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SLEEP BREATHING PHYSIOLOGY AND DISORDERS • ORIGINAL ARTICLE

Will wearing dentures affect edentulous patients' breathing during sleep?

Qiuwen Chen[1] · **Dong Zou**[2] · **Hailan Feng**[3] · **Shaoxia Pan**[1]

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Abstract
Purposes The purpose of this study is to investigate the effect of wearing dentures on obstructive sleep apnea and hypopnea among completely edentulous patients.
Methods and materials A self-controlled study was conducted among 30 edentulous patients. Polysomnograms were recorded in the sleep laboratory on two consecutive nights. Participants slept with their dentures in one night and without dentures in the other. The apnea and hypopnea index (AHI), lowest oxygen saturation (L-SpO_2), and morning blood pressure (MBP) were collected for statistical analysis.
Results Among the edentulous participants, 24 showed a higher AHI when sleeping with dentures. The average AHI for all 30 participants was significantly higher when they slept with dentures than without dentures (16.3 ± 14.7 vs 13.4 ± 14.0/h, $P < 0.05$). Participants in the non-obstructive sleep apnea-hypopnea syndrome (non-OSAHS) subgroup (AHI <5 when sleeping without dentures) had a significant increase in AHI when sleeping with dentures, and nearly half of them (5 out of 11) reached the diagnostic standard for OSAHS (AHI >5). A higher morning diastolic blood pressure was recorded when participants slept with dentures ($P < 0.05$), while no significant difference was found in the L-SpO_2 score and morning systolic blood pressure.
Conclusions Wearing dentures can lead to significant increase of AHI and diastolic MBP among edentulous people. Hence, we suggest that Chinese edentulous people should remove their dentures before sleep.
Trial registration ChiCTR-IOR-16008404

Keywords Obstructive sleep apnea-hypopnea syndrome (OSAHS) · Edentulism · Complete dentures · Polysomnogram (PSG)

Introduction

Obstructive sleep apnea-hypopnea syndrome (OSAHS) is a common sleep disorder, characterized by recurrent nocturnal airflow reduction or cessation of breathing, frequently resulting in blood oxygen desaturation, snoring, and daytime sleepiness. It is under the multidisciplinary spotlight because of its high morbidity, multitudinous general complications, severe impact on quality of life, and potentially fatal consequences [1].

The pathogenesis of OSAHS is multifactorial and commonly associated with anatomical features that favor obstruction of the upper airway. Most current research on OSAHS concentrates on the dentate population, while only a few reports address the role of edentulism in the pathogenesis of OSAHS. Edentulism results in craniofacial changes such as loss of the vertical dimension of occlusion, reduction of lower facial height, and rotation of the mandible, all of which may influence the size and function of the upper airway [2, 3]. It has been reported that edentulism causes a decrease in the dimensions and tone of the pharyngeal musculature [4]. People suffering from edentulism are more likely to develop OSAHS, while wearing dentures during sleep can significantly improve

✉ Shaoxia Pan
panshaoxia@vip.163.com

[1] Department of Prosthodontics, Peking University School and Hospital of Stomatology, 22 Zhongguancun Avenue South, Haidian District, Beijing 100081, China

[2] National Engineering Laboratory for Digital and Material Technology of Stomatology, Beijing, China

[3] Beijing Key Laboratory of Digital Stomatology, Beijing, China

the AHI (apnea and hypopnea index) [3, 5]. However, other studies have shown conflicting evidence [6, 7].

In China, the majority of edentulous individuals are advised to remove their dentures before sleep, and this raises the question of whether denture wearing interferes with breathing during sleep, i.e., whether it reduces or worsens the symptoms of OSAHS. Previous research has failed to come to a clear conclusion on this question due to conflicting evidence. No relevant studies have been reported in Chinese populations [3, 5–9].

Therefore, our aim was to further explore the influence of the presence or absence of complete dentures on OSAHS, based on full-night laboratory PSG recordings from edentulous Chinese people.

