Medical Management of Obstructive Sleep Apnea

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2.1 Positive Airway Pressure Therapy

2.1.1 Introduction

First-line therapy for most adult patients with obstructive sleep apnea (OSA) is positive airway pressure (PAP) applied via facial or nasal mask during hours of sleep. The application of PAP leads to a positive pharyngeal transmural pressure so that the intraluminal pressure overcomes the tendency of the airway to collapse and may stabilize the airway by increasing end-expiratory lung volumes leading a form of caudal traction [1]. By maintaining a patent airway, PAP is capable of reducing apneas and hypopneas [2] and increasing the average hemoglobin oxygenation while the patient is asleep [3]. It has been demonstrated to improve sleep quality and reduce symptoms of obstructive sleep apnea including daytime sleepiness, daytime neurocognitive performance, and snoring [3]. PAP has also been demonstrated to

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improve outcomes of comorbidities related to the development and progression of OSA, including hypertension [4], metabolic derangements [5], and motor vehicle collisions [6]. This has been verified in various studies that examined the application of continuous positive airway pressure versus sham therapy.

Positive airway pressure has been recommended by the American Academy of Sleep Medicine (AASM) for all patients diagnosed with OSA [7], as defined by the respiratory disturbance index (RDI) and presence of any of the symptoms associated with obstructive sleep apnea syndrome (OSAS), such as sleepiness, non-restorative sleep, arousal due to snoring, gasping, or choking, etc. In the United States, reimbursement from the Centers for Medicare and Medicaid Services (CMS) to cover PAP is based on the severity of the RDI and the presence of any symptoms or sequelae.

There are different types of PAP that can be used in the treatment of OSA. The most commonly prescribed is a fixed continuous positive airway pressure, (CPAP), which provides a set pressure throughout the entirety of the respiratory cycle. However, CPAP is not the only positive airway pressure modality that has been used to treat OSA. Bilevel positive airway pressure, or BPAP, is another modality that can be prescribed. BPAP utilizes one pressure setting for the expiratory phase of the respiratory cycle—EPAP—and a second pressure setting for the inspiratory phase—IPAP. BPAP is often utilized in patients who fail CPAP therapy; these patients continue to have symptoms or an unacceptably high apnea-hypopnea index (AHI), the number of apneas and hypopneas found per hour of testing. It is also often prescribed for those who have coexisting OSA and diseases that cause chronic hypercapnic respiratory failure, such as chronic obstructive pulmonary disease (COPD), obesity hypoventilation syndrome (OHS), chronic opioid use, or neuromuscular disorders that affect ventilation. Additionally, patients that have a combination of OSA along with central sleep apnea (CSA) may respond to BPAP. Finally, auto-titrating positive airway pressure, or APAP, is a form of PAP in which the device can detect obstructive events throughout the night and modify the PAP setting periodically to reduce the frequency of those events. It has been proposed for use in the following situations: patients who complain of intolerance of the dose of PAP pressure that is necessary to prevent events in all sleep positions and stages; patients who are subjected to factors that can vary their pressure requirement, like nasal congestion from allergies or frequent upper respiratory infections; or if access to CPAP titration study is limited or delayed. More advanced modalities such as BPAP with ST or adaptive servo-ventilation (ASV) are often used in the setting of more complex disease states such as the combination of OSA and heart failure.

The initiation of CPAP therapy is often directed by CPAP titration studies. These tests are performed following sleep studies that confirm the diagnosis of OSA. During the studies, continuous positive airway pressure is started at a low level for patient comfort—often 5 cm H_2O or less—and then slowly titrated up while electroencephalographic, pulse oximetry data, and patient positioning are recorded throughout the test. Optimal pressure dosage that provides for rapid eye movement (REM) sleep while in the supine position, as well as adequate

oxyhemoglobin saturation, is then recommended by a certified sleep physician and ordered by the same sleep physician or the patient's other providers. Recommendations are often made at the same time regarding appropriate masks to use and whether to include heat and/or humidity to the circuit or a ramp of the pressure level.

Contraindications to long-term use of positive airway pressure include upper airway obstruction not related to a patient's functional upper airway obstruction, inability to cooperate with the therapy or protect their airway, inability to clear secretions, patients with facial trauma or deformity, or patients who are high risk for aspiration.

