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A study to evaluate the effect of different mandibular horizontal and vertical jaw positions on sleep parameters in patients with obstructive sleep apnea

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Objective: The worldwide prevalence of obstructive sleep apnea (OSA) is increasing day by day and is estimated to be as prevalent as asthma and diabetes. Untreated sleep apnea can have dire health consequences and can increase risk of hypertension, diabetes, heart disease, and heart failure. Dentists are often the first professional to become aware of a potential problem since they are usually in contact with their patients more frequently than are physicians. The present study was aimed at evaluating the effect of four different mandibular advancement splints fabricated at different jaw positions on sleep parameters in patients with OSA. **Method and Materials:** 72 patients who fulfilled the study criteria were selected. All the patients were randomly divided into four groups of 18 patients each. All the patients in group 1 were given a mandibular advancement splint (MAS) fabricated at 60% of maximum protrusion and 4 mm of vertical opening. All the patients in group 2 were given a MAS fabricated at 60% of maximum protrusion and 6 mm of vertical opening. All the patients in group 3 were given a MAS fabricated at 70% of maximum protrusion and 4 mm of vertical opening. All the patients in group 4 were given a MAS fabricated at 70% of maximum protrusion and 6 mm of vertical opening. **Results:** The maximum change in all the sleep parameters was observed in group 3 when MAS was fabricated at 70% of maximum protrusion and 4 mm of vertical opening. **Conclusion:** The present study suggested that MAS was more effective with no patient discomfort when fabricated at 70% of maximum protrusion and 4 mm of vertical jaw separation. *(doi: 10.3290/j.qi.a36383)*

Key words: Apnea/Hypopnea Index (AHI), jaw position, mandibular advancement splint, obstructive sleep apnea

Snoring and obstructive sleep apnea syndrome (OSAS) are common disorders related with the narrowing of the upper airway.[1,2] The worldwide OSA prevalence rate in adults ranges between 3.5% and 27%.[3,4] In India, its prevalence ranges between 3% to 28% in men and 2.2% to 16% in women.[5-7] Recent epidemiologic surveys have revealed an increase in the incidence of OSA due to an array of factors, obesity and lifestyle being the most important ones. However, the number of healthcare providers has not increased as the awareness regarding sleep medicine and dental sleep medicine is still at its budding phase. Therefore, training general physicians and general dental practitioners to handle clinical situations of OSA is becoming more important.

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The role of general dentists has greatly increased in the treatment of OSA. In certain cases, continuous positive airway pressure is contraindicated. This led to the invention of oral appliance therapy to improve the quality of life of patients suffering from OSA. Fabrication of these devices relies heavily on the skill of general dental practitioners. Thus, it is of utmost importance for dentists to be familiar with the syndrome and treatment modalities of OSA.

Several treatment modalities have been proposed to treat OSA, such as nasal continuous positive airway pressure (nCPAP), surgical techniques (uvulopalatopharyngoplasty), and use of intraoral appliances (OAs).[8-12]

Oral appliances are basically mandibular repositioners (MRs) that advance the mandible and the tongue base, thereby increasing the space between the base of the tongue and the posterior pharyngeal wall. OAs represent a valuable alternative to continuous positive airway pressure (CPAP) due to certain shortcomings, such as chronically impaired nasal ventilation. Furthermore, CPAP devices are not portable and thus can become cumbersome and inconvenient for frequent travelers. Also, CPAP devices use electrical power to function, which is a scarcity in rural areas of the country.[13]

Several authors have proposed the degree of mandibular advancement in horizontal and vertical directions.[14-17] However, data on their effectiveness are conflicting and there are no clear indications as to which design would be most effective in a given clinical situation.

The aim of the present study was to evaluate the effect of four different mandibular advancement splints fabricated at different jaw positions on sleep parameters in patients with OSA.

METHOD AND MATERIALS

The present study was conducted at Saraswati Dental College and Hospital, Lucknow, in collaboration with the Department of Pulmonary Medicine, King George's Medical University, Lucknow, between January 2014 and July 2014. Prior approval of the institutional ethical committees had been obtained from both the concerned institutions. No external funding was used to complete the study.