Methods

Study subjects

Thirty edentulous patients were randomly recruited into this study in the clinic of the Department of Prosthodontics, Peking University School and Hospital of Stomatology (PKUSS) from August 2013 to June 2015. This self-controlled study protocol was approved by the Biomedical Institutional Review Board of PKUSS (PKUSSIRB-2012044), and each patient gave written informed consent for participation. From previous work, we detected significant difference ($P < 0.05$) between status when people slept with and without dentures [10]. It was estimated that 16 edentulous subjects would provide 80% power with a type I error of 0.05, for a clinical meaningful difference of AHIs between groups. Therefore, this study was sufficiently powered to assess the primary result.

Inclusion criteria are the following: complete edentulism in both jaws, wearing complete dentures for at least 6 months, patients who received new complete dentures in the Department of Prosthodontics at PKUSS, no treatment history of OSAHS, willing and able to accept the protocol, and to give informed consent.

Exclusion criteria are the following: unaccustomed to wearing complete dentures, suffering from severe respiratory diseases or other uncontrolled general physical disorders, and not in a suitable mental state to participate in clinical trials.

Study design

Demographic information and nocturnal sleep habits (wearing dentures or not) were recorded.

Sleep quality and disturbances over 1 month were evaluated using the Pittsburgh Sleep Quality Index (PSQI) [11]. Participants were also asked to fill in the Epworth Sleepiness Scale (ESS) to assess excessive daytime sleepiness (EDS) [12].

All of the 30 eligible patients received a pair of new complete dentures made through standard procedures in the Department of Prosthodontics at PKUSS. After a 7-day adaption for the new dentures, overnight polysomnograms (PSG) (Embla, Sandman, SD32, USA) were recorded from each subject in a supine position in the sleep laboratory of Peking University People's Hospital in two consecutive nights. In one night, the patient wore dentures during sleep (with-denture sleep, WDS), and in the other, he or she did not (no-denture sleep, NDS), in randomized order. Confounding bias in the PSG results was eliminated by using a self-controlled design. A randomized sequence of wearing or not wearing dentures was used in order to reduce the impact of sleeping in an unaccustomed setting on the results. The investigators who performed the statistical analysis of the PSG parameters were strictly trained and blind to the denture wearing status when interpreting the results; this was intended to eliminate information bias. The AHI, apnea index (AI), hypopnea index (HI), and lowest oxygen saturation (L-SpO_2) were recorded and analyzed. Apnea is defined as the cessation of external breathing airflow for at least 10 s, while hypopnea is defined as at least 30% reduction in airflow for 10 s with a 4% oxygen desaturation. And the morning systolic and diastolic blood pressures were recorded at sitting position in 10 minutes after the patients got up (Fig. 1).

OSAHS patients can be classified into three categories of severity according to the following AHI: mild ($5/h \leq AHI < 15/h$), moderate ($15/h \leq AHI < 30/h$), and severe ($AHI \geq 30/h$). An AHI <5/h was considered to be non-OSAHS. We categorized the patients into four subgroups based on the AHI during NDS.

Statistical analysis

Statistical analysis was performed using SPSS statistics 20.0 software (IBM SPSS statistics 20.0, Armonk, NY, USA). Student's t test for paired samples and one-way analysis of variance (ANOVA) were used to compare the data between NDS and WDS. A P value <0.05 was considered to be statistically significant.

Results

Demographics

The average age of the 30 edentulous patients was 67.4 years; 16 were male and 14 were female. The average BMI was 23.9 ± 3.2 kg/m^2. Thirty percent patients showed hypertension. Five participants were used to wearing dentures during sleep; the rest preferred to sleep without them.