2.1.2 Compliance

Compliance, commonly defined as usage of >4 h/night with PAP therapy, is often the greatest initial hurdle to patients receiving the maximum benefit of therapy. It is estimated that 29–83% of patients are non-adherent to PAP. Studies suggest that >6 h/night of PAP usage results in normal levels of objectively measured and self-reported daytime sleepiness. Patients that have positions of employment in which daytime attention and neurocognitive performance is critical—truck drivers, air traffic controllers, etc.—may need more than the minimum 4 h of use nightly that is customarily considered to be compliant [8].

Several studies have shown that the initial experience with CPAP appears to be important predictor of compliance. As such, it is recommended that early evaluation of compliance be performed following the initiation of all PAP therapy. Ideally, patients should be re-evaluated within the first few weeks of therapy [9]. Compliance checks can be performed by requiring that the patient bring in to the office the data storage that is recorded from the CPAP machine, or for those machines equipped with modem or wireless technology, compliance can be checked remotely. Other predictors of compliance are self-reported daytime sleepiness (as measured by the Epworth Sleepiness Scale (ESS) of >10), greater severity of oxyhemoglobin desaturations during sleep, CPAP titration via an attended polysomnography, effect of CPAP on bed partner, and a motivated patient.

Several factors have been shown to predict nonadherence with PAP therapy: those related to the patient, those related to therapy and medication, and those related to the health professional prescribing the PAP. Patient-related factors include failure to understand the importance of or instructions concerning the therapy; physical limitations such as vision, hearing, or hand coordination; feeling too ill or tired to use the therapy; social isolation and lack of social support; and concomitant self-administration of additional medications or alcohol. Therapy- and medication-related factors include complexity or therapy or dosing, lack of efficacy, expense of the therapy, adverse reactions to therapy, and characteristics of the illness. Provider-related factors include poor provider-patient relationship, unwillingness to educate the patient, doubt concerning therapeutic potential, and lack of knowledge of medications that the patient is taking or has access to.

Several interventions can be applied to increase adherence. Compliance is jeopardized by the side effects associated with positive airway pressure therapy. It is recommended that the patient be offered a variety of masks prior to undergoing CPAP titration studies so that the optimum pressure dose using a comfortable mask may be ascertained and so that adherence to therapy can be encouraged. Nasal congestion may be alleviated with the use of adding heated humidity to the circuit during CPAP use. Air leaks and ingestion of air during use may be mitigated with the use of a chin strap. Aerophagia may also be addressed with the use of alternative positive airway pressure modalities, such as APAP. Cognitive behavioral therapy (CBT) has been used shortly following initiation of therapy to improve the likelihood of adherence. Overall, education about the potential side effects that may develop, and early and frequent follow-up after the initiation of CPAP therapy, is important to ensure that patients are receiving the maximum benefit of this treatment. It should be noted that the choice of PAP modality does not alter compliance. In addition, there is a paucity of data on the routine use of sedative-hypnotics at the time of CPAP initiation, and they should not be routinely used to potentially increase CPAP compliance.

2.1.3 Benefits

There have been a host of attempts made to improve compliance with CPAP therapy. Quick response to the development of side effects of CPAP can promote adherence to use. Though proper mask fitting is important, a 2018 study demonstrated that offering patients the chance to change their masks after the first compliance check does not improve compliance [10].

With all that is involved in diagnosing and treating obstructive sleep apnea, including multiple overnight stays in the sleep lab; durable medical equipment that must be ordered, fitted to the patient, and then carefully titrated in order to optimize the patient's response; and high failure rates, a question should be raised: What benefit does the patient receive for having jumped these hurdles and participated in the utilization of a therapy that is costly and cumbersome?

Treatment of OSA has been shown to improve blood pressure modestly, as already mentioned and can augment the use of antihypertensives in patients with both OSA and essential hypertension. CPAP can modify the risk of recurrent atrial fibrillation [11] and nocturnal ischemic cardiovascular events [12]. For patients with comorbid heart failure and OSA, the use of CPAP was associated with improvement in left ventricular ejection fraction [13]. The VAMONOS study showed that outstanding compliance to CPAP reduced fasting blood glucose in patients with OSA, and this may prove beneficial at reducing the rates of the development of diabetes mellitus in patients with OSA [14]. CPAP use has been shown to improve symptoms of depression as evidenced by lower PHQ-9 scores in those patients who were compliant with CPAP therapy [15]. These benefits are all in addition to the improvement in daytime sleepiness, snoring, and sleep quality already mentioned. In conclusion, while PAP therapy can be challenging, it still remains first-line treatment.

