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ORIGINAL ARTICLE

Negative association between self-reported jaw symptoms and apnea–hypopnea index in patients with symptoms of obstructive sleep apnea syndrome: a pilot study

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Abstract
Objectives Prior to oral appliance therapy for snoring and obstructive sleep apnea syndrome (OSAS), patients are screened for jaw symptoms (e.g., pain). However, the presence of jaw symptoms in a large spectrum of OSAS patients remains unknown. This study aimed to assess the distribution of subjective jaw symptoms in patients with symptoms of OSAS.
Methods Five hundred and eleven consecutive patients (66 female, 445 male; mean age 49.6±12.6 years) with clinical symptoms of OSAS were enrolled for cardiorespiratory evaluation. Self-administered questionnaires were used to assess jaw symptoms, tooth grinding and clenching during sleep, morning oral dryness, morning heartburn sensation, and pain in the neck and back.
Results The mean apnea–hypopnea (AHI) index was 32.5± 30.6 per hour of sleep. Nineteen percent of patients (n=96) reported at least one jaw symptom. The presence of jaw symptoms was more frequently reported by patients with AHI less than 15 (25 %) than those with AHI of 15 and more (15 %, p=0.012). In the crude analyses, jaw symptoms were associated with tooth grinding, tooth clenching, morning oral dryness, morning heartburn sensation, and neck/back pain. Multiple logistic regression analysis confirmed that jaw symptoms were associated with AHI less than 15 (odds ratio (OR) 1.99, p=0.009), tooth clenching (OR 1.79, p=0.006), morning oral dryness (OR 2.17, p=0.02), and neck/back pain (OR 1.99, p=0.005).
Conclusions Jaw symptoms can be found in 19 % of patients with symptoms of OSAS and are more frequently reported in patients with lower AHI, a patient population for whom oral appliances are often prescribed.

Keywords Obstructive sleep apnea · AHI · Self-report · Cardiorespiratory evaluation · Jaw symptoms · Tooth grinding · Oral dryness

Introduction

Previous studies have suggested that obstructive sleep apnea (OSA) patients requiring oral appliances as part of their management should be assessed for jaw symptoms (e.g., pain and discomfort in the masticatory muscles) [1–4]. In patients with snoring and OSA, these symptoms can become a reason for discontinuing or hesitating to use oral appliances on a regular basis [5–10]. The effects of oral appliance use on jaw symptoms have been investigated in a number of studies, which have found that patients may complain of jaw symptoms (e.g., pain and discomfort) secondary to the use of oral appliance [3, 4]. However, few studies have investigated the data on jaw symptoms in patients with snoring and OSA in the absence of oral appliance use: while some studies have reported a relatively high frequency of jaw

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symptoms in populations with mild to moderate OSA (10–52 %) [11–15], other studies, including severe OSA patients in their sample, have reported less frequent jaw symptoms (5–13 %) [16]. These studies used patients who were referred for oral appliance therapy; some patients with jaw symptoms were excluded from the study sample. As a result, there is limited information on the presence of jaw symptoms in a large spectrum of OSA patients. Moreover, a few studies have reported that the frequency of complaints for several physical symptoms can differ in patients with different degrees of OSA [17–20]. It has yet to be investigated whether the presence of jaw symptoms in OSA patients is related to the frequency of respiratory events during sleep. In this study, we aimed to fill this gap in knowledge by investigating the frequency of self-reported jaw symptoms in consecutive patients with clinical symptoms of obstructive sleep apnea syndrome (OSAS) and assessing whether the presence of jaw symptoms is associated with a level of respiratory disturbance.

Methods

Patients

For this study, we recruited 521 consecutive patients, newly referred to Osaka Kaisei Hospital Sleep Medicine Center with suspected sleep apnea. The subjects were first interviewed by sleep physicians (MO, MO, and MT) and were suspected of having OSAS based on a history of excessive daytime sleepiness, sleep disturbances, snoring, and witnessed respiratory pauses in sleep [21]. The subjects were also free from co-morbid medical diseases (e.g., pulmonary, neuromuscular, and psychiatric diseases) and signs and symptoms of other sleep disorders (e.g., insomnia, narcolepsy, restless legs syndrome, periodic limb movement disorders, parasomnias, and circadian rhythm disorders). Under the Japanese national health care system, it is suggested that patients with suspected OSAS be evaluated for respiratory events using a portable monitoring system. Accordingly, the subjects were enrolled for a one-night cardiorespiratory evaluation in the sleep laboratory [22]. All subjects agreed to fill out questionnaires approved by the institutional ethics board for clinical research at Osaka Kaisei Hospital. Written informed consent was obtained from patients. After excluding 10 subjects who had missing values for the variables, 511 consecutive patients (66 female, 445 male, mean age 49.6±12.6; range 21–80 years) were used for the analyses.