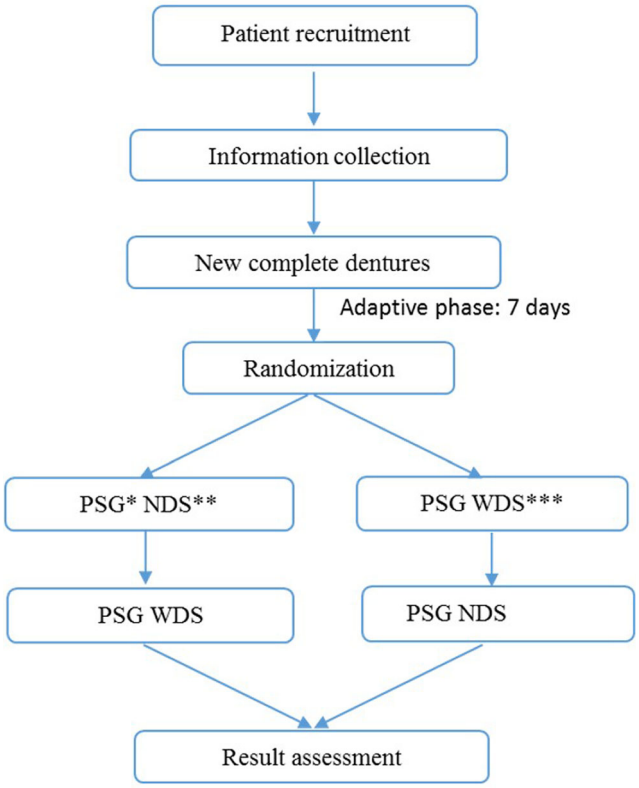

Fig. 1 Protocol outline and flowchart of the study. **PSG* polysomnography, ***PSG NDS* PSG during no-denture sleep, ****PSG WDS* PSG during with-denture sleep

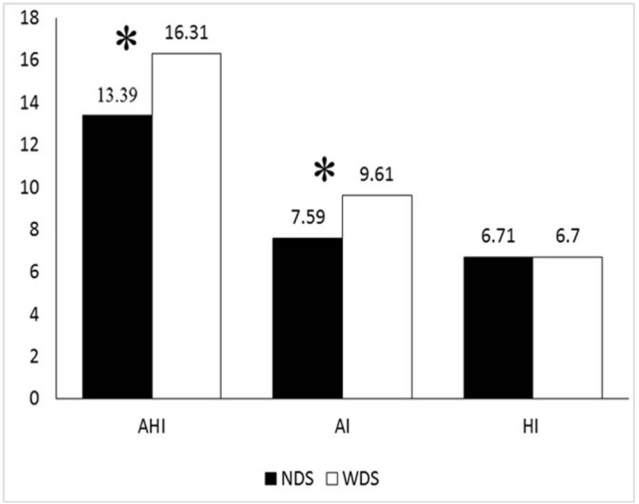

Fig. 2 The apnea and hypopnea episodes of patients sleeping with and without dentures (**P*< 0.05). *AHI* apnea hypopnea index, *AI* apnea index (/h), *HI* hypopnea index (/h)

Self-controlled PSG results

Among the 30 patients, the average AHI and AI during WDS were significantly higher than those during NDS (16.3 vs 13.4/h for AHI and 9.6 vs 7.6/h for AI; $P < 0.05$). HI did not differ between WDS and NDS (6.7 vs 6.7/h; $P > 0.05$). The average morning diastolic blood pressure after WDS was significantly higher than that after NDS (79.7 vs 75.8 mmHg); however, no difference of the morning systolic blood pressure was found between WDS and NDS (Figs. 2 and 3).

The mean longest hypopnea time during WDS was significantly longer than that during NDS (40.7 vs 32.2 s); however, no difference was found in the longest apnea time (35.4 vs 33.2 s) and lowest oxygen saturation (L-SpO_2, 85.7 vs 85.0%) between NDS and WDS.

The patients were classified into four subgroups according to the AHI during NDS. In the non-OSAHS, mild, and severe subgroups, increased AHI values were found in most of the patients sleeping with dentures. But in the moderate subgroup, only one patient has been recorded an increased AHI while sleeping with dentures, and the other three showed lower AHIs sleeping with dentures than without dentures (Fig. 4).

Twenty-four out of the 30 participants had a higher AHI when sleeping with dentures, and for most of them, the difference between AHIs during WDS and NDS was lower than 5.0/h. However, two participants showed over 22/h increase in AHI when sleeping with dentures.

