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ORIGINAL ARTICLE

Role of dental sleep medicine in management of patients with obstructive sleep apnea disorders using a team approach

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ABSTRACT

Objective: Obstructive sleep apnea (OSA) is a significant social and health issue. An integrated multidisciplinary approach to OSA management may be the most effective owing to its multifactorial etiology. In this study, we evaluated the frequency and efficacy of various treatment modalities for OSA administered via an integrated care delivery model, and assessed the role of dental sleep medicine as part of a multidisciplinary team.

Materials and Methods: We retrospectively evaluated 1115 patients with OSA treated at the Tokyo Medical University Hospital's Outpatient Clinic for OSA by a multidisciplinary team under one roof. The various treatment methods included the following: continuous positive airway pressure (CPAP), oral appliance (OA), surgery, and behavioral treatment.

Results: The patient number of study group was as follows: 771 (69.1%) CPAP; 240 (21.5%) OA; 76 (6.8%) behavioral treatment and 28 (3%) surgery. Because significantly fewer patients underwent surgery, there was a discrepancy between the recommended first-choice treatment and the actual treatment. A statistically significant number of younger patients in each treatment group underwent surgery. Success rate of OA and MMA were 74.4 and 80%, respectively.

Conclusions: Proper selection of primary treatment to manage patients with OSA was possible under one-roof system that included dental sleep medicine.

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Dental sleep medicine; maxillomandibular advancement; Obstructive sleep apnea; oral appliance; team approach

Introduction

Obstructive sleep apnea (OSA) is a significant health issue with social ramifications characterized by reduced work efficiency and increased risk of accidents caused by the disturbed nighttime sleep [1]. Additionally, it is well-known that OSA has an influence on cardiovascular diseases [2]. OSA has a multifactorial etiology, and therefore requires a multidisciplinary approach for both diagnosis and treatment [3].

Traditionally, dentists have treated OSA at the request of physicians and do not routinely contribute to diagnosis and treatment. Facial morphology is one of the determinants of OSA, which is evaluated using a cephalogram [4] and is mainly performed by dental professionals. Physicians involved in OSA management are liable to miss the contribution of facial morphology in the pathogenesis of OSA. Moreover, temporomandibular disorders and missing teeth tend to constrain the use of an oral appliance (OA) for OSA [5]. Physicians may exclude the use of an OA in these patients upon initial diagnosis. Therefore, many patients may be denied the recommended first-line treatment, which indirectly increases the involved medical costs [3].

Integrating sleep medicine and dental sleep medicine under one roof was recently shown to improve patient care, reduce treatment costs and improve physician education [3]. In November 2004, the Tokyo Medical University Hospital established an outpatient clinic for the treatment of OSA under one roof in collaboration with departments of cardiovascular medicine, dentistry, oral and maxillofacial surgery and otorhinolaryngology. This multidisciplinary approach to the management of OSA, from initial diagnosis to final treatment, serves as a model for the efficient treatment of OSA. One major advantage of this system is that decisions regarding treatment are less susceptible to bias.

In this study, we retrospectively evaluated the frequency and efficacy of various treatment modalities for OSA administered under this integrated care delivery model and assessed the role of dental sleep medicine as part of a multidisciplinary team.

Patients

A total of 1592 patients who underwent nocturnal polysomnography (PSG) at the Outpatient Clinic for Sleep Apnea Disorders at Tokyo Medical University Hospital between November 2004 and May 2011 were eligible for inclusion. Of these, 37 patients who were diagnosed as normal (apnea–hypopnea index [AHI] < 5) and 440 who did not