The provisional selection of patients was based on subjective evaluation of symptoms, according to the Epworth sleepiness scale and the Berlin questionnaire. Such patients were subjected to all-night polysomnography (PSG), to confirm their Apnea/Hypopnea Index (AHI) status, before being recruited as study subjects. A total of 123 patients were identified. Out of these, patients having AHI > 30, substantial evidence of TMJ disorders including pain, significant joint crepitation, restricted mouth opening, or sites of muscle tenderness in the masseter or temporalis region, more than one missing tooth per quadrant (excluding the third molar), which could minimize retention for the mandibular protruding device, caries and/or compromised periodontal status, which would not allow prolonged use of a mandibular protruding device, were excluded from the study. Thus sample size constituted 72 patients (18 women, 54 men, average age 45 ± 4 years; body mass index [BMI], 22 ± 8; AHI 15 to 30). Oral appliance therapy for OSA is contraindicated in patients with dental limitations.[5] Written informed consent was obtained from all the recruited subjects.

All the patients were randomly divided into four groups of 18 patients each. All the patients in group 1 were given a mandibular advancement splint (MAS) fabricated at 60% of maximum protrusion and 4 mm of vertical opening. All the patients in group 2 were given a MAS fabricated at 60% of maximum protrusion and 6 mm of vertical opening. All the patients in group 3 were given a MAS fabricated at 70% of maximum protrusion and 4 mm of vertical opening. All the patients in group 4 were given a MAS fabricated at 70% of maximum protrusion and 6 mm of vertical opening (Figs 1 to 3).

Five variables were assessed by comparing a preoperative all-night PSG to a postoperative (6 months after wearing the modified mandibular advancement device) all-night PSG. These variables were: sleep efficiency, AHI, oxygen desaturation events/hour, mean O_2 saturation, and Snoring Index.

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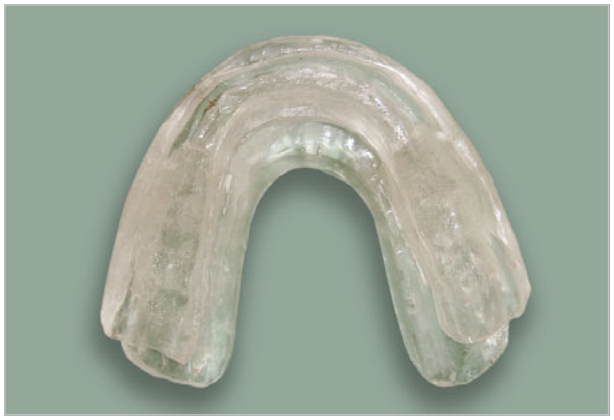

Fig 1 MAS used for the study.

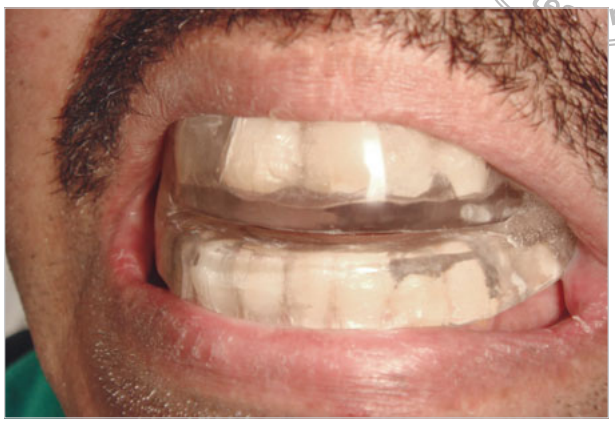

Fig 2 Intraoral view of MAS.

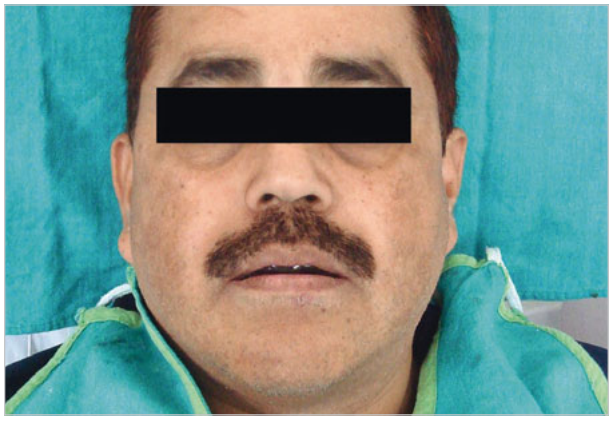

Fig 3 Extraoral profile of the patient with MAS in use.