Six participants had a lower AHI when sleeping with dentures, and the average difference between WDS and NDS was lower than 5/h.

Four of the 5 participants who claimed to be accustomed to wearing dentures during sleep showed a higher AHI during WDS.

Questionnaires

The PSQI and ESS were used to assess the sleep quality and EDS of the patients. The PSQI results showed that only 10% of the patients felt that they experienced a low quality of sleep,

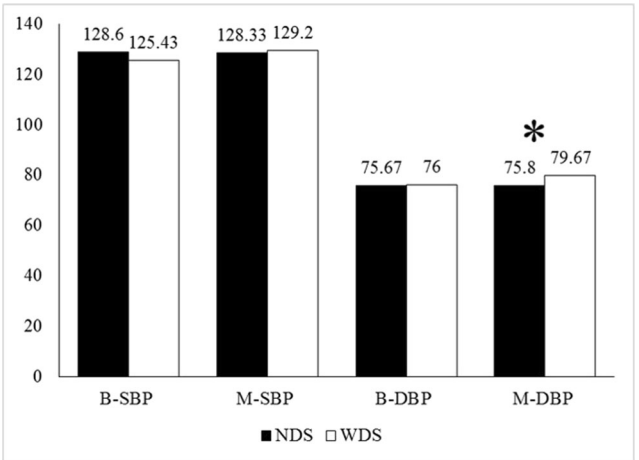

Fig. 3 The blood pressure of patients sleeping with and without dentures (**P* < 0.05). *B-SBP* bedtime systolic blood pressure (mmHg), *B-DBP* bedtime diastolic blood pressure (mmHg), *M-SBP* morning systolic blood pressure (mmHg), *M-DBP* morning diastolic blood pressure (mmHg)

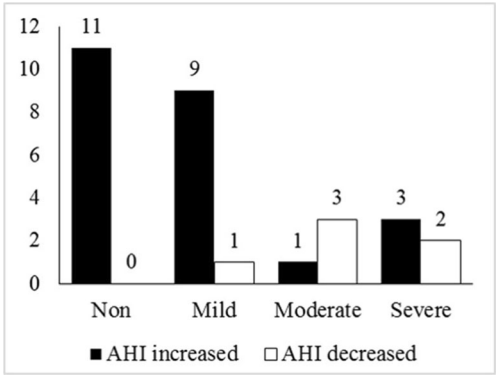

Fig. 4 Effects of wearing dentures on AHI based on OSASH severity. Non-OSAHS participants had a higher AHI when sleeping with dentures, and five of them matched the diagnosis of OSAHS (AHI ≥ 5/h)

while 16.7% indicated daytime dysfunction. In 23.3%, an ESS score of >10 was reported, revealing EDS.

Discussion

A few studies on the effects of wearing complete dentures on sleep breathing have been reported in some western countries [3, 5–9]. Our study is the first conducted in Chinese edentulous population. Our main finding was that sleeping with dentures would increase the AHI of edentulous patients, interfering with their sleep breathing.

Effects of sleeping with dentures on AHI

Variations of AHI, AI, and HI

We found that in the group of edentulous patients we investigated, the average AHI during WDS was 2.9/h higher than that during NDS, indicating a statistically significant difference. Only a few studies have addressed the relationship between edentulism and OSAHS, and the results are paradoxical (Table 1). In 1999, Bucca first reported a male patient who suffered clinical exacerbation of OSAHS after having all his teeth extracted, and then a self-controlled PSG study demonstrated a significantly higher AHI when he slept without dentures than with dentures as well as being higher than the value 1 year previously when he had his natural teeth [5]. Pivetti studied 20 edentulous participants and confirmed Bucca's result [8]. Then in 2006, Bucca carried out PSG studies again among 48 edentulous patients and found that 48% of the patients had an AHI >5/h when sleeping with dentures and the percentage rose to 71% without dentures [3]. Arisaka found that wearing dentures during sleep improved the AHI in two thirds of edentulous OSAHS patients, while one third suffered AHI increases due to the use of dentures [9]. In these previous studies, some had small samples [5, 8], some did not mention the monitor device for AHI [5, 8], some used portable monitoring devices rather than the gold-standard laboratory PSG [3, 9], and some have been using different devices in the same study [3]. It has been reported that ambulatory devices provide an accurate alternative to PSG in sleep clinics at risk for moderate and severe OSAHS populations, but they are not recommended for mild OSAHS patients and normal people [13]. Contrary to previous studies, since 2009, studies using overnight laboratory PSG have achieved different results. Almeida and Chaccur found that patients experienced more apnea events if they slept with their dentures in place [6, 7]. The use of dentures has been reported to substantially increase the AHI especially in the mild subgroup when they sleep in a supine position [6]. These findings were similar to that of our study.

