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CBCT IMAGING AND ANALYSIS OF PRE AND POST OROPHARYNX SPACE IN OBSTRUCTIVE SLEEP APNEA PATIENTS IN CASE OF MANDIBULAR REPOSITIONING USING TWO DIFFERENT TECHNIQUES - AN IN-VIVO STUDY

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ABSTRACT

OBJECTIVE: - To compare the upper airway space in obstructive sleep apnea patients before and after the mandibular repositioning using two different techniques **METHOD:** Group-1Upper and lower primary impressions made, facebow transfer made, centric recordings recorded, maximum protrusion recordings made, 50% protrusion recordings made on George gauze appliance. Articulation done followed by maintenance of 4mm vertical height and appliance was fabricated, finishing and polishing done. **Group-2** Upper and lower primary impressions made, facebow record made, bite registration recorded with bite registration wax, articulation done followed by maintenance of 4 mm vertical height and protrusion is done on Hanau articulator by loosening of centric thumb screw, 5mm protrusion done followed by tightening of centric thumb screw and appliance was fabricated, finishing and polishing done. **RESULT:** The statistical differences between the groups were tested using Statistical analysis was done using paired t- test. The level of significance was set at $P < 0.05$. **Group -1** showed 100% significant changes but for group-2 50% showed significant changes at the level of retropalatal, retroglossal, and epiglottal level at different cross-sectional, mediolateral, and anteroposterior measurements. **CONCLUSION:** Within the limitation of the study statistical difference was seen between Group-1 mandibular advancement done with George gauze appliance and Group-2 mandibular advancement done with Hanau articulator.

INTRODUCTION

Sleep apnea was originally recorded in the early nineteenth century when Charles Dickens wrote in his book "The Posthumous Papers of the Pickwick Club" an obese young man who was tired and snoring. "The old gentleman said he's usually asleep. He goes on errands fast asleep and snores while waiting at the table." Since then, the Pickwickian syndrome, also known as obesity hypoventilation syndrome, has been characterized as a mix of obesity, snoring and excessive drowsiness accompanied by hypoventilation, culminating in awake hypercapnia. OSAHS was not recognized as a clinical condition until more than a century later.[1]

Obstructive sleep apnea (OSA), a respiratory problem that happens while sleeping, is defined by a partial or total obstruction of the upper airway. The collapse of soft tissues and muscles in the upper airway, between the larynx and the hard palate, is the cause of obstructive sleep apnea (OSA).The

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collapsible section of the airway can totally or partially restrict the upper respiratory tract, causing hypopnea and hypoxia.[2]

OSA is defined as the condition of repetitive episodes of complete or partial collapse of the upper airway during sleep that is followed by transient awakening, which results in restriction of the upper airway permeability.

Apnoeas are defined as complete airway obstruction during sleep, which results in obstruction of oronasal airflow which lasts more than 10 seconds. [3,4]. The partial cessation of airflow due to partial obstruction in the upper pharynx or nasal cavity results in snoring, which is known as 'hypopnoea'[4]. OSA symptoms may include day time tiredness, decreased focus and mood, morning headaches, snoring, and breathing pauses during sleep seen by the bed mate. These specific clinical symptoms have varied sensitivity and specificity, and clinical prediction methods integrating these symptoms have been demonstrated to be poor predictors in detecting OSA and measuring OSA severity.[5]Many studies have found a link between OSA severity and other prevalent reasons of increased mortality, including hypertension[6], stroke[7], coronary artery disease [8], occupational [9], and traffic accidents [10]. Risk factors for OSA include male sex [11], postmenopausal status,[12] increasing age (40-70 years),[13.14] and higher body mass index (BMI).[11]

METHODS

There were sixteen obstructive sleep apnea individuals in the study. (2 groups of 8 patients each). 13 males and 3 females were selected according to the inclusive and exclusive criteria.

Inclusion Criteria

1. 18 years and older.
2. Ability to speak, read and write.
3. Ability to follow up.
4. Diagnosis with symptomatic mild or moderate or severe OSA.
5. Patient undergone orthodontic treatment.
6. Ability to give consent to undergo a study.