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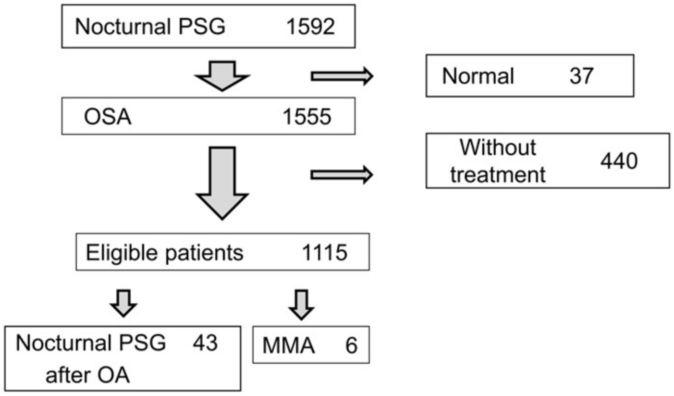

Figure 1. Treatment overview.

receive any treatment were excluded, and the remaining 1115 patients were enrolled in the study (Figure 1). The Medical and Ethics Committee of Tokyo Medical University approved this study (# 665).

Initial examination and diagnostic protocol (Figure 2).

Blood, urine and arterial blood gas analyses were conducted along with respiratory function tests, chest radiographs, echocardiography and pulse wave velocity. An otorhinolaryngologist reviewed the medical interviews, maxillofacial and otorhinolaryngological findings, and results of the endoscopic examination of the upper airway and compared the patient's standard upright and spine cephalogram images. A dentist and oral and maxillofacial surgeon reviewed the medical interviews and dental and maxillofacial findings including those related to the temporomandibular joint (TMJ). Standard upright and spine cephalograms were analyzed using CephaloMetrics A to Z software (Yasunaga Computer Systems Co., Inc., Fukui, Japan).

Next, nocturnal polysomnography (PSG) (Alice IV, Respironics Inc., Marietta, GA) was performed by simultaneous recordings of electroencephalograms (EEG, C3-A2, C4-A1, O1-A2, O2-A1), electrooculograms, submental electromyograms of both the anterior tibialis muscles, nasal and oral airflow, chest and abdominal movements and oxygen saturation (SaO2). Airflow was measured with a pressure sensor. The sleep stages were visually scored based on the Rechtschaffen and Kales criteria [6], and arousals were scored according to the criteria of the American Sleep Disorders Association [7]. Total apnea and hypopnea events were calculated. OSA syndrome was defined as AHI $\geq$5 events/h, according to the American Academy of Sleep Medicine criteria [8].

After detailed review by the multidisciplinary team, a treatment strategy was determined for every patient during a weekly case conference attended by representatives of all departments. In the conference, we discussed the potential treatment options, and a first-choice treatment method was determined for each case. The primary (attending) doctor informed the patient of the first-choice treatment; if the patient did not agree to the first choice, second-line options were given, after which the actual treatment method was finally determined. Sometimes, we could offer only a single choice due to the restriction of social health insurance.

Treatment selection

In Japan, almost basic medical and dental treatment was covered under the government-provided national health insurance. OSA treatments were performed according to the rules of the national health insurance that mandates the use of CPAP only in patients with AHI >20. OA did not limit the number of AHI; however, a request letter for the sleep medicine with PSG data was indispensable. So far in the surgical procedure, there is no limitation of the national health insurance.

Continuous positive airway pressure (CPAP) treatment was performed by the department of cardiovascular medicine. A custom-made monobloc mandibular advanced oral appliance (OA) was used for each patient during dentistry and oral and maxillofacial surgery outpatient treatment, and 50–70% of the maximum mandibular protruded position was titrated to the OA. We referred to Sleep, Vol. 29, No. 2, 2006, "Oral Appliances for Snoring and Obstructive Sleep Apnea: A Review" at the time of positioning, and forward movement amount of $\geq$50% and $\leq$70% according to side effects and snoring was set for each individual patient. If there was a problem in judging effectiveness, we corrected or recreated it several times [9].