2.2 Positional and Medication Therapy

2.2.1 Introduction

Positional therapy is another treatment option in the management of OSA. The most important risk factor for OSA is obesity. Neck circumference increases with obesity as deposited adipose tissue increases the thickness of the lateral pharyngeal walls, leading to narrowing the airway. Sleeping in the supine position further exacerbates this process due to gravity drawing soft tissue into the pharyngeal space, further constricting the upper airway. Confounding risk factors include short mandibular size, tonsillar and adenoid hypertrophy, and a small midface. Cumulatively, this leads to increased upper airway resistance and decreased ventilation due to diminished neural output to the upper airway dilator muscles, chest wall, and accessory muscles. The current theory is that OSA is a progressive disease that may not be reversible if left untreated. A way to counter this pathophysiology is a method for the patient to sleep in the lateral recumbent position, called positional therapy.

There are various devices used in positional therapy; the classic example is a wedge-shaped device that restricts the patient from transitioning into a supine sleeping position. There are various other devices patients wear on the back which also function as a deterrent to sleeping in the supine position. Examples include wearing a T-shirt with a tennis ball attached to the back, a backpack with tennis balls or baseballs, or any other mechanism that will cause discomfort when lying supine. The rationale behind positional therapy is that the awkwardness will wake the patient, forcing them to sleep in the lateral recumbent position. In one study comparing sleep positional therapy and tennis ball method in positional OSA, success was achieved in improving respiratory indices [16]. The goal of AHI <5 was achieved in 68% of sleep positional therapy patients and 42.9% of those using the tennis ball technique. However, sleep positional therapy was shown to significantly outperform tennis ball technique in the categories of compliance, quality of life, and sleep quality compared to the tennis ball technique. Tennis ball technique can be a cheap option if patients elect to make their own positional therapy device, such as wearing a backpack with a baseball inside. However, this may be cumbersome, and compliance with these devices is typically low.

There are newer, more compact sleep positional therapy devices which show promise. Three have so far been approved by the US Food and Drug Agency (FDA). These include the Zzoma Device (a light semirigid wedge-shaped device that is attached to the upper torso), the Night Shift Sleep Positioner (a battery powered neck-positioning device), and the SONA Pillow (a double incline triangular pillow). Other devices are available on the market but are not FDA approved. These include the chest vibratory device that sends impulses until the patient changes to a non-supine position [17, 18], as well as the Rematee Bumper Belt [19].

Numerous studies have investigated the efficacy of positional therapy. When compared to nonstandard therapy, positional therapy led to significant reductions in AHI, time spent in the supine position, as well as reductions in ODI [20, 21]. When compared to CPAP therapy, CPAP therapy was more effective at reducing AHI

compared to positional therapy [22, 23]. A recent study published in *Journal of Sleep Medicine* in 2017 [24] evaluated the newer positional therapy devices as described above. The study demonstrated improvement in AHI by 54%, and had a high compliance rate with a median rate of 92.7–96%, at 1 month follow-up. However, the vast majority of studies are small case series and cohort studies. Large good-quality randomized controlled trials with long-term follow-up are lacking. This poses a limitation in providing a good evidence base for the routine use of PT in clinical practice. In addition, outcome measurements have focused primarily on AHI. There are a few studies looking at secondary outcomes such as sleepiness and quality of life measurements, and measuring compliance remains a challenge.

Given the lack of robust clinical trials, this treatment modality is most appropriate for positional OSA patients with a non-supine apnea-hypopnea index (AHI) < 5 or OSA patients who have a non-supine AHI less than the overall AHI. It can also be used as salvage therapy in patients who cannot tolerate CPAP. However, positional therapy is not effective for patients who have non-positional sleep apnea, as their sleeping derangements are not affected by body position.

Additional studies are needed looking at long-term compliance and to further evaluate positional therapy as both a primary and adjunct treatment modality for positional obstructive sleep apnea.

2.2.2 Medications for the Treatment of OSA

Currently, there are no proven effective medication options available for the treatment of OSA.