Exclusion Criteria

1. Untreated periodontal problems, dental pain and a lack of retention possibilities for a MAD.
2. Medication used/related to sleeping disorders.
3. Evidence of respiratory/sleep disorders other than OSA (e.g. central sleep apnea syndrome).
4. Systemic disorders (based on medical history and examination, e.g. rheumatoid arthritis).
5. Increased freeway space in patients.
6. Medical history of known causes of tiredness by day, or severe sleep disruption (Insomnia, PLMS, Narcolepsy).
7. Known medical history of psychiatric diseases, memory problems, or mental impairment.
8. Reversible morphological upper airway abnormalities (e.g. enlarged tonsils).
9. Inability to provide informed consent.
10. Previous treatment for obstructive sleep apnea.

Patients arrived at Maharaj Vinayak Global University's Jaipur Dental College's Department of Oral Medicine and Radiology. The diagnosis of OSA patients was done on the basis of STOP- BANG questionnaire, they were asked to fill out a validated questionnaire and they were selected according to STOP-BANG score and they were referred to Department of Prosthodontic, crown and bridge, the first step was to confirm the symptoms and ask about their daily routine and habits. After diagnosis they were explained about the 2 different techniques of treatment for obstructive sleep apnea and were randomly chosen for the adequate treatment according to inclusion and exclusion criteria. The procedures followed got a ethical clearance from the committee and detailed informed consent was signed by the patient before starting.

Technique for Fabrication of Mandibular Advancement Device

Technique 1: (mandibular advancement done with custom made george gauze appliance)

Upper and lower Alginate impressions made using irreversible hydrocolloid material (alginate).[15] Cast was poured using dental stone.[16]Using a green stick, maxillary teeth indentations were generated on a dentulous bite fork, and then facebow recordings were created.[17] Using a green stick, maxillary and mandibular tooth indentations were created on the upper and lower arms of specially George Gauze Device. Lower arm was screwed to the chamber. Patients were asked to occlude in centric (Figure-1) and marking were recorded and then patient was asked to protrude the mandible to the maximum limit (Figure-1) and markings were recorded. Mandibular protrusion values were obtained and 50% of the protrusion values were added to the centric values and maxillary bite fork was tightened with the help of screw to maintain the protrusive values (Figure-1). 50% protrusion bite was recorded with the help of green stick (Figure-1). Facebow records are made using spring facebow. Maxillary cast was articulated on the Hanau Wide Vue Arcon 183-2 Articulator using facebow transfer records with the help of dental plaster. Bite fork was removed by unscrewing the thumb nut from the maxillary arm of the custom-made George gauze appliance. Mandibular cast was articulated using bite registration made using custom made George gauge appliance with the help of dental plaster. Surveying of maxillary and mandibular cast was performed using dental surveyor and height of contour was marked using carbon marker.[19] Undercuts were blocked using modelling wax of maxillary and mandibular cast. Vertical height was raised by 4mm by raising the vertical pin by 4 markings (4 mm). Cold Mold seal was applied onto the maxillary and mandibular cast. Selfcure clear acrylic was mixed in Porcelain jar and was adapted onto the interocclusal space in dough stage. After acrylization of the appliance (Figure-3). Appliance made was retrieved from the cast and trimmed and polished and residual wax was removed with the help of Mini Jet Spray. Monoblock mandibular advancement device is ready for insertion (Figure-3), it was kept for 10 hrs in water to remove residual monomer.[20]

Technique: 2 (mandibular advancement done with hanau articulator)

Upper and lower Primary impressions were made using irreversible hydrocolloid material (alginate).[15]Cast was poured using dental ston.[16]Indentations of maxillary tooth were made on dentulous bite fork using green stick followed by facebow

Figure-1

Figure 2.

Figure 3.

records were made.[17] Interocclusal bite were made using Bite registration wax.[18] Facebow records are made using spring facebow. Maxillary cast was articulated on the Hanau using Facebow transfer records with the help of dental plaster. Mandibular cast was articulated using bite registrationwith the help of dental plaster. Surveying of maxillary and mandibular cast was performed using dental surveyor and height of contour was marked using carbon marker.[19] Undercuts were blocked using modelling wax of maxillary and mandibular cast. Vertical pin was raised on Hanau Wide Vue Arcon 183-2 Articulator to increase thevertical height about 4 mm and marking was made on the incisal table and with the help of digital vernier caliper 5 mm of marking was made posterior to the marking present (Figure-4). Central thumb screws were loosened and central pin was taken to the 5 mm protrusion marking and central thumb nuts screw were tightened and it was secured at the position. Cold Mold seal was applied onto the maxillary and mandibular cast. In a porcelain jar, self-curing transparent acrylic was mixed and applied to the interocclusal area during the dough stage. After acrylization of the appliance. Appliance was retrieved from the cast and trimmed and polished and residual wax was removed with the help of mini jet spray. Monoblock mandibular advancement device is ready for insertion (Figure-6), it was kept overnight in water to remove residual monomer.[20]