We initially performed uvulopalatopharyngoplasty (UPPP), genioglossal advancement (GA), or both as phase 1 surgery by an otolaryngologist, and maxillomandibular advancement (MMA) as phase 2 surgery by an oral and maxillofacial surgeon, according to the Stanford criteria [10]. Conventional [10] and modified [11] MMA were performed. Behavioral treatments included counseling on dietary measures and postural measures during sleep. Sleep disorder diagnoses other than obstructive sleep apnea syndrome (OSA) were made according to the International Classification of Sleeping Disorders, Second Edition (ICSD-2, 2005) [12], and patients were treated by the mental health department (Figure 3).

Methods

Discrepancy between therapeutic strategy and actual treatment

Treatment methods were classified as OA, CPAP, surgery (tonsillectomy, phase 1 surgery; UPPP/GA, phase 2 surgery and MMA) and behavioral treatments. Discrepancies between the first-choice therapeutic strategy determined at the conference and the actual treatment administered were analyzed. To determine this discrepancy, patients who underwent secondary treatment were identified from the patient files.

Characteristics of each treatment method

Age, sex, body mass index (BMI) and severity of daytime sleepiness were measured using the Japanese version of the Epworth Sleepiness Scale (JESS) [13], and AHI and the lowest value of SaO2 (LAST) were compared among the groups. Treatment efficacy criteria were achievement of a 50% reduction in AHI and <5 events/h in patients with AHI [14].