PSG

All-night PSG sleep studies (S-7000, Cogent technologies, EMBLA System) included electroencephalograms (EEG) (C3–A2, C4–A1, O2–A1, O3–A2), bilateral electrooculogram (ROC, LOC), chin and leg electromyogram (EMG), nasal airflow, thoracic and abdominal movements, electrocardiogram (ECG), oxygen saturation measurement by finger pulse oximeter, and body position recorders. AHI was calculated with the help of Somnologica Studio software (Cogent technologies, EMBLA System). The apnea episodes were defined as complete cessation of airflow for ≥ 10 seconds; 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 recurrence of these events per hour during sleep, based on the results of the overnight PSG. Recorded data was cross-checked manually for scoring of sleep stages, apneas, and hypopnea events. PSG test as well as interpretation of data was performed by a qualified and experienced sleep physician.

Data were analyzed using SPSS, version 15.0 (IBM). One-way ANOVA with post-hoc Tukey's test was used to analyze the difference between the four study groups. A *P* value less than .05 indicated a statistically significant association.

RESULTS

A substantial decrease in AHI, oxygen desaturation events/hour, and Snoring Index was observed following the use of MAS at different jaw positions in all the groups. A substantial increase in % sleep efficiency, and oxygen saturation was observed in all the groups (Table 1).

The maximum change in all the sleep parameters was observed in group 3 (difference of 16.33 in AHI, –13.53 in sleep efficiency, 15.23 in oxygen desaturation, –1.36 in oxygen saturation, and 5.67 in Snoring Index) when MAS was fabricated at 70% of maximum protrusion and 4 mm of vertical opening (Table 2). An intergroup comparison revealed that the AHI score and Snoring Index showed significant variation ($P = .001$) (Table 2).

Table 1 One-way ANOVA with posthoc Tukey test

Parameter	Group	N	Mean	SD	Statistics/mean squares	df2 (welch)/F (ANOVA)	*P* value
Preop AHI	Group 1	18	20.33	3.395	2.072	33.832	.122
	Group 2	18	22.50	2.526			
	Group 3	18	21.78	4.278			
	Group 4	14	20.36	3.565			
	Total	68	21.29	3.541			
Preop sleep efficiency	Group 1	18	61.25	4.700	16.312	0.802	.497
	Group 2	18	60.06	4.782			
	Group 3	18	60.26	3.465			
	Group 4	14	62.28	5.064			
	Total	68	60.88	4.490			
Preop oxygen desaturation	Group 1	18	17.18	17.986	36.347	0.125	.945
	Group 2	18	20.01	16.544			
	Group 3	18	19.41	18.394			
	Group 4	14	17.25	14.606			
	Total	68	18.56	16.745			
Preop O_2 saturation	Group 1	18	94.01	1.249	4.944	32.920	.006
	Group 2	18	91.97	1.872			
	Group 3	18	93.34	0.978			
	Group 4	14	93.75	1.815			
	Total	68	93.24	1.679			
Preop Snoring Index	Group 1	18	6.89	1.410	4.788	3.107	.033
	Group 2	18	8.00	0.970			
	Group 3	18	7.83	1.200			
	Group 4	14	7.21	1.369			
	Total	68	7.50	1.299			
Postop AHI	Group 1	18	8.28	3.140	40.579	6.133	.001
	Group 2	18	7.50	2.149			
	Group 3	18	5.44	2.431			
	Group 4	14	5.07	2.433			
	Total	68	6.66	2.853			
Postop sleep efficiency	Group 1	18	70.20	6.200	59.659	1.624	.193
	Group 2	18	71.28	6.026			
	Group 3	18	73.79	5.539			
	Group 4	14	74.02	6.557			
	Total	68	72.22	6.145			
Postop oxygen desaturation	Group 1	18	6.28	4.424	34.449	2.471	.070
	Group 2	18	6.02	4.173			
	Group 3	18	4.17	3.418			
	Group 4	14	3.25	2.233			
	Total	68	5.03	3.855			
Postop O_2 saturation	Group 1	18	94.50	1.422	11.220	4.934	.004
	Group 2	18	93.17	1.652			
	Group 3	18	94.71	1.397			
	Group 4	14	95.00	1.558			
	Total	68	94.30	1.635			
Postop Snoring Index	Group 1	18	2.67	0.767	13.602	13.305	< .001
	Group 2	18	4.00	1.237			
	Group 3	18	2.17	0.985			
	Group 4	14	2.07	0.997			
	Total	68	2.76	1.259			

SD, standard deviation.