Various medications have been studied; however none were shown to be of statistically significant value [25]. Examples of previously studied medications include but are not limited to progesterone, fluticasone, mirtazapine, physostigmine, donepezil, and paroxetine among many others. A study published in 2013 [25] performed a meta-analysis of 30 trials that studied 25 medications including the ones mentioned previously. It was concluded that none of the medications studied showed sufficient evidence to recommend their use. Interestingly, a new study published in 2018 [26] which investigated hypertension and OSA compared acetazolamide combined with CPAP to acetazolamide and CPAP individually. The acetazolamide alone and acetazolamide combined with CPAP arms were both shown to decrease mean arterial blood pressure by 7 mmHg. Additionally, the AHI was significantly reduced in all three arms, the most significant being the combined acetazolamide and CPAP arm. However, this study was very small (only 13 subjects enrolled) and was only investigated for 2-week periods. Additional larger-scale studies will be needed to confirm the efficacy of acetazolamide in OSA management.

Cannabinoids have been investigated more recently as a potential treatment option. However, a recent article suggests that cannabinoids may improve in sleep disordered breathing. Thus far, these investigations have been met with mixed results. There currently is a promising phase II trial investigating the effects of the medication Dronabinol, a synthetic version of delta-9 tetrahydrocannabinol (THC) [27].

This medication is currently FDA approved but only for the treatment of nausea and vomiting in patients receiving chemotherapy. According to a recent article published in Sleep Journal in 2018, results so far demonstrated that patients with moderate-severe OSA had a significant reduction in AHI, as well as subjective improvement in their sleepiness with Dronabinol, when compared to placebo. One hypothesis is that OSA patients may benefit from cannabinoids due to their effects on serotonin-related apneic episodes.

The role of Dronabinol in treatment of OSA has yet to be determined; however, the data so far suggests it may be an option for patients in the future who fail CPAP or require an adjunct to their current regimen. While sleep latency appears to be improved with Dronabinol, one study suggests that there may be some concern that Dronabinol could have a long-term negative effect on sleep quality [28]. Additional long-term studies, including a phase 3 trial, will need to be performed before this medication is a viable option in the OSA population. In conclusion, there are currently no recommendations for the use of medications in the treatment of OSA.

2.3 Weight Loss

2.3.1 Introduction

Obesity is the strongest risk factor for the development of OSA and also plays a role in disease progression. Although a modifiable independent risk factor is treatable, many patients solely rely on continuous positive airway pressure (CPAP) without addressing weight management. The prevalence of obesity in adults in the United States is estimated at 39.8%, which has increased by over 3% in the past 2 years [29, 30].

Obesity, particularly visceral obesity, exhibits mechanical, neurochemical, and anatomical alterations that predispose individuals to upper airway obstruction while sleeping. Obesity contributes to reductions in lung volumes and increasing pharyngeal collapsibility. Adipose deposition around the neck increases the neck circumference and contributes to airway narrowing. In addition, the presence of adipokines (central nervous system signaling proteins) has a detrimental effect on neuromuscular control, which ultimately influences upper airway collapsibility and sleep apnea severity [31]. Interestingly, weight loss reduces upper airway collapsibility during sleep; however whether this is primarily due to alterations in mechanical and anatomical properties, or due to improved neuromuscular control, is controversial, as weight loss does improve hyperlipidemia, leptin levels, and insulin resistance [32, 33].

Whatever the mechanism by which weight loss improves OSA, weight loss is a highly effective strategy for management of sleep apnea. A ten to fifteen percent decrease in total body weight has been proven to decrease the sleep apnea severity index by up to 50% in obese male patients [34, 35]. Although the process of weight loss can be challenging, especially in those where mobility is limited by obesity, the results of weight loss are well established as a disease modifying agent and can be

a curative intervention as well. Weight loss discussion should include an interdisciplinary approach including primary care physicians, pulmonologists, and dieticians, among others with a common goal of weight loss while improving patient satisfaction. Although weight loss is effective, it is not always curative as many do not achieve ideal BMI. However, it can only help to augment OSA therapy and minimize severity.

Weight loss options for OSA are classified into medical and surgical approaches each with their own caveats.