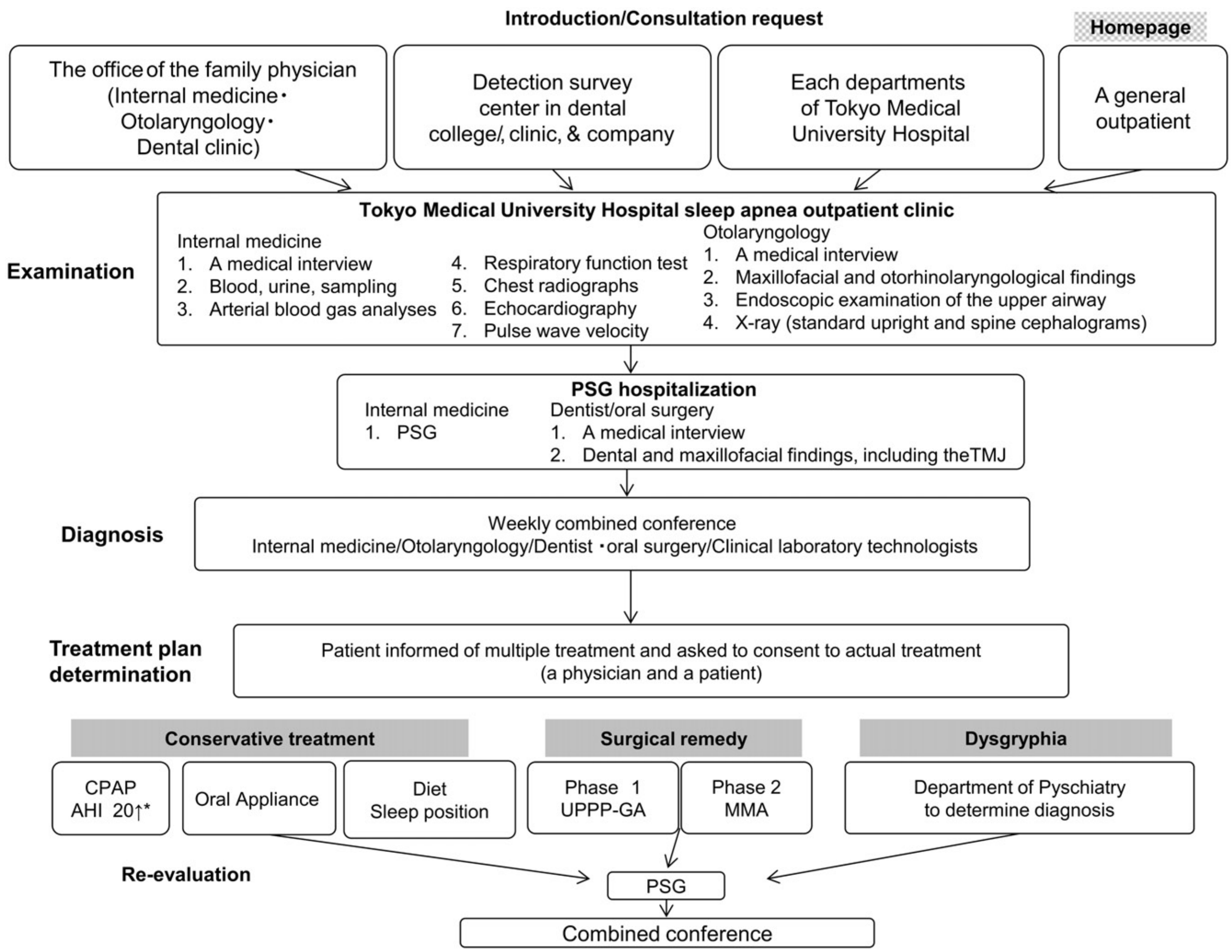

Figure 2. Procedures from initial examination to diagnosis and treatment.

Role of dental sleep medicine

We evaluated the effectiveness of OA treatment in 43 patients who underwent nocturnal PSG after OA (Figure 1). Severity was classified as mild, moderate, or severe [15].

We classified the application of OA into three categories: only single-choice, first-choice or second-line option.

Characteristics of MMA

We evaluated age, sex, BMI, JESS, pre- and post-surgical AHI, and time to surgery (time between PSG preoperatively and performing the surgery) in patients who underwent MMA. The chief complaints were classified as sleep disorder and jaw deformity.

Statistical analysis

Data pertaining to continuous variables are presented as mean ± standard deviation (SD). The discrepancy between the therapeutic strategy and actual treatment was assessed using $M \times N$ Chi-squared test. Between-group differences with respect to age, BMI, ESS, AHI and LAST were compared using the Kruskal–Wallis H test followed by the post hoc Bonferroni-corrected Mann–Whitney U test. The relationship between the effect of OA on the severity of OSA or therapeutic strategy was evaluated using $M \times N$ Chi-square analysis. The timing of the MMA was compared between sleep disorders and jaw deformity using the Chi-squared test. All data analyses were performed using Statistical Package for the Social Sciences (SPSS) software version 16.0 (SPSS, Chicago, IL). A $p < .05$ was considered to be statistically significant.

Results

Discrepancy between therapeutic strategy and actual treatment

Of 1115 patients, the numbers selected for each first-choice treatment modality were 743 (CPAP), 202 (OA), 87 (behavioral treatment), and 83 (surgery). The numbers of each actual treatment modality were CPAP, $n = 771$ (69.1%); OA, $n = 240$ (21.5%); behavioral treatment, $n = 76$ (6.8%) and surgery, $n = 28$ (3%).

The numbers of the patients who selected CPAP, OA and behavioral treatment as their first choice were approximately similar to the numbers of each actual treatment. However, a significantly lower number o actually underwent surgery, although in >10% of patients, surgery was recommended as the first-choice treatment at the time of the treatment planning conference (Figure 4).

More specifically, treatment was changed to OA for 15 of 771 (1.9%) patients initially selected for CPAP and to CPAP

Treatment	Department
Continuous positive airway pressure (CPAP)	Cardiovascular internal medicine
Oral appliance (OA)	Dentistry, oral and maxillofacial surgery
Surgical treatment: Tonsillar extraction	Otolaryngology
Surgical treatment ,Phase 1 operation : Uvulopalatopharyngoplasty (UPPP)	Otolaryngology
Surgical treatment, Genioglossal advancement (GA)	Otolaryngology
Surgical treatment, Phase 2 operation: Maxillo-mandibular Advancement (MMA)	Dentistry, oral and maxillofacial surgery
Diet, Sleep position instruction	Cardiovascular internal medicine
Psychological treatment	Psychiatry

Figure 3. Treatment selections at this hospital.

