different mandibular positions were analysed using ANOVA with post hoc tukey test. The significance level was set at p=0.05. Regression analysis equation was used to derive any possible correlation between percentage change in pharyngeal volume and mandibular advancement.

RESULTS

The baseline characteristics of the patients are shown in Table 1. The mean pharyngeal volume, AHI, oxygen desaturation events/hr and mean oxygen saturation were 13.45±0.65, 21.76±4.41, 15.49±3.38, 93.42±0.75 respectively.

All the subjects showed an increase in pharyngeal volume at both level of mandibular advancement. There was a mean difference of 2.05 cm^3 and 3.7 cm^3 in pharyngeal volume at 60 % of mandibular advancement and 70 % of mandibular advancement respectively verses baseline (Table 2).

There was a drastic improvement in AHI values from 21.76 to 15.82 at 60 % of mandibular advancement and 17.76 at 70 % of mandibular advancement (Table 2).

The oxygen desaturation events were also reduced from 15.49 to 3.86 at 60 % of mandibular advancement and 15.49 to 2.87 at 70 % of mandibular advancement with mean improvement of 2.55 in the mean oxygen saturation at 60 % and 4.55 at 70 % of the mandibular advancement respectively (Table 2).

All these variations were statistically significant using Tukey HSD test (p<0.05).