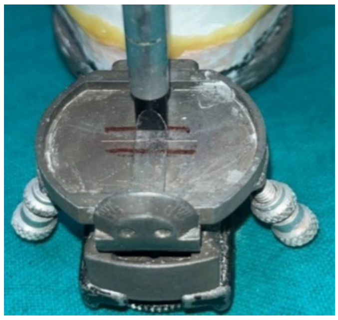


Figure 4.

Figure 5.

Figure 6.

Minor corrections were done if required. Monoblock Mandibular advancement device insertion was done and pre-CBCT scan was done when patient was standing straight, awake during quiet nasal breathing with mouth closed. Retropalatal (RP), retroglossal (RG), and epiglottal (EG) slices were acquired. Using image analysis software, the cross-sectional area of the upper airway was measured along with its lateral and anterior diameters.[21]

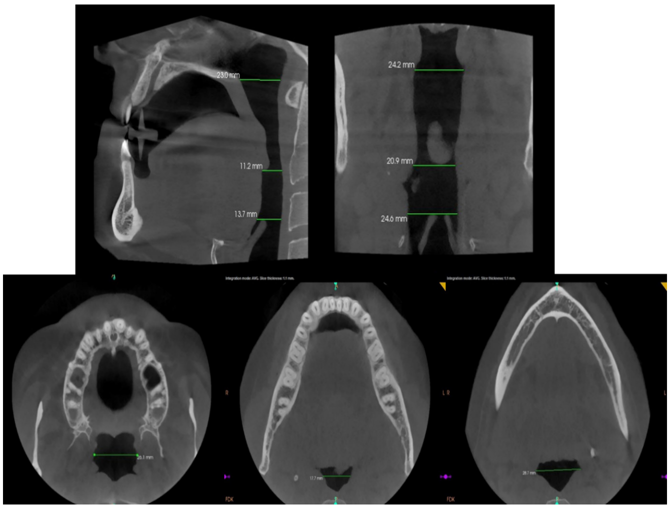


Figure 7. Technique1 Pre-op CBCT

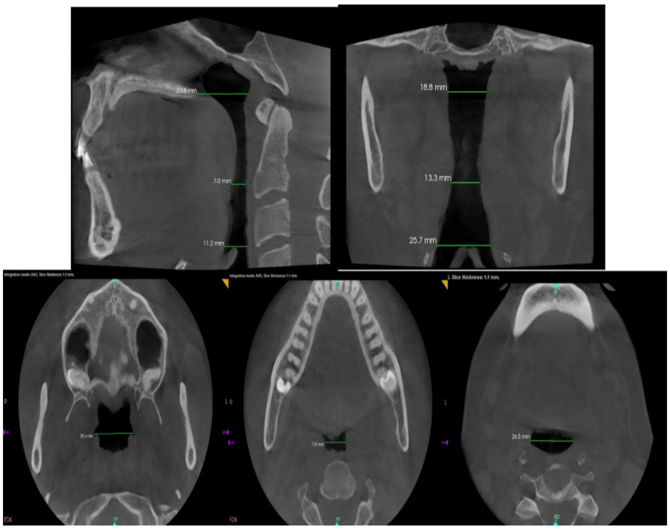


Figure 8. Technique 2 Pre- op CBCT

Patient was asked to wear the appliance for 5-6 hrs a day for 1 month. Regular follow up was done.[21]After 1-month post-CBCT scan was done for patient wearing the appliance when patient was standing straight, awake during quiet nasal breathing with mouth closed. Retropalatal (RP), retroglossal (RG), and epiglottal (EG) slices were acquired. Using image analysis software, the cross-sectional area of the upper airway was measured along with its lateral and anterior diameters. [21]

- Anteroposterior measurements: - When the midsagittal plane is adjusted in axial slice and is maintained at the incisive foramen region or between the central incisors, anteroposterior measurements are taken. The axial line is maintained at the levels of the retropalatal, retroglossal, and epiglottal folds Markings are produced.
- Medio-lateral dimensions: - Markings are taken when the coronal line is altered in the sagittal slice and axial line is maintained at the maximum dimensions of the retropalatal, retroglossal, and epiglottal folds are present, markings are made.
- Cross-sectional dimensions: - When the axial line is adjusted in the midsagittal slice to match with the retropalatal, retroglossal, and epiglottal folds, cross-sectional measurements are taken at maximum dimensions and markings are made.