No significant difference was found in HI between PSG results from the two nights. Almeida found no difference in AI or HI among the Brazilian edentulous people, despite a statistically significant difference of AHI [6]. In Chaccur's study (Brazil), the only two PSG parameters exhibiting significant differences were the AHI and HI [7]. It has been reported that Chinese patients have more severe underlying craniofacial skeletal discrepancies with a significantly smaller maxilla and mandible and more severe mandibular retrognathism when compared to Caucasian OSAHS patients [14]. As a result, for Chinese people, the denture base may occupy a considerable proportion of the space of the tongue and push

Table 1 Previous studies on the relationship between complete denture wearing and OSAHS

Author	Year	Patients	M/F	Age (years)	BMI (kg/m^2)	PSG	AHI-WDS (/h)	AHI-NDS (/h)
Bucca	1999	1	1/0	44	39	NA	22.4*↓	41.1*
Pivetti	1999	11 (OSA)	7/4	64	NA	NA	9.4 ± 3.3 *↓	16.2 ± 12*
		9 (NOSA)	3/6	64			0.86 ± 0.27	1.06 ± 0.4
Bucca	2006	48	29/19	69	27.5	Laboratory/ambulatory	11.0 ± 2.3*↓	17.4 ± 3.6*
Arisaka	2009	34	16/18	72.5	22.5	Ambulatory	13.3 ± 10.0*↓	17.7 ± 14.6*
Almeida	2012	23	9/14	69.6	26.7	Laboratory	25.9 ± 14.8*	19.9 ± 10.2*↓
Chaccur	2012	18	4/14	71.1	23.94	Laboratory	31.06 ± 21.22*	24.92 ± 12.22*↓

NA No information or data were provided in the article

*Significant differences between the AHIs during NDS and WDS

it backward, which may lead to apnea directly without showing the symptom of hypopnea.

Grouping and discussion for the variation of AHI

When the patients were divided into four subgroups according to their AHI data, significant difference between the AHIs during NDS and WDS was only found in the non-OSAHS group ($P = 0.002$), nine out of 10 patients in the mild subgroup had a higher AHI value (mean difference 3.4/h) when they slept with dentures. There is a rising tendency of WDS AHI in the mild subgroup, which was similar to a previous study [6]. The data from the middle and severe subgroups were not representative because of the limited sample sizes in these subgroups (Fig. 4).

Reasons underlying the influence of nocturnal denture use on AHI

Changes in the vertical dimension of occlusion (VDO)

Previous investigators have made the point that edentulous patients have prominent anatomical craniofacial changes including loss of the VDO, reduction of the lower face height and mandible rotation [2, 3]. These changes might influence the size and function of the upper airway. It has been reported that decrease in VDO results in the collapse of upper airway structures and reduction of the retropharyngeal space (RPS) and posterior airway space (PAS) in the supine position as assessed by cephalometry [15]. Some researchers demonstrated that the RPS and PAS increase after reconstructing the VDO with complete dentures or a mandibular advancement appliance [5, 15]. However, only the anteroposterior diameter of the upper airway can be recorded by cephalometry and significant but weak correlations have been found between AHI and lateral cephalometric measurements reflecting upper airway dimensions. Furthermore, the complete dentures are used to reconstruct a normal maxilla-mandibular relationship, including vertical and horizontal relationships, and they, rather than mandibular advancements, are not aimed at guiding mandibular protrusion to prevent upper airway collapse [16]. We speculate that improvement of supine upper airway stenosis by using only complete dentures to restore the VDO is not as effective as expected, especially in the mild and non-OSAHS subgroups. Other facts should also be taken into account; for example, the denture base might occupy the space of the tongue and impact airflow through the mouth, causing a higher AHI when sleeping with dentures. More studies and radiographic evidence are needed to test this hypothesis.