Cardiorespiratory recordings

Cardiorespiratory recordings were performed according to the recommendations made by the American Academy of Sleep Medicine [22, 23]. In order to properly fit the sensors, calibrate the variables, and avoid data loss, individual recordings were made in the sleep laboratory at Osaka Kaisei Hospital. On the night of their appointment at the sleep laboratory, patients first filled out a questionnaire before the sensors were set between 20:00 and 22:00. Height, weight, neck circumference (NC), and blood pressure were also measured. The following variables were recorded by the portable cardiorespiratory recording system (EdenTrace II®, NELLCOR, Boulder, CO, USA): nasal airflow, abdominal respiratory movements, oxygen saturation, and heart rate. This system is often used in epidemiological studies, and high correlations between the data recorded by portable monitoring and in-laboratory polysomnography have been reported [24–26]. Patients were instructed to sleep at 23:00, or they if they so wished, they were allowed to go to sleep before 23:00. During the night, the recording was monitored with video by certified sleep technicians (RPSGT) in a separate room. In the morning, the recording was terminated when the sensors were detached (6:00–6:30 am). Patients reported the time of sleep onset and waking in the morning. Total sleep time (TST) was determined by the patient's morning report. The recorded data were downloaded to a PC computer for off-line analysis.

Scoring respiratory events

The recorded data were scored manually by sleep technicians [22, 23]. Apnea events were scored if nasal airflow did not appear for least 10 s. Hypopnea events were scored if nasal airflow decreased by at least 30 % and oxygen saturation dropped by at least 3 %. The apnea–hypopnea index (AHI) was calculated by the number of respiratory events per hour of sleep time. Patients were classified into two groups (AHI < 15 and AHI ≥ 15) for further analysis [22].

Physical characteristics

Body mass index (BMI) was calculated from the height and weight. NC and systolic and diastolic blood pressure (SBP and DBP) were also compared between groups.

Questionnaires

To assess jaw symptoms (morning jaw discomfort, morning jaw pain, daytime jaw pain, and jaw opening difficulty) for the last month, subjects were asked to respond to questions with one of four answers: (a) not at all, (b) sometimes, (c) often, or (d) very frequently. The answer "sometimes" was determined to be a positive sign of symptoms for further analysis. Other symptoms such as oral dryness, heartburn, and pain in the neck and back were assessed using a

question with the same options for response. The answer "often" was determined to be a positive sign of these symptoms for further analysis. Whether the patient was a denture wearer or not was asked by a Yes/No question. Subjective awareness of tooth grinding and clenching during sleep was assessed with the questions "How often do you grind your teeth during sleep?" and "How often do you clench your teeth during sleep?" with five optional answers: (a) never or rarely, (b) once a week, (c) two or three nights a week, (d) four to five nights a week, or (e) almost every night. The answer "once a week" was determined to be a positive sign of these symptoms for the subsequent analysis [27].

Statistics

Chi-square tests and two-sample *t* tests were used to analyze the statistical differences among characteristics of the study participants categorized according to AHI level. Correlations between variables were analyzed. Crude and multivariate logistic regression analyses were performed to assess the independent association between AHI levels, tooth grinding, tooth clenching, morning oral dryness, morning heartburn sensation, and head/neck pain with the presence of jaw symptoms. Crude and adjusted odds ratios and 95 % confidence intervals were generated to evaluate the associations. We used SYSTAT® 11 for Windows (SYSTAT Software Inc., USA) for statistical analyses. All reported *p* values are two-tailed and the level of statistical significance was set at $p<0.05$.

Results

The characteristics of this study sample are summarized in Table 1. Cardiorespiratory evaluation showed that the mean AHI was 32.5±30.6 times per hour of sleep in 511 patients. Among the patients, 163 had AHI less than 15 and 348 patients had AHI equal and more than 15. Variables were significantly different between the two groups with the exception of male sex, sleeping pill use, and diastolic blood pressure.