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Table 2 One-way ANOVA for the variables of differences

Parameter		N	Mean	SD	Statistics/mean squares	df2 (welch)/ F(ANOVA)	*P* value
Difference in AHI	Group 1	18	12.06	2.261	60.002	9.751	< .001
	Group 2	18	15.00	2.351			
	Group 3	18	16.33	2.828			
	Group 4	14	15.29	2.431			
	Total	68	14.63	2.926			
Difference in sleep efficiency	Group 1	18	−8.95	4.785	63.977	1.969	.127
	Group 2	18	−11.22	5.343			
	Group 3	18	−13.53	5.460			
	Group 4	14	−11.74	7.328			
	Total	68	−11.34	5.822			
Difference in oxygen desaturation	Group 1	18	10.91	15.016	61.129	0.269	.848
	Group 2	18	13.99	13.852			
	Group 3	18	15.24	17.249			
	Group 4	14	14.00	13.602			
	Total	68	13.51	14.833			
Difference in O_2 saturation	Group 1	18	−0.49	1.739	2.787	0.667	.575
	Group 2	18	−1.20	2.546			
	Group 3	18	−1.36	1.640			
	Group 4	14	−1.25	2.150			
	Total	68	−1.06	2.029			
Difference in Snoring Index	Group 1	18	4.22	1.309	10.803	6.128	.001
	Group 2	18	4.00	1.495			
	Group 3	18	5.67	1.085			
	Group 4	14	5.14	1.406			
	Total	68	4.74	1.472			

SD, standard deviation.

DISCUSSION

The present study evaluated the effect of various jaw positions on the intensity of OSA in dentulous patients. During the patient recruiting period (between January 2014 and July 2014), a total of 72 patients were selected, who were randomly divided into four groups of 18 patients each. Out of 18 patients in group 4, two patients were intolerant to the device due to hypersalivation, one suffered from temporomandibular joint (TMJ) pathosis, and one did not respond to follow-up appointments. The exact diagnosis for the TMJ pathosis was not investigated, but it was presumed to be due to alterations in the geometry of the teeth and the facial skeleton as reported by Fritsch et al.[14] Hence, only 14 patients constituted group 4.

It is still subject to controversy whether an increased vertical opening (VO) is beneficial in oral appliance therapy for the treatment of OSA. The result of Vroegop et al's work[18] indicated that the effect of VO on the degree of pharyngeal collapse as assessed during sleep endoscopy tends to be adverse, causing an increase in collapsibility in the majority of patients. In contrast, Lamont et al[16] designed two different types of MAS (types A and B). The type A device produced 3 to 4 mm of interincisal opening, while type B permitted

6 to 9 mm of vertical opening. They found that the type B device was more effective on AHI than type A.

De Almeida et al[19] evaluated the relationship between different increments of mandibular protrusion and AHI after the insertion of a titratable OA (Klearway). They found that the reduction in the AHI was directly proportional to the amount of mandibular protrusion.

Kuna et al[20] suggested that if the mandible was advanced to 85.2 ± 25.8% of maximum voluntary protrusion by the Klearway appliance during treatment in OSA patients, acceptable reduction in AHI could be obtained. This might be due to the progressive advancement and more patient compliance with a titrable mandibular advancement device as compared to MAS.

Pitsis et al[21] showed that altering the amount of bite opening by a mandibular advancement device did not alter its polysomnographic effects in patients with OSA. The results of the present study contradicted those reported by Pitsis et al.[21]

All the patients showed improvement with MAS on the polysomnogram. MAS was more effective, with almost no patient discomfort when fabricated at 4 mm of vertical jaw separation. The degree of mandibular protrusion had a significant effect on sleep parameters. The maximum effectiveness was obtained when MAS was fabricated at 70% of maximum protrusion.

Vertical opening and 70% of maximum protrusion of the mandible results in its forward and downward movement. This transition increases the upper airway volume and prevents the tongue from falling back in the pharyngeal space. Thus, the primary cause for the chances of occurrence of OSA is obliterated.

CONCLUSION

The present study suggested that MAS was more effective, with no patient discomfort, when fabricated at 70% of maximum protrusion and 4 mm of vertical jaw separation.

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