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Effect of oral appliances on cephalometric measurements and sleep apnea severity: A clinical study

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Abstract

Aim: This study aimed to evaluate the effects of oral appliances (OA) in OSA cases by using cephalometric measurements that rejected the use of CPAP therapy. The research question focused on whether oral appliances could significantly alter craniofacial structure and reduce sleep apnea severity.

Material and Methods: Ten participants (8 males and 2 females) from the sleep clinic were included in this study. The medical instructor advised them to use the CPAP device, but the participants confirmed to use OA. The patients underwent the same polysomnography laboratory with a sleep oral appliance continuously one month after using it all night. Cephalometric radiographs were taken before and after using the OA. The Apnea-Hypopnea Index (AHI) and other sleep apnea parameters were measured through polysomnography. Statistical analysis was performed using the Mann-Whitney U test.

Results: The median AHI significantly decreased from 26.2 events/hour to 11.3 events/hour (p=0.008) after using the oral appliance. The SNB angle increased from 75.6 to 78.8 degrees (p=0.003), and the ANB angle decreased from 5.6 to 2.8 degrees (p=0.01), indicating improved mandibular positioning. The Sn-GoGn angle also increased significantly from 37.0 to 43.1 degrees (p=0.001), suggesting changes in mandibular plane orientation.

Discussion: The study demonstrated that oral appliances significantly reduce the severity of sleep apnea and induce favorable cephalometric changes. These appliances are effective alternatives for patients who are unable to tolerate CPAP, potentially improving airway patency by repositioning the jaw.

Keywords

Oral Apnea Appliances, Sleep Apnea, Polysomnography (PSG), Mandibular Advancement Devices (MAD)

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Introduction

The word apnea originates from the Greek Word apnoia and means without breathing. Obstructive Sleep Apnea Syndrome (OSAS) is characterized by episodes of obstruction of the upper airway during sleep, resulting in a reduction in oxygen saturation [1]. These situations lead the patients to a reduction in oxygen saturation. Untreated OSAS may carry a high risk of comorbid diseases, such as systemic hypertension, depression, stroke, and cardiac dysrhythmias [2, 3]. Excessive daytime sleepiness is a significant symptom, and due to this problem, patients have an increased risk for motor vehicle accidents [4].

OSAS affects 3.9% of men and 1.2% of women, and this prevalence increases with age, to approximately 20-54% for elderly women and 28-67% for elderly men [5].

Continuous positive airway pressure (CPAP) is accepted as a gold standard treatment for OSA by most authorities [6]. It is effective in reducing breathing disturbances during sleep. CPAP has been shown to improve daytime sleepiness, cognitive function, blood pressure, and quality of life [7]. Contrary to these positive outcomes, only half of the patients with OSA adhere to the CPAP therapy [8]. Patients complain that CPAP is difficult to tolerate due to high pressure and wearing a mask during the night. This reduces the clinical effectiveness of CPAP [9]. In recent years, it has been observed that Oral sleep appliances are an alternative treatment option for snoring and mild to moderate OSA in patients who refuse CPAP or can not tolerate it. Recently, studies have shown that oral appliance may be an alternative option for patients who refuse to use CPAP [10].

Cephalometric analysis, which uses standardized lateral skull radiographs, has become an essential tool for studying the craniofacial structures associated with OSAS. Through cephalometric measurements, clinicians and researchers can identify skeletal and dental characteristics that contribute to the pathophysiology of OSAS [11].

The purpose of the present study is to observe the effects of Oral appliance in patients who refused to use CPAP by using Cephalometric landmarks.

Material and Methods

In the present study, a significance level of 0.05 ($\alpha = 0.05$) was chosen for the power analysis to control the probability of errors. A desired power level of 0.90 ($1 - \beta = 0.90$) was selected to ensure adequate sensitivity to detect the specified effect size. An effect size of 1.2 (Cohen's $d = 1.2$) was estimated based on the observed differences in the AHI score. Using these parameters by GPower 3.1.9.7 software, a sample size of 10 participants per group was determined to be enough to achieve the desired level of statistical power.

The study group consisted of ten subjects. The subjects were enrolled into the study from the sleep clinic belonging to the department of Neurology, University of Sütçü İmam, Kahramanmaraş, Turkey.

Untreated and CPAP noncompliant participants were included in the study. This study was approved by the local ethical committee. All participants were recommended for oral sleep appliance therapy by a neurologist supervising the sleep clinic.

