Efficacy of Mandibular Advancement Device in the Treatment of Obstructive Sleep Apnoea by Evaluating Upper Airway Space Volume Using CBCT

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ABSTRACT

Objective: To evaluate the efficacy of mandibular advancement device as a treatment of mild to moderate obstructive sleep apnoea and to evaluate the change in upper airway space volume by using cone beam CT (CBCT).

Study Design: *In vivo* observational study.

Place and Duration of the Study: Department of Prosthodontics, Crown and Bridge, Sri Aurobindo College of Dentistry, Indore (M.P), India, from March 2017 to January 2021.

Methodology: Patients with mild to moderate obstructive sleep apnoea patients using Berlin questionnaire were selected. Pre- and posttreatment-CBCT analysis was done to compare the changes in superior and inferior upper airway space before and after using mandibular advancement device. The pre and postoperative CBCT were also compared using a paired t-test for the quantitative variables. After two months, the patients were asked to complete a self-administered questionnaire to assess their sleep improvement, initial symptoms regression, and effectiveness of the mandibular advancement device.

Results: On comparative evaluation of the pre- and post-CBCT, the mean score before the mandibular advancement device placement was found to be 7.77 ± 2.79 cc, whereas the mean score after the mandibular advancement device placement was found to be 9.75 ± 3.34 cc ($p<0.001$). Significant volumetric change was seen in upper airway space after receiving treatment for the two months. The patient noticed a substantial improvement in their sleep as well as a reduction in the original symptoms.

Conclusion: This study showed statistically significant volumetric change in the upper airway space and reduction in their symptoms after treatment with the mandibular advancement device (MAD).

Key Words: *Obstructive sleep apnoea syndrome (OSA), Continuous positive airway pressure (CPAP), Cone beam computed tomography, Mandibular advancement device (MAD), Upper airway volume.*

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INTRODUCTION

Obstructive sleep apnoea (OSA) is a disorder, demonstrating continual episodes of upper airway (UA) obstruction that occur throughout the sleep; sometime these apnoeic events happen due to decrease of oxygen in the blood which eventually leads to gasping for air.[1] People with obstructive sleep apnoea frequently stop breathing for a second or longer while they are asleep. There can be abnormal flow of air into the lungs, generally caused by the collapse of the soft tissue within the UA and tongue throughout the sleep.[2]

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Since ancient times dating back over 2000 years, OSA had been observed, and its symptoms had been recorded as snoring.[3] Other common symptoms of obstructive sleep apnoea may include daytime sleepiness, mood changes, impaired concentration, morning headaches, drooling, depression, dry mouth, and breathing pause during sleep noticed by the partner.[4]

In India, the prevalence rate is higher in males as compared to females, i.e. 19.5% of males and 7.5% of females.[5] A North Indian population-based survey in 2006 calculated the prevalence of OSA syndrome at 3.6% (4.9% of males and 2.1% of females).[6]

The Berlin Questionnaire (BQ) is a brief and validated survey and screeming tool that aids in the diagnosis of OSA and identifies persons in the community who are at high risk of OSA.[7,8] BQ includes questions about snoring, daytime somnolence, body mass index (BMI), and hypertension. Radiologic imaging like cone beam computed tomography had been employed to detect variation in the morphology of the UA.[9] The analysis of the airways with CBCT has become more accurate thanks to the possibility, as well as the low dose of radiation to which the patient is subjected to when compared to MRI and other radiologic imaging.[10,11]

Treatment options for OSA include lifestyle changes, such as quitting alcohol in the evening, learning healthy sleeping positions, using an oral appliance, applying continuous positive airway pressure, and upper airway surgery.[12]

According to the American Academy of Sleep Medicine, one of the primary indications for treatment is persistent snoring.[13] MAD is the most used treatment option for treating snoring and mild to moderate OSA. There are different types of oral appliances other than MAD for treatment of OSA and snoring such as tongue-retaining or repositioning devices (TRD), which can be used for edentulous patients.[12]

Monobloc mandibular advancement device (one-piece device) is easier to construct, economical and a custom-made device. The monobloc mandibular advancement device was one of the first functional appliance, with the aim of obtaining a functional advancement of the mandible, moving it forward to a more advanced position,[14] to adjust mandibular protrusion and enhance velopharyngeal airway patency by involving the maxilla and mandible. The range of fifty to seventy-five percent of the maximum protrusion is the most frequently cited mandibular repositioning dimension (approximately 5 to 7mm).[15]