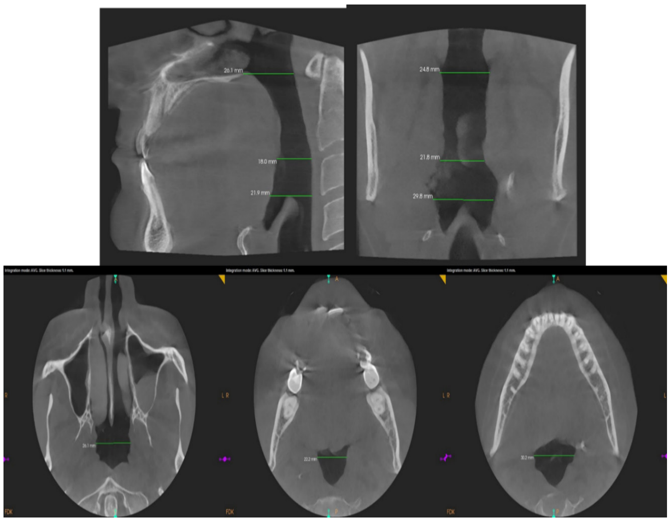


Figure. 9 Technique1 Post- op CBCT

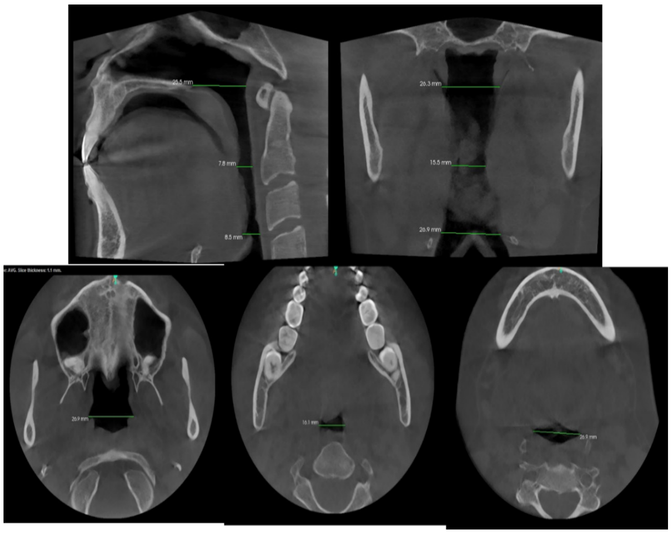


Figure10. Technique 2 Post- op CBCT

RESULT

The statistical differences between the groups were tested using Statistical analysis was done using paired t- test. The level of significance was set at $P < 0.05$.

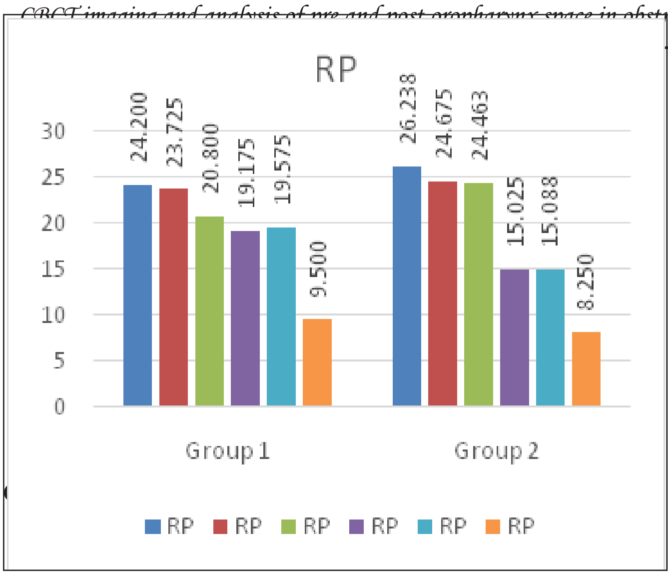
Group -1 showed 100% significant changes (Table-1, graph A, B, C) but for Group-2 50% showed significant changes (Table-2, Graph- A, B, C) at the level of retropalatal, retroglossal, and epiglottal level at different cross-sectional, mediolateral, and anteroposterior measurements.