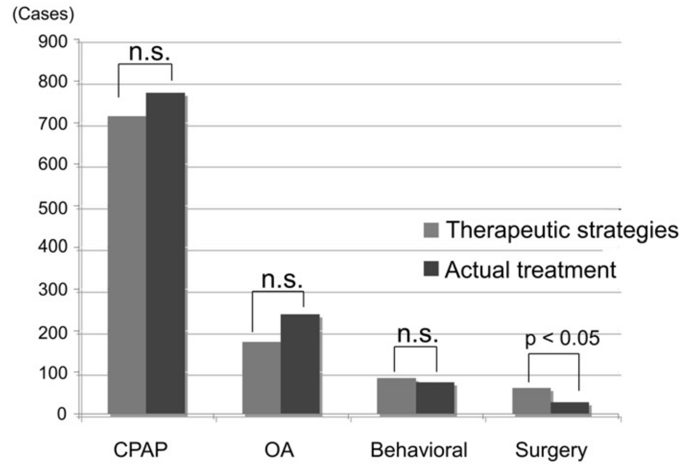

Figure 4. Discrepancy between therapeutic strategies and actual treatments.

for 6 of 240 (2.5%) patients initially selected for OA. The type of therapy did not change for patients who initially selected to undergo behavioral treatment; however, therapy was changed for 14.3% of those who were initially selected to undergo surgery.

Patient characteristics by treatment group

The study population ($n = 1115$) included 961 men and 154 women (mean age, 54.4 ± 13.7 years; average BMI, 26.8 ± 4.8; JESS, 9.1 ± 4.9; AHI, 40.6 ± 23.8/h; and LAST, 78.8 ± 9.5% (Table 1). The average AHI at CPAP titration was 4.29 ± 4.81/h ($n = 707$), and the mean AHI after OA treatment and surgery was 7.00 ± 5.86/h ($n = 43$) and 18.95 ± 17.17/h ($n = 18$), respectively.

Kruskal–Wallis *H*-test analysis revealed significant between-group differences with respect to age ($F = 42.37$, df 3, $p < .01$), BMI ($F = 156.6$, df 3, $p < .01$), AHI ($F = 552.5$, df 3, $p < .01$), and LAST ($F = 246.5$, df 3, $p < .01$); however, JESS values did not differ between the two groups (F = 12.05, df 3, ns).

The mean BMI in the CPAP group was significantly higher than in the other treatment groups, and mean age of patients who underwent surgery was significantly lower than in the other three groups. Additionally, patients treated with OA were significantly younger than those treated with CPAP.

In contrast, there was a significant between-group difference in AHI values. AHI was highest in the CPAP group followed by the surgery, OA and behavioral treatment groups.

The LAST values were similar between groups compared with those of AHI but did not differ significantly between the OA and surgery groups (Figure 5).

Therapeutic efficacy of OA

The 43 patients in the OA group included 42 men and one woman; average age, 52.2 ± 13.3 years; average BMI, 24.6 ± 2.6; JESS, 9.2 ± 4.3; AHI, 19.5 ± 7.0/h; and LAST, 85.2 ± 5.3%. With respect to the post-treatment values, 51.2% of patients reached AHI <5, 79.0% reached AHI <10, and 48.8% reached AHI ≤50% overall. OA was effective in 74.4% (32/43) of patients. OA was effective for 75% (3/4), 76.7% (23/30), and 66.7% (6/9) of patients with severe, moderate and mild OSA, respectively. In contrast, post-treatment values of AHI <5 were achieved in 25% (1/4), 40% (12/30) and 100% (9/9) of patients with severe, moderate, and mild OSA, respectively. Of patients 68.4% (13/19), 78.6% (11/14) and 80% (8/10) were effectively treated with only OA, only single-choice, first choice, or second-line option, respectively. Post-treatment values of AHI <5 were achieved for 52.6% (10/19), 50% (7/14) and 40% (4/10) for only OA, first choice, and no first-choice treatments, respectively. There was no significant difference between these three groups in either severity or application (Figure 6).