Table 2 shows the percentages of subjects with positive responses to the self-administered questionnaire for the two groups. In total, 18.8 % ($n=96$) of patients reported at least one jaw symptom. The percentage of patients who reported at least one jaw symptom was higher in the patients with AHI < 15 (25.1 %) than in those with AHI ≥ 15 (15.1 %) ($p=0.012$). Tooth grinding and clenching during sleep did not differ between the two groups. Morning oral dryness was more frequently reported in patients with AHI ≥ 15 (46.0 %) than in those with AHI < 15 (34.4 %) ($p=0.013$). Morning heartburn sensation and neck and back pain did not differ between the two groups.

Table 1 Demographic data and the outcomes of the cardiorespiratory evaluation

	AHI < 15	AHI ≥ 15	*p*
Demographic data			
N	163	348	
Males (%)[a]	83.4	88.8	0.092
Age	46.1±11.9	51.2±12.7	<0.001
BMI	25.1±7.5	27.0±4.3	0.004
Neck size (cm)	38.5±6.7	40.1±4.4	0.005
SBP (mmHg)	125.2±16.3	130.0±16.1	0.002
DBP (mmHg)	77.1±13.1	78.8±12.2	0.169
Sleeping pill (%)[a]	25.8	21.6	0.291
Denture users (%)[a]	8.0	19.5	0.001
Cardiorespiratory evaluations			
AHI (h)	7.4±4.1	44.3±30.6	<0.001
TST (min)	368.5±82.1	349.8±90.1	0.021
mSpO2 (%)	86.9±6.4	74.5±10.3	<0.001

BMI body mass index, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *AHI* apnea–hypopnea index, *TST* total sleep time, *mSpO2* minimal oxygen saturation

[a] Chi-square tests were used. Other variables were analyzed by two-sample *t* tests

Table 3 shows the distribution for sex and other variables, such as denture use, AHI, grinding and clenching during sleep, and oral dryness, that were included in the logistic regression analysis. It also presents both crude and adjusted odds ratios of these variables.

In the crude analysis, factors showing a significant association with the presence of at least one jaw symptom were AHI < 15 (crude odds ratio (OR) 1.79, $p=0.012$), tooth grinding during sleep (crude OR 2.76, $p=0.001$), tooth clenching during sleep (crude OR 3.87, $p<0.001$), morning oral dryness (crude OR 2.12, $p=0.001$), morning heartburn sensation (crude OR 3.05, $p=0.018$), and neck/back pain (crude OR 2.12, $p=0.001$).

When multiple variables were adjusted, AHI < 15 was independently associated with the presence of jaw symptoms (adjusted OR 1.99, $p=0.009$). The association between jaw symptoms and tooth clenching during sleep remained significant (adjusted OR 2.72, $p=0.006$) in contrast to tooth grinding during sleep (OR 1.79, $p=0.125$). Morning oral dryness (OR 2.17, $p=0.02$) and neck/back pain (OR 1.99, $p=0.005$) were independently associated with the presence of jaw symptoms.

Discussion

This study investigated the presence of self-reported jaw symptoms in 511 patients who presented clinical symptoms

Table 2 Frequency of self-administered questionnaire

Variables	AHI < 15 (n=163)	AHI ≥ 15 (n=348)	p	Total (n=511)
Jaw symptoms	25.1 % (41)	15.1 % (55)	0.012	18.8 %
Grinding awareness	11.7 % (19)	8.9 % (31)	0.330	9.8 %
Clenching awareness	10.4 % (17)	9.2 % (32)	0.659	9.6 %
Morning oral dryness	34.4 % (56)	46.0 % (160)	0.013	42.3 %
Morning heartburn sensation	4.9 % (8)	3.4 % (12)	0.428	3.9 %
Neck and back pain	41.1 % (67)	44.3 % (154)	0.503	43.3 %

AHI apnea–hypopnea index

of OSA. Cardiorespiratory recording revealed that these patients showed a large range in the number of OSA events during sleep. Out of these patients, 18.8 % reported at least one jaw symptom. The data are somewhat lower than the results from previous studies (13 to 52 %) in OSA patients as described below.