Table 1. Mean Comparision of Pre and Post values for Group-1

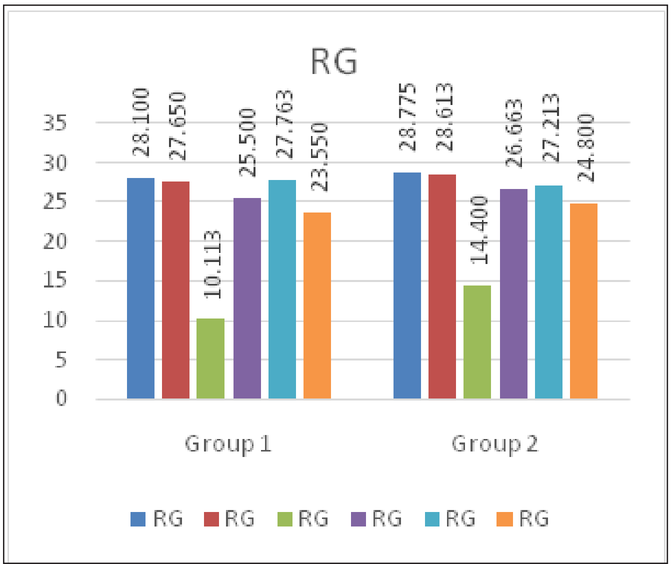
GROUP 1			Mean	N	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		Mean Difference	t'	p value
							Lower	Upper			
RP	CS	Pre	24.200	8	3.731	1.319	-2.246	-0.354	1.300	3.250	0.014
		Post	25.500	8	4.182	1.479					
	ML	Pre	23.725	8	4.704	1.663	-6.450	-1.625	4.038	3.958	0.005
		Post	27.763	8	5.604	1.981					
	AP	Pre	20.800	8	3.719	1.315	-5.322	-0.178	2.750	2.528	0.039
		Post	23.550	8	4.293	1.518					
RG	CS	Pre	19.175	8	4.082	1.443	-6.222	-3.578	4.900	8.765	0.000
		Post	24.075	8	4.248	1.502					
	ML	Pre	19.575	8	3.791	1.340	-4.825	-1.700	3.263	4.937	0.002
		Post	22.838	8	3.268	1.156					
	AP	Pre	9.500	8	2.836	1.003	-5.510	-0.440	2.975	2.775	0.027
		Post	12.475	8	2.975	1.052					
EG	CS	Pre	28.100	8	2.261	0.799	-4.980	-0.445	2.713	2.829	0.025
		Post	30.813	8	1.832	0.648					
	ML	Pre	27.650	8	2.058	0.728	-4.752	-0.423	2.588	2.827	0.026
		Post	30.238	8	2.233	0.790					
	AP	Pre	10.113	8	3.280	1.160	-5.490	-0.835	3.163	3.213	0.015
		Post	13.275	8	4.100	1.450					