Participants were excluded by study dentist if sleep oral appliance therapy was contraindicated in these participants. These exclusion criteria were periodontal disease and insufficient teeth for device retention.

Patients were excluded by the sleep clinic director if they had central sleep apnea or were taking medications affecting sleep or breathing. Patients with mental conditions preventing the use of an oral sleep appliance or the ability to provide informed consent were also excluded.

Oral Sleep Apnea Appliance Protocol

The patients referred from Polysomnographic laboratories (PSG) and agreed to use an oral sleep appliance were referred to the dental clinic. The referred participants underwent dental intervention in the dental clinic. An experienced dentist took dental impressions from the participants. The material of the oral sleep appliance was polyvinyl siloxane (PVS). The thickness of this material was 1.0mm (.040").In the second appointment, the mandibular advancement was applied following the trademark OSP sleep appliance patent under the PCT/TR2020/050697-PCT05 (Figure 1).

After completing the oral sleep appliance, detailed information was given to the participants. They confirmed that they use it during sleep. All the participants were called after 3 days by phone to provide feedback about their comfort with the oral sleep appliance. If there were no problems, they were accepted as participants in this study.

The second PSG was conducted 1 month after using the oral sleep appliance at night. The second PSG record was taken with the oral sleep appliance in the same polysomnographic laboratory.

Cephalometric Records

All the cephalometric radiographs were obtained from all participants under standardized conditions with their teeth in centric occlusion. The radiographs were taken by the participants with and without oral sleep appliances. The second cephalometric with appliance was taken before going to the second PSG. All the cephalometric radiographs were traced by the same investigator (HB).

Cephalometric parameters that were used in this study included:

SNAo: Angle formed by the intersection of sella-nasion and nasion-A-lines.

SNBo: Angle formed by the intersection of sella-nasion and nasion-B- B lines.

ANBo: Angle formed by the intersection of nasion- A and nasion- B lines.

These angles describe the relative positions of the maxilla and mandible.

Sn-GoGn Angle: SN-GoGno is the angle between the SN planes and the mandibular plane (GoGn). This angle elucidates the behavior of the mandibular base with the cranium base, indicating the facial growth type, whether horizontal, vertical, or balanced. This angle indicates the mandibular plane angle (Figure 2).

Statistical analysis

Statistical analysis was performed using SPSS software, version 27.0 (SPSS Inc., Chicago, IL, USA). Quantitative data were described as medians (Min-Max), and categorical data were presented as frequencies and percentages. Shapiro Wilk test was used to control the conformity of continuous variables to normal distribution. Wilcoxon Test was applied to assess

the difference between the parameters before and after using an oral sleep appliance. Relationships between categorical variables were tested with Chi-square analysis. Statistical significance was set at $p < 0.05$.

Ethical Approval

This study was approved by the Ethics Committee of Elazığ University, Faculty of Medicine (Date: 2024-11-14, No: 2024 /301).

Results

The demographic characteristics of the cases are shown in Table 1. A total of 10 participants were included in the study, with a median age of 53 years (range: 40-72 years). The majority of participants were male (80.0%, 8/10), with females comprising 20.0% (2/10) of the study group (Table 1). The effect of Oral Appliance on Sleep Apnea Severity was shown in Table 2. The Apnea-Hypopnea Index (AHI) showed a significant reduction following treatment with the oral appliance. The median AHI decreased from 26.2 events per hour (range: 11.9-60.3) without the appliance to 11.3 events per hour (range: 2.9-35.5) with the appliance, representing a statistically significant change (p=0.007).

Hypopnea events per hour also demonstrate a slight decrease, from a median of 9.0 (range: 2.2-44.5) without the appliance to 7.6 (range: 2.5-14.0) with the appliance (p=0.023), which was statistically significant.

Regarding apnea events per hour, there was a decrease from a median of 11.0 (range: 3.6-26.5) to 4.2 (range: 0.4-24.9) with the appliance (p=0.042). However, this reduction was statistically significant.