In patients with mild to moderate OSA (9 female/33 male, AHI 17.5±10.3), jaw fatigue was reported in 35 % [13]. In another study with 87 mild to moderate OSA patients (41 female/46 male; AHI = 17.3±8.7/h), 52 % of patients had some type of jaw symptoms [28]. In 40 patients with AHI higher than 10 (9 female/31 male), 25 % of patients had jaw symptoms [14]. In a recent study, temporomandibular disorders (TMD) were diagnosed in 29 % of 103 OSA patients (11 female/92 male) with AHI ≥ 5 [11]. In 21 snorers and 44 OSA patients, 34 % of patients had at

Table 3 Logistic regression analyses showing the crude and adjusted association between jaw symptoms and 11 variables

	Jaw symptoms, yes/no (%)	OR crude (95 % CI)	p values	OR adjusted (95 % CI)	p
Age	–	0.988 (0.97–1.01)	0.190	0.99 (0.98–1.02)	0.791
Sex					
Female	13/53 (19.7)	1		1	–
Male	83/362 (18.7)	0.94 (0.49–1.79)	0.839	0.90 (0.44–1.85)	0.778
BMI	–	0.98 (0.94–1.03)	0.416	0.99 (0.95–1.03)	0.573
Denture use					
No	80/350 (19.8)	1	–	1	–
Yes	16/65 (18.6)	1.08 (0.59–1.96)	0.808	1.33 (0.65–2.74)	0.442
Sleeping pill use					
No	75/273(21.6 %)	1	–	1	–
Yes	42/121(25.8 %)	1.15 (0.69–1.93)	0.586	0.99 (0.56–1.74)	0.962
AHI					
<15	41/122 (25.2)	1.79 (1.13–2.83)	0.012	1.99 (1.19–3.35)	0.009
≥15	55/293 (15.8)	1	–	1	–
Grinding					
No	78/383 (16.9)	1	–	1	–
Yes	18/32 (36.0)	2.76 (1.48–5.17)	0.001	1.79 (0.85–3.75)	0.125
Clenching					
No	75/387 (16.2)	1	–	1	–
Yes	21/28 (42.9)	3.87 (2.09–7.18)	<0.001	2.72 (1.33–5.56)	0.006
Morning oral dryness					
No	41/254 (13.9)	1	–	1	–
Yes	55/161 (25.5)	2.12 (1.35–3.32)	0.001	2.17 (1.33–3.55)	0.02
Morning heartburn					
No	88/403 (17.9)	1	–	1	–
Yes	8/12 (40.0)	3.05 (1.21–7.69)	0.018	2.37 (0.87–6.42)	0.091
Neck/back pain					
No	40/250 (13.8)	1	–	1	–
Yes	56/165 (25.3)	2.12 (1.35–3.33)	0.001	1.99 (1.24–3.20)	0.005

BMI body mass index, *AHI* apnea–hypopnea index, *OR* odds ratio, *CI* confidential intervals

least one jaw symptom [12], while the same group reported a somewhat lower frequency in another study [15]. On the other hand, in 100 consecutive patients (20 female/80 male) with a mean AHI of 42±20/h, jaw symptoms were less frequently reported (5 to 13 %) [16]. Large variations among the previous studies and the difference between the present and previous studies are due to the nature of study samples such as sex distribution [28], exclusion criteria (e.g., bruxism, pain or limitation of jaw movements) [11, 13], and severity of OSA (e.g., AHI) [11, 12, 14, 16]. It should be noted that most studies were done in mild to moderate OSA patients referred for oral appliance therapy [11–14, 28]. These studies reported a higher frequency of jaw symptoms than the studies including severe OSA patients [16]. The present study, made of patients with a large spectrum of AHI levels, supports this observation by demonstrating that jaw symptoms were negatively associated with AHI in patients with OSA symptoms.

The reason for the independent negative association between AHI and jaw symptoms remains unclear. However, this result is consistent with previous findings that physical symptoms are more frequently reported by mild than moderate to severe OSA patients [17]. In addition, a recent study reported that TMD patients with mild OSA were less sensitive to nociceptive stimuli than those without [29]. Nonetheless, a more recent study showed that pain sensitivity in non-pain patients with severe OSA was reduced by continuous positive airway pressure therapy [30, 31]. On the other hand, it is known that sleep loss or disturbance amplifies pain perception [32] and that patients with sleep disturbance often complain of physical symptoms (e.g., pain, muscle stiffness, etc) [33, 34]. Thus, the results of the previous and present studies suggest that the frequent occurrence of apnea and hypopnea events during sleep might dampen the awareness of jaw symptoms in patients predisposed to the conditions related to the symptoms.