2.3.2 Medical Weight Loss

Medical weight loss include lifestyle changes, exercise, diet, medications (orlistat, fluoxetine, phentermine), and cognitive behavioral therapy. The risks and complications of medical therapy are far less than surgical interventions; however the pace and degree of weight loss are usually significantly lower. Although weight loss is mentioned in the clinical guidelines, there is a paucity of well-executed studies discerning the impact lifestyle interventions have on OSA. Meta-analysis of randomized control trials involving the effects of lifestyle intervention (low-calorie diet, liquid meals replacements, diet and exercise information, and behavioral therapy) showed that a weight reduction of 14 kilograms resulted in a decrease in AHI by 16 events per hour. In clinical trials only, a minority of patients have been cured with medical weight loss. Medical weight loss is often sluggish and time-consuming and requires close follow-up with multiple specialists (physicians, dietitians, and personal trainers) which can ultimately lead to lack of adherence.

2.3.3 Surgical Weight Loss

Surgical intervention is a complex decision involving the patient's comorbidities, psychiatric assessment, and previous attempts at healthy weight loss. After an ample trial of a multidisciplinary approach to weight loss, bariatric surgery is considered for patients who have a BMI > 35 kg/m^2 with the presence of obesity-related comorbidities (type II diabetes, hypertension, sleep apnea, and others) or BMI > 40 kg/m^2 without any complications. Bariatric surgery promotes weight loss by caloric restriction, malabsorption, or both. The data comparing efficacy of the distinct types (Roux-en-Y gastric bypass, laparoscopic sleeve gastrectomy, and biliopancreatic diversion of bariatric procedures) in the management of OSA are sparse. However, the impact of bariatric surgery in OSA population has resulted in higher cure and improvement rates than medical weight loss groups, likely due to the dramatic sustained weight loss seen after surgical intervention. Over 80% of patients who undergo bariatric surgery will see improvement or resolution of OSA symptoms. In a small minority of patients, bariatric weight loss may result in cessation of upper airway collapsibility; however, many patients may equate their improvement in their symptoms as a cure. Inappropriate termination of CPAP use may lead to

increased cardiovascular risks and weight gain. Although beneficial, surgical intervention is not without risk. Complications include steatorrhea, iron deficiency, and fat-soluble vitamin deficiencies [36–38].

2.3.4 Weight Loss in Combination with CPAP

Regardless of the manner chosen to achieve weight loss, patients using CPAP in combination with weight loss require close follow-up to ensure continued adherence with all aspects of therapy. For many patients, liberation from CPAP is a major motivation for weight loss; however CPAP adherence decreases as a result. Reductions in compliance are likely due to an assortment of factors including unfavorable CPAP titration, improvement in symptoms, and changes in facial fat area resulting in improper mask fitting. Indeed, there is a linear relationship between visceral fat loss and midfacial fat volume loss; whereby alterations in the facial structure following significant weight loss can lead to air leakage, rendering the CPAP system unusable [38–40]. After significant weight loss, physicians should subsequently ensure proper consideration is made regarding proper mask fitting, pressure requirements, and continued CPAP adherence if necessary. Significant weight changes have been proven to reduce the mean optimal CPAP pressure by approximately 3 cm H_2O.

Weight loss with CPAP use should be encouraged. A randomized control trial sought to examine the relationship between C-reactive protein (CRP) levels in OSA patients being treated with CPAP alone vs CPAP combined with weight loss treatment. CRP levels were used as a marker of cardiovascular disease. In the groups treated with combined CPAP and weight loss, the CRP levels declined significantly more than those treated with CPAP alone. Combination therapy also showed reduction in hyperlipidemia, hypertension, blood pressure, and insulin sensitivity [32, 33, 41]. As seen in the Sleep Apnea Cardiovascular Endpoints (SAVE) study, CPAP therapy alone did not prevent cardiovascular events in patients with known cardiovascular disease and moderate-to-severe OSA [42]. However, the patients enrolled in the SAVE study only used CPAP for 3.3 h/night, well below what is considered to be compliant. The combination of these studies highlights the importance of accompanying a weight loss treatment strategy along with CPAP therapy in obese patients with OSA.

2.3.5 Weight Loss and Exercise

Weight loss and exercise should be recommended to all patients with OSA who are overweight or obese. While rarely leading to complete remission of OSA, weight loss, including that from bariatric surgery, and exercise have been shown to improve overall health and metabolic parameters. They can also decrease the apnea-hypopnea index (AHI), reduce blood pressure, improve quality of life, and likely decrease excessive daytime somnolence.