Significant changes were observed in certain cephalometric measurements. In terms of skeletal changes, the SNA angle remained stable (P = 0.833), suggesting no significant maxillary movement. However, a notable increase in the SNB angle from 75.6 (72.0–78.1) to 78.8 (74.8–80.4) (P = 0.002) indicates a forward shift of the mandible, which can enhance airway patency. Although the ANB angle showed a downward trend from 5.6 (2.9–7.8) to 2.8 (0.7–50.9), this change was not statistically significant (P = 0.082). Additionally, the Sn-GoGn angle increased significantly from 37.0 (33.7–43.0) to 43.1 (39.2–48.3) (P = 0.002), reflecting vertical mandibular movement that may further contribute to reduced airway obstruction (Table 2).

Table 1. Demographic and clinical characteristics of the cases

	Median (Min-Max) or N (%)
Age	53,0 (40-72)
Gender	
Male	8 (80,0%)
Female	2 (20,0%)

Table 2. Effect of Oral Appliance on Sleep Apnea Severity (Wilcoxon test)

Parameters	Without Appliance	With Appliance	P value
AHI	26.2 (11.9-60.3)	11.3 (2.9-35.5)	0.007**
Apnea /hour	11.0 (3.6-26.5)	4.2 (0.4-24.9)	0.042*
Hypopnea/hour	9.0 (2.2-44.5)	7.6 (2.5-14.0)	0.023*
SNA	80.9 (79.2-83.2)	80.8 (80.1-83.7)	0.833
SNB	75.6 (72.0-78.1)	78.8 (74.8-80.4)	0.002**
ANB	5.6 (2.9-7.8)	2.8 (0.7-50.9)	0.082
Sn-GoGn	37.0 (33.7-43.0)	43.1 (39.2-48.3)	0.002**

Discussion

The results of this study demonstrate that the use of OA can significantly reduce the severity of sleep apnea, as indicated by the decrease in the Apnea-Hypopnea Index (AHI). The results revealed that OA has a clinically meaningful effect on reducing apnea and hypopnea events during sleep. Many studies support our findings. Serra-Torres et al. found these appliances to be an effective alternative solution for snoring and in mild to moderate OSA patients [12]. In another study, researchers mentioned that using an OA reduces snoring and obstructive breathing events and shows positive effects on daytime sleepiness [13]. In this recent study, the mean AHI score was 26.2, close to the severe level (AHI=30). After using OA, the decrease was significant, with a score of 11.3.

The other parameters, apnea/hour and hypopnea/hour values, showed a decrease after the use of the OA. The results did not show a significant decrease in AHI scores. The changes in apnea per hour and the saturation of oxygen are limited by the number of participants in this study. The limited number of participants may prevent a significant reduction. Only 1 month

Figure 1. The material of the oral sleep appliance

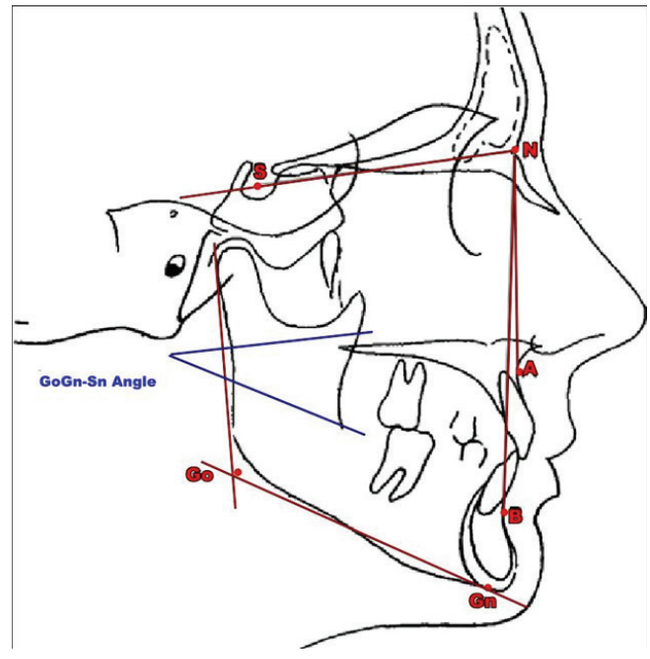

Figure 2. The measurement of Sn-GoGn Angle

after using the oral sleep appliance may not be enough time to show improvement in these parameters in OSA patients. Studies on the effects of using an OA in many other studies focused on blood pressure, heart rate, and the cardiovascular system waited from 3 months to 1 year [14-16].