Table 2. Mean Comparision of Pre and Post values for Group-2

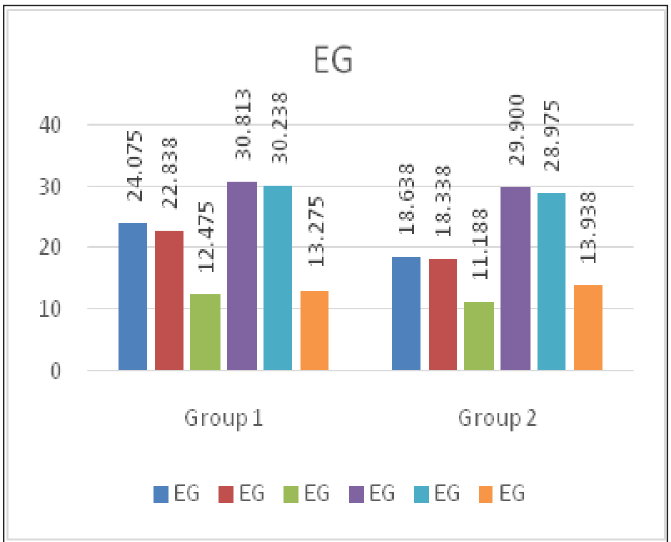
GROUP 2			Mean	N	Std. Deviation Lower	Std. Error Mean Upper	95% Confidence Interval of the Difference		Mean Difference	t'	p value
							Lower	Upper			
RP	CS	Pre	26.238	8	2.509	0.887	-1.799	0.949	0.425	0.732	0.488
		Post	26.663	8	2.780	0.983					
	ML	Pre	24.675	8	5.370	1.899	-5.132	0.057	2.538	2.313	0.054
		Post	27.213	8	3.516	1.243					
	AP	Pre	24.463	8	1.454	0.514	-1.699	1.024	0.338	0.586	0.576
		Post	24.800	8	1.337	0.473					
RG	CS	Pre	15.025	8	2.106	0.745	-5.878	-1.347	3.613	3.771	0.007
		Post	18.638	8	2.863	1.012					
	ML	Pre	15.088	8	1.669	0.590	-5.116	-1.384	3.250	4.119	0.004
		Post	18.338	8	2.332	0.824					
	AP	Pre	8.250	8	2.591	0.916	-4.403	-1.472	2.938	4.741	0.002
		Post	11.188	8	2.938	1.039					
EG	CS	Pre	28.775	8	2.471	0.874	-1.938	-0.312	1.125	3.273	0.014
		Post	29.900	8	2.158	0.763					
	ML	Pre	28.613	8	2.976	1.052	-2.075	1.350	0.362	0.500	0.632
		Post	28.975	8	2.726	0.964					
	AP	Pre	14.400	8	3.981	1.408	-1.856	2.781	0.463	0.472	0.652
		Post	13.938	8	3.329	1.177					



A



B



C

DISCUSSION

Sleep is a fundamental biological process essential for physical health, cognitive functioning, emotional regulation, and overall well-being. Despite its critical role, modern society increasingly underestimates the value of sleep, often sacrificing it infavour of work, social obligations, or digital engagement.

According to the American Academy of Sleep Medicine (AASM), there are five primary phases of sleep: wakefulness (W), rapid eye movement (REM), non-rapid eye movement (NREM), which is further subdivided into three stages (N1, N2, and N3). Stage N1, or light sleep, is the period of time between waking and sleep. Stage N2, also known as intermediate sleep, is the deeper stage of light sleep when the body starts to relax even more. The deepest NREM sleep state is state N3, also referred to as delta sleep. Sleep studies provide information about sleep stages and disorders. Some common sleep disorders may include Insomnia, REM Sleep Without Atonia (RSWA), Obstructive Sleep Apnea (OSA), Idiopathic REM sleep behaviour disorder (iRBD).

We conducted a study were patients reported to Jaipur Dental College, Maharaj Vinayak Global University for routine checkup where they were asked about the questions and according to inclusion and exclusion criteria patients were selected. The diagnosis of OSA patients was done based on STOP- BANG questionnaire after diagnosis they were explained about the treatment plan for obstructive sleep apnea. BMI threshold of 27.5 kg/m^2 was kept for predicting OSA in STOP-BANG QUESTIONNAIRE.[22]

The results of this study align with the findings of prior literature on the use of mandibular advancement devices (MADs) in the management of obstructive sleep apnea (OSA). Mean age, height, weight of Group 1 is 29.75,166.75, 72 respectively, mean age, height, weight of group 2- 37.125,167.25, 83.125 respectively. BMI of grp1 and grp2 was 26,29.5 respectively. With mean protrusion of grp1 and grp2was 5.75 and 5mm respectively. Male female ratio was 83:17 respectively.

Notably, Chand et al. (2024)[21] conducted a computed tomographic evaluation and demonstrated that mandibular advancement at different horizontal jaw positions positively impacted airway dimensions, with Mean age, height, weight was 47,165.1 cm, 77.5 kg. mean BMI 28.4 kg/m2, mean protrusion of 9.2 mm, Male female ratio was 85:15.