On evaluating the percentage change in pharyngeal volume

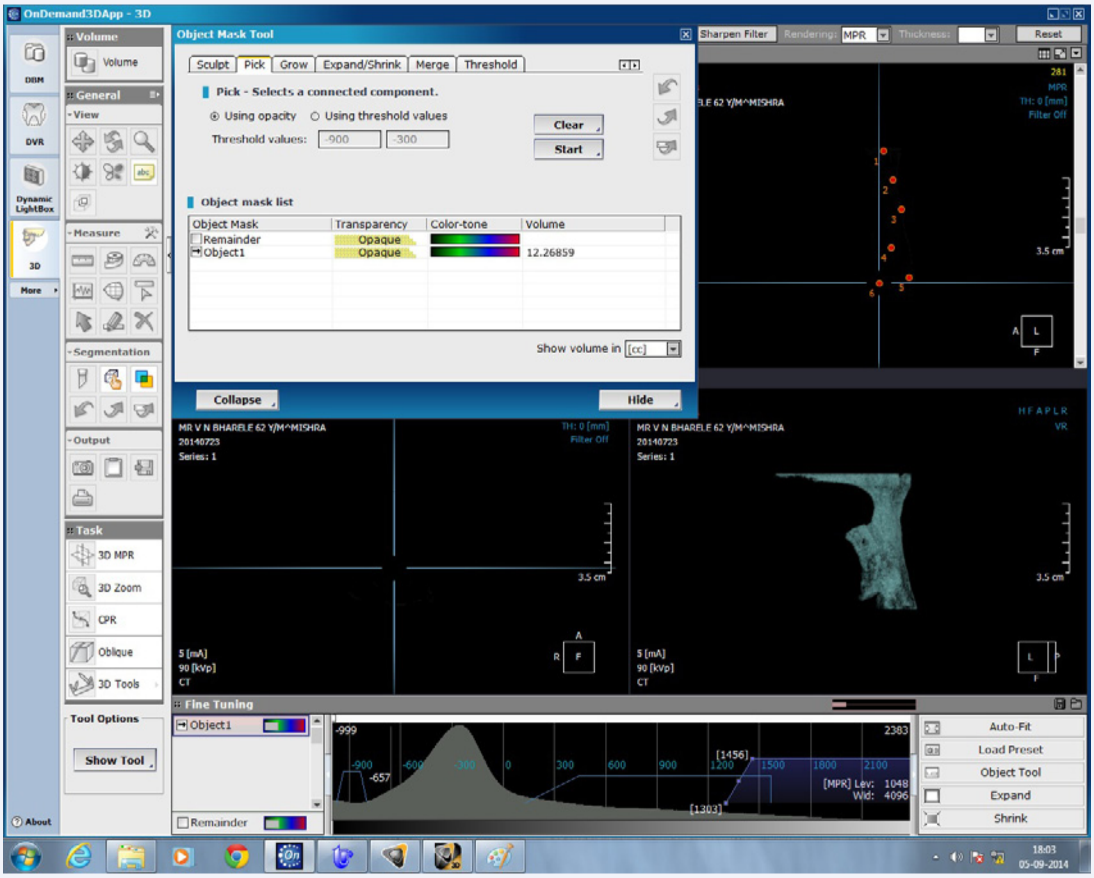

Figure 2 Airway dimension without denture.

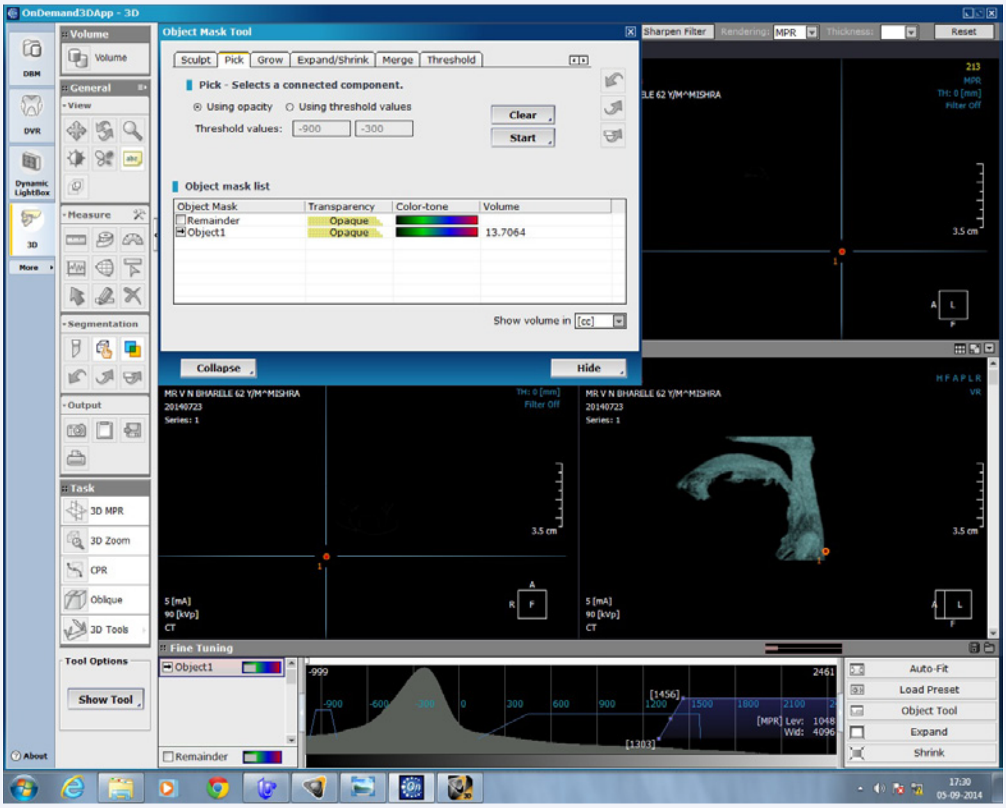

Figure 3 Airway volume with MAS at 60% of mandibular advancement.