The cephalometric data indicate that the appliance affects mandibular positioning, as evidenced by the significant increase in the SNB angle and the decrease in the ANB angle. SNB means the forward position of the chin, and ANB is the relationship with the position of the maxilla. These changes in mandibular alignment likely contribute to a more open airway, thereby reducing the frequency of apnea and hypopnea events. These findings support the notion that oral appliances work by repositioning the jaw to improve airway patency during sleep. Previous studies have shown that people with sleep apnea may have a small retruded mandible, a narrow posterior airway space, an enlarged tongue and soft palate, an inferiorly positioned hyoid bone, and a retroposition of the maxilla [17].

Our study used another landmark that is widely used in orthodontics: SN-GoGn. This showed the relationship between mandible and craniofacial structure. Our results showed that using OA has significantly positively affected the OSA scores. A larger Sn-GoGn angle suggests a more downwardly tilted mandible, potentially reducing airway space and increasing the risk of airway obstruction [18]. It is known that holding the lower jaw in a more anterior position enlarges the upper airway space and provides expansion in the lateral dimension of the velopharyngeal region [19]. Contrary to this, it has been shown that the patients with OSA have smaller Sn-GoGn angles than the control group [17].

Our study supports that there is a negative relationship between AHI scores and the mandible downward retruded position. The position of the mandible did not affect only the AHI scores but also the posture of the head. According to this topic many years ago, Solow and Kreiborg termed 'the soft tissue stretching hypothesis' that means upper airway obstruction causes a change in posture via extension of the skeletal structures such as cervical angle [20]. From childhood till adult age, subjects spontaneously put their head in more extension positions to eliminate the obstruction of the airway. This leads the subjects on skeletal structures and causes a decrease in the forward growth of the maxilla and mandible. Unfortunately, this is a severe sign in the future to be a a patient with apnea and declared in year 1977.

In 2019, researchers estimated that nearly 1 billion adults aged 30-69 years worldwide could have OSA [21]. Nearly half of them are classified as moderate to severe sleep apnea patients and need any intervention to treat. Under the light of this result, we need a new approach to OSA in the early stage. Dental and medical specialists who have experience with OSA cases have to come together. Potential OSA cases in childhood may have to be treated orthodontically to eliminate apnea. The solution is upgrading the Medicine and Dental Program, including OSA cases. Prevention from apnea needs severe steps to do with all disciplines, otherwise, it could not be solved by traditional methods.

Limitation

This study has several limitations that should be acknowledged. First, the sample size was small, with only ten participants included, which may limit the generalizability of the findings. A larger cohort would provide more robust statistical power and better represent the broader population of OSA patients. Second, the follow-up period was relatively short, with outcomes assessed after just one month of oral appliance use. Long-term studies are needed to evaluate the sustained efficacy of oral appliances and their impact on clinical parameters over time. Third, the study did not include a control group, which limits the ability to directly compare the effects of oral appliance therapy to alternative treatments such as continuous positive airway pressure (CPAP) or no intervention. Additionally, self-reported compliance and subjective feedback from participants may introduce bias in assessing the device's acceptability and effectiveness. Future research should aim to address these limitations by incorporating larger sample sizes, longer follow-up durations, and controlled study designs.

Conclusion

Our findings showed that OA is an effective alternative treatment for sleep apnea, especially in patients who may not tolerate continuous positive airway pressure (CPAP) therapy.

The observed reduction in AHI is consistently reinforcing the role of OA in managing sleep apnea. All the participants have a good tolerance to use this OA, and subjectively, the patients have positive moods, and voluntarily they want to use it in furthermore.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and Human Rights Statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or compareable ethical standards.

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Conflict of Interest

The authors declare that there is no conflict of interest.

References

1. Vezina K, Mariasine J, Young R, Reyna M, Lu Z, Subbarao P, et al. Cardiorespiratory Monitoring Data during Sleep in Healthy Canadian Infants. Ann Am Thorac Soc. 2020;17(10):1238-46.

2. Henning RJ, Anderson WM. Sleep apnea is a common and dangerous cardiovascular risk factor. Curr Probl Cardiol. 2025;50(1):102838-48.

3. DiCaro MV, Lei K, Yee B, Tak T. The Effects of Obstructive Sleep Apnea on the Cardiovascular System: A Comprehensive Review. J Clin Med. 2024;13(11):1-7.

4. Lee JJ, Sundar KM. Evaluation and Management of Adults with Obstructive Sleep Apnea Syndrome. Lung. 2021;199(2):87-101.