Position and morphology of the tongue

Long-term mandibular edentulism can lead to tongue retraction and hypertrophy. The incidence rate of tongue reduction at rest state in the intact dentition group is 12.3%; in the mandibular edentulous group, it rises up to 67.8% [17, 18]. Moreover, macroglossia has been reported as another factor related to PAS on cephalometry, as the tongue occupies the space of natural dentate and causes retroglossal space obstruction [19, 20]. The above phenomena were brought up as one of the causes of OSAHS; they can also be the reason of increased AHI when people sleep with dentures. Complete dentures occupy the tongue space, causing the hypertrophy tongue to move backward instead of rehabilitating a normal tongue posture, therefore causing narrowness of the upper airway and contributing to a higher AHI [18].

Other factors

The retention of complete denture comes from the interfacial force between denture and oral mucosa, the denture border seal provided by oral and facial musculature, and the atmospheric pressure. Unfortunately, none of the factors related to retention is 100% secure to prevent dentures from getting loose. We observed that the dentures could get loose and floated in the mouth during sleep, hence the interference in breathing.

Previous studies also suggest that some edentulous patients suffer from impairment of neural reflexes and neuromuscular activity, which may impair the activation of the pharyngeal dilators in response to upper airway stimuli and cause the upper airway collapse [21, 22]. Nonetheless, the complete denture prostheses could not eliminate those impairments.

Impact of denture wearing on lowest oxygen saturation and morning blood pressure

In spite of the significant difference between AHIs during NDS and WDS, no significant decrease was found in lowest oxygen saturation in this study. This result is similar to that in previous studies, and the relationship between AHI and oxygen saturation in edentulous individuals has not been profoundly understood yet [6, 7, 9]. In addition to age and obesity, OSAHS was an independent risk factor for the development of hypertension [23, 24]. Sharabi has demonstrated that individuals who experienced OSAHS at a relatively early stage had higher DBP (4 mmHg difference) without increase in SBP before other metabolic consequences [23]. In our study, morning diastolic blood pressure (M-DBP) significantly increased when people slept with dentures than without dentures, and this is in accordance with the change in AHI value. The change in M-DBP could be a collateral evidence of the influence of wearing dentures on sleep breathing.

Influence of denture wearing habits

Sleeping with dentures can result in denture stomatitis; therefore, prosthetic practitioners generally advise patients to remove their dentures before sleep [25, 26]. But some patients still prefer to sleep with dentures. In this study, the majority of those patients who claimed wearing dentures made them feel more comfortable also experienced AHI increasing while sleeping with dentures, indicating that might be just a subjective psychological feeling.

Conclusion

Wearing dentures can lead to significantly increased AHI and morning diastolic blood pressure, especially in the non-OSAHS and mild OSAHS Chinese edentulous population. Hence, we suggest that Chinese edentulous people should remove their dentures before sleep.

Compliance with ethical standards

Funding The Peking University School and Hospital of Stomatology (PKUSS) provided financial support in the form of Fund of Peking University School and Hospital of Stomatology (PKUSS20120209, PKUSS20140211). The sponsor had no role in the design or conduct of this research.

Conflict of interest The authors declare that they have no competing interests.

Ethical approval All procedures performed in studies involving human participants 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 comparable ethical standards. This study protocol was approved by the Biomedical Institutional Review Board of PKUSS (PKUSSIRB-2012044).

Informed consent Informed consent was obtained from all individual participants included in the study.

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