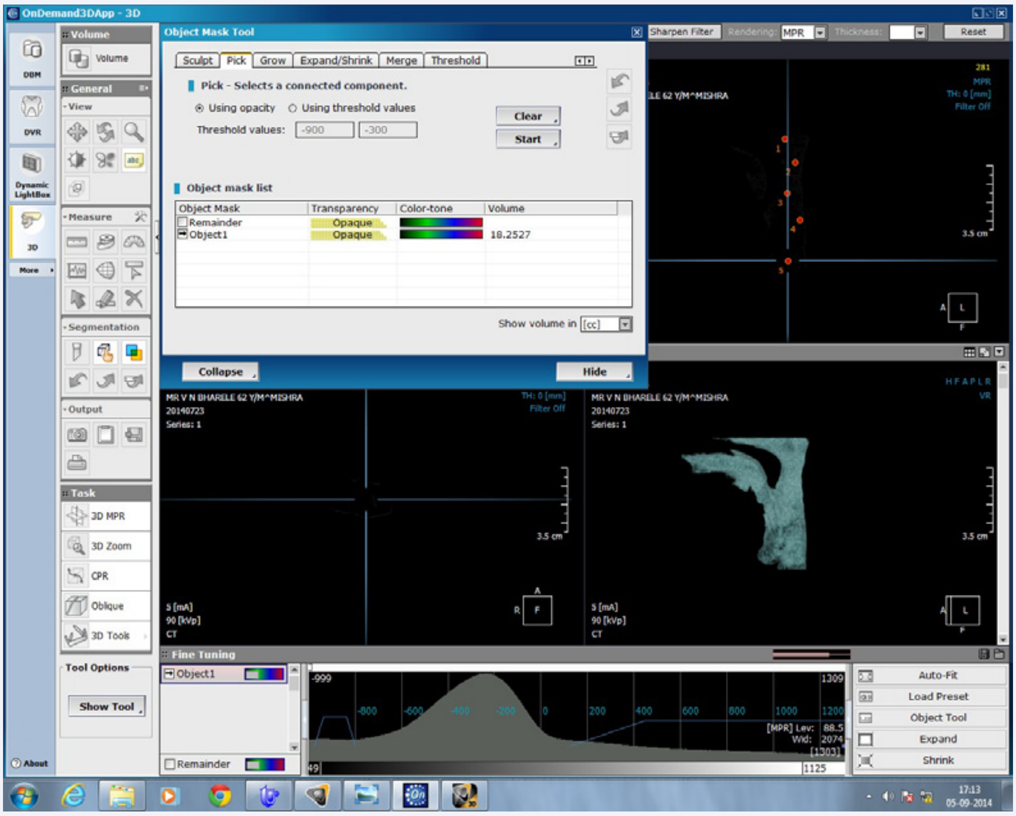

Figure 4 Airway volume with MAS at 70% of mandibular advancement.

Table 1: Baseline characteristics of the patients.				
	Mean	**Std. Deviation**	**Minimum**	**Maximum**
Initial pharyngeal volume	13.45	0.65	12.26	14.62
AHI	21.76	4.41	16.00	30.00
Oxygen desaturation events/hr	15.49	3.38	10.90	24.50
Mean oxygen saturation	93.42	0.75	91.70	94.50

Table 2: Multiple comparison using Tukey HSD test.

Multiple Comparisons				
Tukey HSD				
Dependent Variable			Mean Difference	Sig.
Initial Pharyngeal Volume	baseline	60 % of mandibular advancement	-2.05471*	.000
		70 % of mandibular advancement	-3.69824*	.000
	60 % of mandibular advancement	baseline	2.05471*	.000
		70 % of mandibular advancement	-1.64353*	.000
	70 % of mandibular advancement	baseline	3.69824*	.000
		60 % of mandibular advancement	1.64353*	.000
AHI	baseline	60 % of mandibular advancement	15.82353*	.000
		70 % of mandibular advancement	17.76471*	.000
	60 % of mandibular advancement	baseline	-15.82353*	.000
		70 % of mandibular advancement	1.94118	.109
	70 % of mandibular advancement	baseline	-17.76471*	.000
		60 % of mandibular advancement	-1.94118	.109
Oxygen desaturation events/hr	baseline	60 % of mandibular advancement	11.62941*	.000
		70 % of mandibular advancement	12.62353*	.000
	60 % of mandibular advancement	baseline	-11.62941*	.000
		70 % of mandibular advancement	.99412	.363
	70 % of mandibular advancement	baseline	-12.62353*	.000
		60 % of mandibular advancement	-.99412	.363
Mean oxygen saturation	baseline	60 % of mandibular advancement	-2.55294*	.000
		70 % of mandibular advancement	-4.55294*	.000
	60 % of mandibular advancement	baseline	2.55294*	.000
		70 % of mandibular advancement	-2.00000*	.000
	70 % of mandibular advancement	baseline	4.55294*	.000
		60 % of mandibular advancement	2.00000*	.000
*. The mean difference is significant at the 0.05 level.				