2.4 Oral Appliance Therapy

2.4.1 Introduction

Oral appliances (OAs) have been used in the treatment of obstructive sleep apnea (OSA) since the 1980s. It was then that Cartwright and Samelson first published about a nonsurgical treatment for OSA, with a tongue-retaining device. Since that time, there have been many different appliance designs, with over 100 currently on the market, and many more to likely emerge in the future. OAs currently are the second most common treatment of OSA. They are recommended for patients with mild-to-moderate OSA and, for severe cases, only when patients are unable to tolerate CPAP [43]. Multiple studies have shown patients generally prefer OAs over CPAP and have better reported compliance [44]. A multidisciplinary team approach to treatment is vital for maximizing treatment outcomes. Teams should involve a sleep physician, dentist, sleep surgeon to evaluate for source of obstruction, and a general medicine physician. Additionally, all patients, regardless of OSA severity, should first be counseled on lifestyle changes, including weight loss and cessation of alcohol use.

2.4.2 Patient Selection

Patients should not be seen for fabrication of an OA without a referral from a trained sleep medicine physician, who performed a full evaluation of the patient. If nasal obstruction is suspected as the etiology of the OSA, the patient should be referred to sleep surgeon for evaluation. Nasal obstruction can cause increased mouth breathing, which decreases hypopharyngeal space and increases upper airway resistance, leading to more apneas and hypopneas [45]. All patients will need a comprehensive oral examination, including evaluation of the dentition, temporomandibular joints (TMJ), and supporting tissues prior to fabrication of an OA. Patients should not have active decay or periodontitis, as an OA can exacerbate both. A stable dentition is needed, with ideally at minimum ten teeth per arch; however some authors have recommended as few as six [46], distributed evenly among the arches. Included in the comprehensive oral exam is obtaining radiographic images, specifically, a lateral cephalogram and panoramic radiograph. These images are important for the evaluation of the patients' dentition and skeletal relationship and also serve as a baseline prior to initiating OA therapy. Patients with bruxism should be identified at this stage, as they will be at higher risk of breaking an OA not made of durable materials. TMJ evaluation should reveal unrestricted lateral, vertical, and protrusive excursive movements and a healthy, pain-free TMJ complex. OAs can exacerbate pain if there is restriction, causing patients to be less compliant with treatment. Lastly, patients need to have a current diagnosis of mild or moderate OSA with polysomnography (PSG) and a desire for nonsurgical treatment. CPAP is almost always offered as the first-line treatment, so referred patients are likely known to be refractory to CPAP.

2.4.3 Mechanism of Oral Appliances

Common features shared by OSA patients are mandibular retrognathism, retropositioning of the tongue, inferior positioned hyoid bone, tonsillar hypertrophy, or nasal obstruction [46]. OAs are able to overcome retrognathism and retropositioning of the tongue by functioning to protrude the mandible or tongue with the purpose of increasing the upper airway volume and reducing pharyngeal collapsibility [47]. There are multiple etiologies for OSA, so OAs will therefore have a variable treatment outcome for different patients. OAs can effectively improve pharyngeal collapsibility; however they have no effect on patients with overly sensitive ventilatory control systems or reduced arousal thresholds [48]. Titratable devices are the most common and effective and are recommended by the author. They are constructed as an upper and lower part, with intermaxillary adjustment mechanism between them allowing for forward movement of the mandible into optimal position [49]. OAs that allow for mouth opening are less effective in reducing OSA [50]. The use of non-custom-made devices is also not recommended, due to inferior fit and retention, which could affect overall patient comfort and compliance.

2.4.4 Types of Oral Appliances

There are two classifications of OAs for OSA: (1) mandibular repositioning devices (MRDs) and (2) tongue-retainer devices (TRDs). MRDs have the ability to position the mandible and tongue forward anywhere from 50 to 100% of maximum protrusive movement as tolerated, therefore brining attached soft tissue anteriorly and opening the pharyngeal airway (Fig. 2.1). MRDs have better reported compliance than TRDs and are more widely used [51]. TRDs protract the tongue into a bulb compartment on the device, through use of negative pressure. They do not need support from the teeth, which makes them ideal for patients with an insufficient number teeth or poor distribution, as well as periodontitis.