MMA outcomes

Six patients underwent MMA (four men, two women; mean age: 39.2 ± 13.4 years). Their chief complaints were jaw deformity ($n = 3$) and sleep disorder ($n = 3$). Two patients with sleep disorders underwent phase 2 followed by phase 1 surgery. Three patients each underwent conventional MMA or modified MMA (average BMI, 21.4 ± 3.7; JESS, 13.8 ± 4.2 and AHI, 25.6 ± 16.8/h). Five patients underwent post-surgical PSG, and the average AHI value was 11.4 ± 9.62 (min 2.1, max 27.2)/h. Four patients (80%) were effectively treated, and two patients (40%) achieved AHI <5. The time from diagnosis (at the time of PSG) to surgery was 8.5 ± 8.1 months and was significantly longer for patients with sleep disorders (average, 14.3 months) compared to those with jaw deformities.

Discussion

The goal of the present study was to determine the characteristics of OSA treatments and the role of dental sleep medicine as part of an integrated, multidisciplinary approach for management of OSA. Integrating sleep medicine and dental sleep medicine under one roof was recently advocated to improve patient care [3].

In our system, we solved the problem of separating sleep medicine and dental sleep medicine by selecting treatments at a weekly conference that included a dental sleep clinician. Recently, a study of the organization of a multidisciplinary dental sleep clinic was reported [16]. Although many studies have reported the application and effectiveness of the various OSA treatment methods [17], there is no report, to our knowledge, that evaluates the outcomes achieved with integrated care delivered under one roof. Here we assessed the

Table 1. Baseline characteristics of patients disaggregated by type of treatment.

Actual treatment	Age	Gender M	Gender F	BMI	PSG AHI	Lowest SpO2	Case No.
CPAP	55.75 ± 13.21	680	91	27.88 ± 4.87	50.22 ± 21.34	76.07 ± 9.48	771
OA	52.11 ± 13.27	199	41	24.51 ± 3.13	19.16 ± 7.02	84.41 ± 6.04	240
Surgery	38.25 ± 12.15	26	2	23.56 ± 3.19	33.53 ± 20.62	82.12 ± 7.95	28
Behavioral therapy	54.12 ± 16.76	56	20	23.85 ± 4.09	12.49 ± 14.15	87.46 ± 5.30	76

AHI: apnea-hypopnea index; BMI: body mass index; CPAP: continuous positive airway pressure; PSG: polysomnography; OA: oral appliance.