METHODOLOGY

This study was carried out in the Department of Prosthodontics, Crown and Bridge, Sri Aurobindo College of Dentistry, Indore (M.P), India. CBCT scan was done in the Department of Oral Medicine and Radiology at Sri Aurobindo College of Dentistry after the ethical approval from the institution. Desired sample size of 30 individuals was obtained by using simple random sampling technique of mild to moderate OSA patients investigated by using CBCT. Patients over 15 years, of either gender, with a history of snoring, daytime sleepiness, and exhaustion, who could respond to the BQ, and consented to give their CBCT data for essential information and research instruction, were included in the study. All patients were asked to answer the BQ for diagnosis of OSA. The patients who were found positive were included in the study. Depending on the snoring, the patients were divided into 3 categories of OSA (mild, moderate, and severe). According to the BQ, mild to moderate came in low-risk category and moderate to severe came in high--risk category. The exclusion criteria included pregnant or lactating females, patients with prior craniofacial surgery related to OSA or with any other respiratory disorder.

Once the patient was identified as having mild to moderate OSA, CBCT scan was done. The patient's position was standing with the Frankfort Plane parallel to the floor during their waking period. The pre and postoperative CBCT scan was then loaded into the medical imaging software's on-demand 3D app. Two areas, superior area and an inferior area, all were perpendicular to the median sagittal plane of symmetry.

Patient's superior and inferior upper airway volume was calculated. Three planes were then built, an upper, a middle, and lower one, all perpendicular to the median sagittal plane (S-N-Ba) of symmetry to obtain 2 areas, a superior and an inferior one (Figure 1). The upper plane passed through basion point and the posterior nasal spine point. The middle plane passed through the middle anterior point to first vertebra and parallel to cranial base plane; the lower plane passed through the lowest anterior point to first vertebra and the menton point.

Mandibular advancement devices were then made in a conventional method. And, it was placed into the patient's mouth. Desired adjustment were done in the patient's mouth and it was made sure that the appliance was seated properly in the position. Initially, all the patients felt strain because of the retention components. After the adjustment was done in patient's mouth, postoperative instructions and follow-up instructions were given to the patients. The patients were recalled after a week, then after two weeks, and finally at the end of the two months.

After two months of therapy, postoperative CBCT were done to assess the effectiveness of mandibular advancement devices in reduction of initial symptoms (Figure 2).

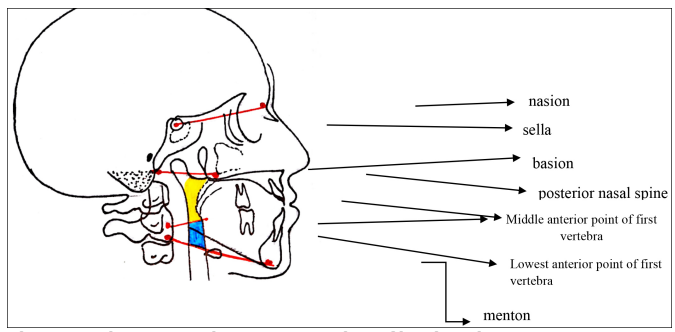

Figure 1: Diagrammatic representation of landmarks.

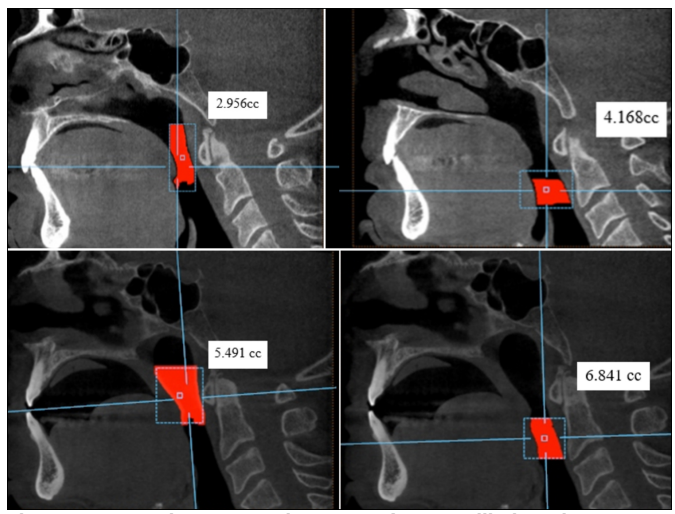

Figure 2: Pre and postoperative CBCT after mandibular advancement device application.

RESULTS

The analysis was conducted using the Statistical Package for the Social Sciences (SPSS, IBM Version 20.0). Categorical variables were expressed as counts and percentages and continuous variables were expressed as mean and standard deviation. Statistical significance was defined as $p \leq 0.05$, with the threshold of significance fixed at 5%. Paired t-test was performed for comparingoperative and postoperative CBCT.

Table I: Evaluation of CBCT changes before and after oral appliance treatment.