A result that our study corroborates. Our data showed statistically significant improvements in upper airway parameters including cross-sectional area (CS), mediolateral (ML), and anteroposterior (AP) dimensions across 50% protrusive position, which is consistent with their observations.

In agreement with Mostafa and Hosny (2022)[23], who compared the accuracy of protrusive records with and without the George Gauge and advocated for its use,by measuring the amount the amount of midline shift, the protrusive record that done by aiding of George gauge bite showed more accuracy. This study also confirms the effectiveness of the George Gauge in determining optimal mandibular protrusion. The appliance-facilitated advancement using standardized measurement tools produced reproducible and favorable results to record mandibular protrusion more accurately and in terms of airway patency.

Classical studies such as those by Johal et al. (2005) and Bonham et al. (1988)[24] emphasized the mechanical role of mandibular advancement in preventing airway collapse during sleep. The improvements in CS, ML, and AP dimensions post-treatment in this study, particularly in group 1, provide further support to these biomechanical explanations. By moving the tongue and soft palate forward, MADs probably increase the distance between the retropalatal and retroglossal airways, which lessens soft tissue collapse and vibration.

Furthermore, Additionally, the study's results are consistent with those of Ryan et al. (1991)[25] and Schwab et al. (1993), who used imaging modalities like CT to assess upper airway changes and demonstrated that such structural modifications correlate with clinical improvement. The consistent volumetric and linear dimensional increase in post-treatment scans in our results substantiates these earlier conclusions.Of note, our use of both EG and RG values allows for a more granular understanding of where the anatomical changes are most significant- suggesting that the greatest gains occur in the retroglossal region.

It is also noteworthy that significant differences were found between groups in terms of pre- and post-operative airway dimensions, suggesting that the extent of mandibular protrusion plays a crucial role.

Group 1, with lower BMI and STOP-Bang scores, showed moderate airway improvements in airway dimensions post-treatment. More significant changes were seen in Group 2, which had higher BMI and STOP-Bang scores. This suggests that patients with more severe OSA may benefit more from mandibular advancement therapy, suggesting that anatomical and physiological traits unique to each patient may affect the results of MAD therapy. This observation is supported by work from Chan et al. (2010)[26] and Chen et al. (2018)[27], who highlighted individual variability in response to MADs.

This is consistent with the conclusions of De Backer et al. (2007)[28] and Fairburn et al. (2007)[29], who utilized advanced imaging and computational techniques to predict treatment success and observed similar changes in airway morphology. Moreover, the longitudinal impact discussed by Robertson (2001)[30] and Ringqvist et al. (2003)[31] concerning dental and skeletal changes supports the need for follow-up and monitoring of side effects in long-term use.Prosthodontists, sleep specialists, and orthodontists must work together in a multidisciplinary manner since progressive dental or occlusal alterations might affect long-term comfort and effectiveness.

The results also underscore the importance of selecting appropriate protrusive positions, as overly aggressive advancement may lead to discomfort or adverse effects without significantly increasing therapeutic benefit. This is consistent with Marklund et al.'s findings (2006)[32], who emphasized the balance between efficacy and side effects in MAD titration. Customizing advancement based on both clinical and anatomical criteria may yield optimal outcomes.

CONCLUSION

This study contributes to the growing body of evidence supporting the effectiveness of mandibular advancement devices in improving upper airway dimensions in OSA patients. It underscores the importance of individualized treatment planning, thorough diagnostic imaging, and the utility of standardized measurement tools like the George Gauge for consistent and optimal results. Future studies should focus on long-term outcomes, patient compliance, and integration with other diagnostic modalities for a comprehensive treatment approach.Furthermore, prospective multicenter trials with larger sample sizes and inclusion of polysomnographic parameters would help validate and extend these findings in broader clinical contexts.

Limitations and Future Directions

Limitations of the study includes the small sample size and short-term follow-up. Future studies should focus on long-term outcomes, patient compliance, and the correlation between airway dimensional changes and polysomnographic parameters. Additionally, incorporating 3D imaging techniques like CBCT and computational fluid dynamics could provide deeper insights into airflow dynamics and treatment efficacy. Future research should aim to integrate airway imaging with airflow dynamics modelling—using techniques like computational fluid dynamics—to better understand the impact of mandibular protrusion on airflow resistance and collapsibility. Longitudinal studies evaluating the durability of airway changes and treatment adherence will further inform clinical guidelines.

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