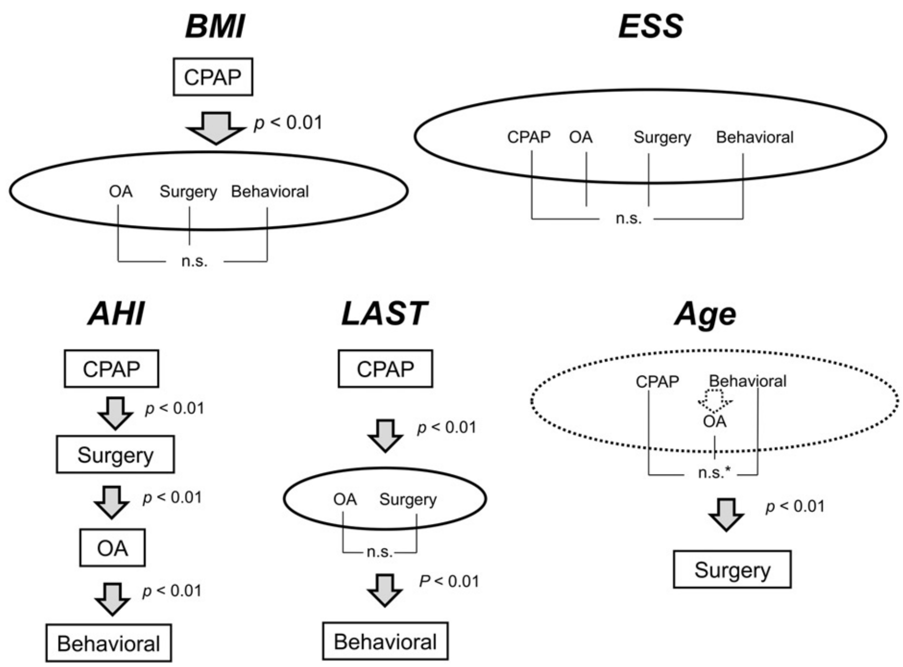

Figure 5. Relation between severity and age on each treatment method.

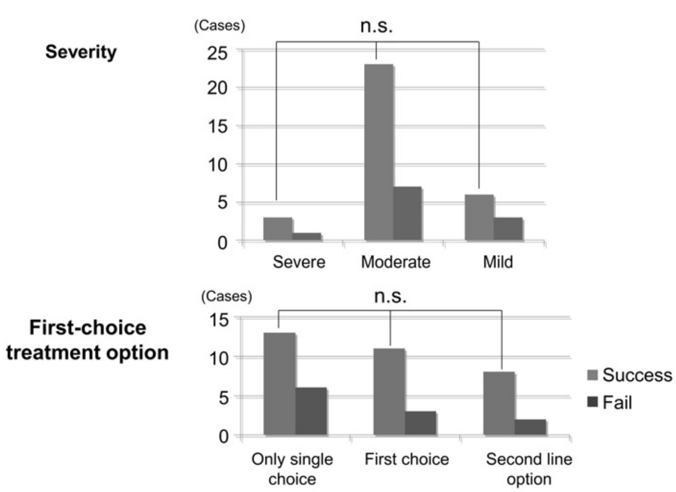

Figure 6. Applications of Oral appliance.

actual frequency, clinical status and preference of treatment methods as determined under our one-roof approach. For example, > 30% of the patients with OSA were eligible for treatments other than CPAP and approximately 20% were treated with an OA.

Krucien *et al.* [18] reported frequencies of 60.2 and 36.2% for CPAP and OA, respectively. In our study, the cardiovascular physicians actively performed PSG in patients with heart failure as the frequency of OSA in these patients is high, hence the low frequency of OA in our patient population. Moreover, CPAP is known to be effective in these patients [19]. Therefore, the average AHI of patients in this study was higher than reported in previous studies [20].

Surgery is among the first-line treatment methods for OSA [21]. In the present study, the discrepancy between the first-choice therapeutic strategy and the actual treatment was small. Although surgery was determined to be the first-choice treatment in >10% of patients, significantly fewer patients actually underwent surgery, i.e. the selected surgical approach depended on the patient preferences.

The integrated service delivery model made it possible to present patients with available treatment options. It was easy to support patients who dropped out of the first-choice treatment when their cases were presented in the next weekly conference. Martin reported a 46% dropout rate among patients treated with CPAP [20]. In this study, there were relatively fewer dropouts from first-choice treatment, indicating that the team approach achieved high patient satisfaction.

BMI was the most significant factor for CPAP selection; obese patients were selected for CPAP because high BMI is considered an unfavorable characteristic for OA and surgery [22]. Therefore, we avoided OA for patients with BMI >33 kg/m^2, and surgery was selected for patients with BMI <30 kg/m^2. Severity of OSA, BMI, and cardiovascular diseases are closely related [19] and

CPAP is recommended in these patients. Moreover, obesity is a significant risk factor in the perioperative period [23]. OA mainly improves upper airway narrowing based on the expansion of the craniofacial skeleton [24] and does not affect the soft tissue volume. In addition, older age is an important factor in deciding on a surgical procedure as it is a significant risk factor in the perioperative period [25]. Therefore, CPAP is the safest and most effective treatment for severely obese patients with OSA.