Area	N	Before Oral Appliance Treatment Mean ± S.D.	Minimum	Maximum	After Oral Appliance Treatment Mean ± S.D.	Minimum	Maximum	p-value Paired t-test
Superior	30	4.78 ± 1.65	1.66	9.89	5.46 ± 1.66	2.09	10.40	0.001*(S)
Inferior	30	3.01 ± 1.41	1.13	6.98	4.29 ± 1.91	1.79	10.88	0.001*(S)
Total	30	7.77 ± 2.79			9.75 ± 3.34			0.001*(S)

Statistical test employed: Paired t-test (S) = Significant p-value ≤0.05.

A total comparative evaluation of the pre and post-scores revealed significant (p<0.001) difference between the two scores before and after monobloc mandibular advancement device placement. The mean score of pre-CBCT of the upper airway volume in the superior region before the MAD was measured to be 4.78 ± 1.65cc whereas post-CBCT mean score after appliance in superior area was found to be 5.46 ± 1.66cc. The mean score of the pre-CBCT of the inferior region before appliance was found to be 3.01 ± 1.41cc. The mean score after appliance in inferior area placement was found to be 4.29 ± 1.91cc. The mean score before appliance placement was found to be 7.77 ± 2.79cc whereas the mean score after appliance placement was found to be 9.75 ± 3.34cc which revealed (p<0.001) significant difference between the two scores (Table I).

DISCUSSION

The main aim of this study was to evaluate the efficacy of the upper airway space volume in patients with OSA with mandibular advancement device. In this study, 30 patients of mild to moderate OSA were treated with mandibular advancement device and evaluated with CBCT. Upper airway volume was examined in the presence and absence of mandibular advancement device, and the volume was measured and compared in two different areas as a superior and an inferior one.

The mean score on the superior area before MAD treatment was found to be 4.78 ± 1.66 cc whereas there was a significant increase in the mean score after oral appliance placement with the mean score being 5.46 ± 1.65 cc. Similar results were found by Cossellu *et al.* who observed the superior volume in the posterior soft palate region slightly increased (from 5.381 to 5.579 cc) on 10 Italian patients.[16] An evaluation of the mean scores before and after the appliance treatment in the inferior area revealed significant increase in the CBCT mean scores from 3.01 ± 1.41 to 4.29 + 1.91 cc. They also observed the mean score in the inferior area (from 2.988 to 3.974.8 cc) on 10 Italian patients. The total comparative evaluation of the pre- and post-scores revealed significant difference between the two scores before and after the appliance placement.[11] The mean score before appliance placement was found to be 7.77 + 2.79 cc whereas the mean score after appliance placement was 9.75 + 3.34 cc. The mean upper airway volumes increased significantly from 8.299 cc to 9.457 cc.[16] Other studies used computed tomography (CT) images to evaluate the efficacy of the oral appliance. There was a significant increase in (p <0.05) after delivery appliance by measurement at retropalatal (before appliance: 119.5 ± 8.8, and after oral appliance 95.8 ± 4.86) and retroglossal (before appliance: 300.8 ± 19.04, and after appliance: 319.0 ± 12.56).[17-19] These results were comparable to the present results.

Clark *et al*. compared the efficacy of a removable MAD to continuous positive airway pressure (CPAP) in patients with OSA.[20] They observed 23 male subjects with confirmed OSA. The MAD achieved substantial success in most cases, but was less effective than CPAP, especially for the more severe cases. In general, the MAD was strongly preferred over the CPAP by the subjects of Clark's study.

A mandibular advancement device showed consistent advantages in patients with mild or moderate OSA. It was a useful tool for treating snoring and OSA, with minimal side effects, easy to use, and more cost-effective than CPAP. For patients who could not tolerate positive airway pressure devices, it was a helpful therapy choice.

CONCLUSION

On evaluation of the CBCT, the minimum average change in the upper airway volume was 0.64cc and the maximum average change was 5.208cc of patients who showed improvement in their sleep and decrease in the frequency of snoring. The minimum change in upper airway volume (0.64cc) was effective in reducing the symptoms of OSA by treating with mandibular advancement device.

ETHICAL APPROVAL:

This study was performed after an approval from the institutional ethical committee of the Sri Aurobindo College of Dentistry (IRC2017/No.09).

PATIENTS' CONSENT:

Consent was taken from the patients to publish the data of the study.

COMPETING INTEREST:

The authors declared no competing interest.

AUTHORS' CONTRIBUTION:

AV: Analysis and interpretation of data, drafting, and revising the manuscript for important intellectual content.

SJ: Supervision, writing, reviewing.
All authors approved the final version of the manuscript to be published.

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