at various levels of mandibular advancement using regression analysis, the following equation was derived

Percentage change in volume (Y) = 0.347*X +57.55

Where percentage change in volume is dependent (Y) and percentage of mandibular advancement (X) is independent.

DISCUSSION

Successful treatment of Class II patients with OSA is very difficult owing to the presence of small posterior pharyngeal airway dimensions and anatomical adaptation of the soft palate. The primary goal involves increasing the posterior pharyngeal airway dimensions either through surgery or through mandibular advancement appliance in order to relieve the symptoms of OSA. Analysis of the literature reveals that the surgery is better for increasing posterior airway pharyngeal dimension than appliance therapy however likely success of surgical treatment and amount of surgical movement necessary to create an adequate airflow is still controversial and under development besides the other side effects of surgery [34-36].

The benefits of oral appliances therapy on upper airway dimension in OSA patients are well established in dentate and Class I edentulous patients. Edentulous Class II situation is very rare as compared to Class I or pseudo Class III, however once present is extremely difficult to manage by any of the present available methods. In the present study, all the patients had increased posterior airway dimension and improved polysomnographic data. The improvement was directly proportional to the amount of mandibular advancement. The maximum advancement done was 70 %. Although we tried to further advanced the mandible upto 80% but all patients reported paint in TMJ 3 to 7 days after wearing MAS hence the maximum advancement was fixed at 70%. Kuna et al. [37], suggested that if the mandible was advanced to 85.2±25.8% of maximum voluntary protrusion by Klearway appliance during treatment in OSA patients, acceptable reduction in AHI could be obtained. However, they gave their appliance on the normal patients and not on retruded mandible position, also their appliance was titrable mandibular advancement device which is more patient friendly as compared to MAS. In our previous study on dentate patients we found that MAS was more effective with no patients discomfort when fabricated at 70 % of maximum protrusion [38].

Schwab et al. [39], showed that advancing the jaw increases the lateral and anterioposterior dimensions of airway. Cozza et al. [40], reported that use of oral appliances in OSA patients had no effect on the thickness of the posterior pharyngeal wall, but it did produce a significant expansion by 13 % in the areas most involves in the collapse. In the present study we found maximum improvement of 3.73 cm^3 (27%) in mean pharyngeal volume. The possible explanation to this drastic improvement in the morphology of upper airway is due to forward positioning of the tongue and elevation of the hyoid bone following mandibular advancement. Schutz et al. [32], found that after class II correction, the anterior displacement of mandible and the hyoid bone caused an anterior traction of the tongue, which increased the posterior airway by 3.2 mm and reduced the airway resistance.

Another mechanism of improvement in the upper airway dimension was through the reduction in the posterior pharyngeal wall thickness. Ghodke et al. [41], reported a minor reduction in posterior pharyngeal wall thickness with twin block appliance although the results were insignificant statistically. Moreover reduction in pharyngeal wall thickness occurs in growing phase and all patients in the present study were above 55 years of age.

Thus our null hypothesis was rejected. The major limitation in the present study was absence of control group. The control group could be patients with complete denture without mandibular advancement. Studies have shown that denture itself acts as therapeutic device in reducing the severity of OSA and hence patients with denture could have created biased results whether improvement in OSA symptoms was due to denture or due to MAS or combination. Another limitation in the present study was small sample size.

CONCLUSION

Present study showed that mandibular advancement splint is effective in increasing the upper airway volume and reducing the severity of OSA. Also the percentage change in posterior pharyngeal volume is directly proportional to mandibular advancement up to certain limit.

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