In the present study, CPAP was most frequently administered to patients with the most severe symptoms of OSA, followed by surgery, OA, and behavioral therapy. Several studies have compared the outcomes of CPAP versus OA [26] and CPAP versus surgery [21]; however, to the best of our knowledge, evaluation of multiple treatment options has not yet been reported. Moreover, behavioral therapy is often used as a supplement to other treatments with low efficacy [27]. In this study, patients who were solely selected for behavioral treatment were not suitable for other treatment or had refused other treatment options.

Craniofacial evaluation using cephalometry is important in the workup of patients with OSA [4], and evaluation of teeth and TMJ is an essential element of the pre-treatment evaluation in order to determine suitability for OA use [5]. These evaluations were conducted for most patients during the weekly conferences. An OA is usually effective for treating patients with mild to moderate AHI [28].

For various reasons, we occasionally selected OA treatment for patients with severe OSA, based on the weekly conference. Our results, 51.2% of AHI <5, 79.0% of AHI <10, and 48.8% of AHI $\leq 50\%$, are superior to those of other case control studies [29], because we avoided OA for patients with BMI $>33\,\text{kg/m}^2$. The present study shows that there was no significant difference in the effectiveness of treatment according to the severity of OSA. In addition, the effectiveness of OA did not diminish when OA was used as the first-choice treatment. If OA was the second-line option, it was effective and patients were satisfied. Although the number of subjects studied was relatively small, our results are similar to those of larger studies [17], and therefore imply that OA is a good option in a carefully selected subset of patients with severe AHI. Recently, some new information such as effectiveness of the imaging and/or (drug-induced sleep) endoscopy has been reported [30], and the effectiveness of mandibular anterior positioning [31] has been clarified. We tried to evaluate the sleep position during PSG, the sine-mode MRI for the pre-surgical diagnosis, and endoscopy to decide the advancement position of the mandible, and good feel were obtained, but this evaluation was not performed for all patients. We would like to perform case control studies in order to evaluate these results in future.

Though the success rate of MMA is high [29,32] and it does not have the problems associated with patient non-compliance [29] it carries same risks associated with invasive surgery [11]. An advantage of the present study is that it demonstrates the effectiveness of surgery and CPAP for treating patients with severe OSA, indicating that surgery is as an important treatment option for OSA.

However, we experienced several difficulties performing MMA. Primarily, few patients actually agreed to undergo surgery and it took a long time to accomplish all of the treatment procedures. The time from diagnosis to surgery for patients who underwent MMA concomitantly with orthognathic surgery was significantly shorter because they had already decided to undergo surgery. In contrast, it took significantly longer to treat patients who initially complained of sleep disorders.

The Stanford protocol was the only method followed for sleep surgery when we started our team corroboration in 2004. Recently, another treatment protocol [33] and results of the meta-analysis [32] has been reported. These new ideas may change the discrepancy of the sleep surgery between the first choice therapeutic strategy and the actual treatments. Moreover, two different teams (sleep and orthognathic) managed the patients during the long treatment period.

Thus, we conclude that oral and maxillofacial surgeons who are familiar with dental sleep medicine can play an important initial role in successfully accomplishing MMA.

This study has several limitations. First, there was a regulatory bias because OSA treatments were performed according to the rules of the government-provided national health insurance in Japan that mandates the use of CPAP only in patients with AHI >20. Second, evaluation of the efficacy of OA was limited by the small sample size. However, another study shows that OA was evaluated for only 18% of patients [34]. Third, the selection of OA was greatly affected by craniofacial condition, including the TMJ and missing teeth [5], although these factors were not evaluated.

Conclusions

In summary, $>30\%$ of patients with OSA were treated with modalities other than CPAP and $>20\%$ of patients were treated with an OA. These results suggest that proper treatment selection for the management of patients with OSA is possible under a one-roof system, and dental sleep medicine can play a significant role in facilitating OA treatment and MMA.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional committee and the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent

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

Disclosure statement

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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