In addition to AHI, tooth clenching during sleep was significantly associated with jaw symptoms. The results of this study are consistent with those from many studies in which subjective awareness of increased jaw motor activity during sleep and/or wakefulness (e.g., clenching and/or grinding) is associated with subjective jaw symptoms [35–39]. Previous studies have shown that patients with OSA symptoms report jaw motor activities more frequently than those without [27, 40–42]. Polysomnographic studies have suggested that tooth clenching frequently occurs at the termination of respiratory events and that frequent occurrence of grinding is not always associated with jaw symptoms [42–44]. In this study, tooth clenching and grinding during sleep were significantly correlated (r=0.41, p< 0.001). As the previous studies have suggested, a combination of jaw motor phenotypes during sleep can influence the presence of jaw symptoms [36, 42–45]. Morning oral dryness is reported frequently in OSA patients because of the frequent occurrence of mouth breathing (Table 2) [15, 18, 20]. The positive association between morning oral dryness and jaw symptoms cannot be simply explained since oral dryness is related to hypnotic use, age, and other conditions related to sleep disturbance, pain, and stress [46]. Nonetheless, a recent study has reported that jaw symptoms and xerostomia/hyposalivation can be concomitant [47]. Patients presenting with associated morning oral dryness and jaw symptoms may form a subgroup of patients with OSA symptoms and oral dryness. Neck and back pain is often reported as a co-morbid condition in patients with chronic jaw symptoms such as TMD as well as those with sleep disturbance [48–52]. Taken together, the results suggest that several complaints related to jaw, face, and body can be found concomitantly when patients with OSA symptoms report jaw symptoms.

Certain methodological limitations should be taken into account when understanding the results of this study. First, self-administered questionnaires were used to estimate jaw symptoms in a large number of OSAS patients who visited sleep clinics. Thus, specific or objective diagnoses of the symptoms could not be made to determine active TMD. In addition, OSA was evaluated by cardiorespiratory recordings. Thus, the influence of sleep on jaw symptoms was not assessed, and concomitant sleep disorders could not be completely ruled out. Moreover, some sleep parameters (e.g., respiratory effort related arousals) important for assessing respiratory disturbance could not be measured. To avoid any technical errors that might occur in home recordings of the cardiorespiratory system, the recordings were made in a sleep laboratory and sleep technicians made a manual analysis of the raw data [22, 23]. Then, a cut-off value of AHI = 15 was used for dividing the groups because cardiorespiratory evaluation is more appropriate for diagnosing moderate to severe OSA than mild OSA [22, 23]. Due to the reduced diagnostic power of cardiorespiratory evaluation for detecting mild OSA, there is a possibility that our study population included patients with snoring and upper airway resistance syndrome. This possibility might have contributed to the negative association between AHI and jaw symptoms in patients with symptoms of OSAS, since patients with upper airway resistance syndrome reported physical symptoms more frequently than OSA patients [17]. Clearly, the results of the present study should be confirmed by polysomnographic recordings with systematic diagnoses of TMD and sleep breathing disorders.

In summary, self-reported jaw symptoms were reported by 18.8 % of patients with clinical symptoms of OSAS. Jaw symptoms can be found more frequently in patients with lower than higher AHI: the patient population for which an oral appliance is often prescribed. Previous studies have shown that patients complain of jaw symptoms during a

short time period after commencing use of an oral appliance [5–10]. A transient increase of jaw symptoms, in balance with other complaints (e.g., discomforts and dissatisfaction), influences the patients' compliance with oral appliance therapy [9, 10, 14]. It was suggested that the presence of jaw symptoms at the baseline could be a risk for developing a transient increase in jaw symptoms among OSA patients without active TMD [11]. However, long-term use of an oral appliance did not usually aggravate jaw symptoms in OSA patients with TMD symptoms [11, 12, 14]. It would be useful to investigate whether extra efforts or strategies (e.g., aggressive follow-ups, patient education, and home exercise) could assist OSA patients with jaw symptoms to successfully complete the initial period of oral appliance therapy[53].

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