5. Okşayan R, Sökücü O, Uyar M, Topçuoğlu T. Effects of edentulism in obstructive sleep apnea syndrome. Nigerian Journal of Clinical Practice. 2015;18(4):502-5.

6. Kim HY, Jo JH, Chung JW, Park JW. The multisystemic effects of oral appliance therapy for obstructive sleep apnea: A narrative review. Medicine (Baltimore). 2022;101(29):1-9.

7. Tong BK, Tran C, Ricciardiello A, Chiang A, Donegan M, Murray N, et al. Efficacy of a novel oral appliance and the role of posture on nasal resistance in obstructive sleep apnea. J Clin Sleep Med. 2020;16(4):483-92.

8. Oliver C, Li H, Biswas B, Woodstoke D, Blackman J, Butters A, et al. A systematic review on adherence to continuous positive airway pressure (CPAP) treatment for obstructive sleep apnoea (OSA) in individuals with mild cognitive impairment and Alzheimer's disease dementia. Sleep Med Rev. 2024;73(11):1-12.

9. Rubanenko AO, Dyachkov VA, Miroshnichenko AI. Factors affecting adherence to CPAP therapy in patients with obstructive sleep apnea syndrome. Zh Nevrol Psikhiatr Im S S Korsakova. 2024;124(5):58-65.

10. Tsai MS, Chen HC, Liu SY, Lee LA, Lin CY, Chang GH, et al. Holistic care for obstructive sleep apnea (OSA) with an emphasis on restoring nasal breathing: A review and perspective. J Chin Med Assoc. 2022;85(6):672-8.

11. Nomura T, Sasaki A, Fujimoto M, Mano M, Suda N, Kondo K. Effects of jaw movement in bimaxillary orthognathic surgery on the upper airway: Computational fluid dynamics analysis. Orthod Craniofac Res. 2023;26(3):311-9.

12. Serra-Torres S, Bellot-Arcis C, Montiel-Company JM, Marco-Algarra J, Almerich-Silla JM. Effectiveness of mandibular advancement appliances in treating obstructive sleep apnea syndrome: A systematic review. Laryngoscope. 2016;126(2):507-14.
13. Sutherland K, Vanderveken OM, Tsuda H, Marklund M, Gagnadoux F, Kushida CA, et al. Oral appliance treatment for obstructive sleep apnea: an update. J Clin Sleep Med. 2014;10(2):215-27.
14. Langaliya A, Alam MK, Hegde U, Panakaje MS, Cervino G, Minervini G. Occurrence of Temporomandibular Disorders among patients undergoing treatment for Obstructive Sleep Apnoea Syndrome (OSAS) using Mandibular Advancement Device (MAD): A Systematic Review conducted according to PRISMA guidelines and the Cochrane handbook for systematic reviews of interventions. J Oral Rehabil. 2023;50(12):1554-63.
15. Cohen-Levy J. The influence of obstructive sleep apnea syndrome on the orthodontic treatment decision in children and adolescents. Part 2: Which orthodontic treatments for children with apnea? Orthod Fr. 2023;94(1):173-85.
16. Segu M, Cosi A, Santagostini A, Scribante A. Efficacy of a Trial Oral Appliance in OSAS Management: A New Protocol to Recognize Responder/Nonresponder Patients. Int J Dent. 2021;20211-10.
17. Sokucu O, Oksayan R, Uyar M, Ademci KE, Usumez S. Relationship between head posture and the severity of obstructive sleep apnea. Am J Orthod Dentofacial Orthop. 2016;150(6):945-9.
18. Sfondrini MF, Gallo S, Pascadopoli M, Gandini P, Roncoroni C, Scribante A. Upper Airway Dimensions among Different Skeletal Malocclusions: A Retrospective Observational Study by Cephalometric Analysis. Dent J (Basel). 2024;12(1):1-8.
19. Brown EC, Cheng S, McKenzie DK, Butler JE, Gandevia SC, Bilston LE. Tongue and lateral upper airway movement with mandibular advancement. Sleep. 2013;36(3):397-404.
20. Solow B, Kreiborg S. Soft-tissue stretching: A possible control factor in craniofacial morphogenesis. Scand J Dent Research. 1977;85:505-7.
21. Benjafield AV, Ayas NT, Eastwood RP, Heinze R. Estimation of the global prevalence and burden of obstructive sleep apnoea: a literature-based analysis. Lancet Respir Med. 2019;8(1):687–98.

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