2.4.5 Fabrication and Delivery

The authors prefer and recommend the use of custom oral appliances. This requires obtaining impressions of the maxillary and mandibular arches, as well as a bite registration in centric occlusion. The impressions, and/or dental casts, and bite registration are then sent to a dental lab to fabricate the prosthesis. Once patients are fitted with their OA, they should titrate to effect. Patients will need to be seen for adjustments after delivery, usually only for 3 months. During this period the patient will work with just the dentist or other practitioner to titrate the OA to ideal therapeutic position. At 6 months, patients should return to their sleep medicine physician for repeat PSG to evaluate response to treatment. Once treatment goals with the OA are met, the patient should be seen by their practitioner every 6 months for the first 2 years, then annually. At these visits, patients should be evaluated for

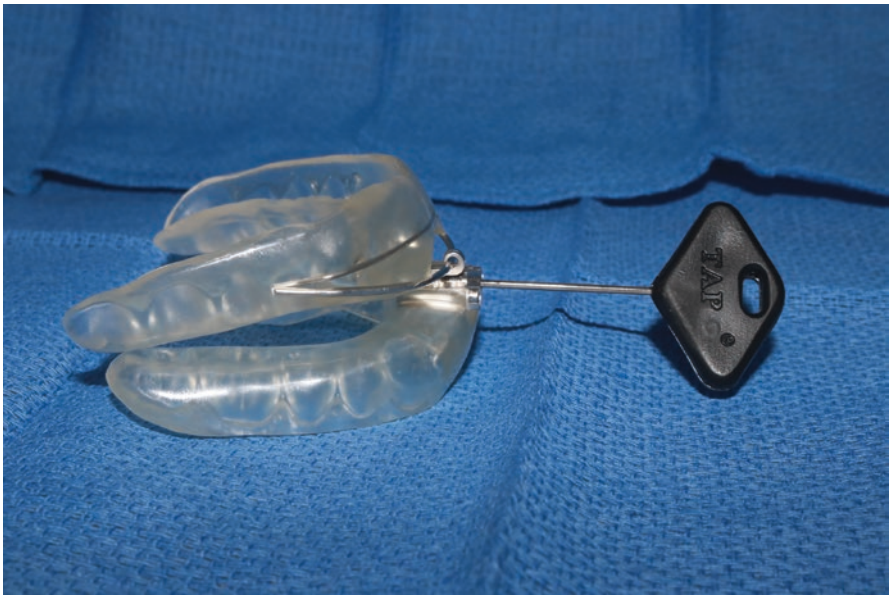

Fig. 2.1 DreamTap picture

subjective symptoms of snoring and sleepiness via the Epworth Sleepiness Scale (ESS), assessed for changes in the integrity of the OA, and monitored for side effects. Annual radiographic (i.e., panorex/lateral cephalogram or CBCT) images should be obtained as well, to evaluate for any changes in dentition and occlusion. If there is any evidence that the OA is no longer effective, the patient should be referred back to the sleep physician. OAs can last 5 or more years but may need periodic adjustments.

2.4.6 Outcomes

Studies have shown OAs are able to reduce AHI and ESS scores and on average reduce the RDI by 56% [49, 52]. They can also be as effective as CPAP in patients with positional OSA [53]. Treatment success across all levels of OSA severity with OAs is approximately 50%, with average reduction in baseline AHI of 55%. They also have been shown to have positive effects on snoring and daytime sleepiness, but less so than CPAP, and can increase quality of life. A recent meta-analysis showed treatment successes were less in severe OSA, but 70% of patients still had reduction in AHI greater than or equal to 50%, while 23% had complete resolution of OSA [54]. Of note, better results have been found with custom-made OAs compared to prefabricated devices [55]. Additionally, younger, nonobese females have been found to have greater success with OAs, and those who gained weight during treatment had a positive correlation with treatment failure [56].

Because patients have the ability to self-titrate, there will be a difference in outcomes based on variability in movement of the lower jaw forward. Success of an OA positively correlates with a less collapsible upper airway and less sensitive ventilatory control system [57]. Patients can be screened prior to fabrication of OA with nasoendoscopy to see if they are a good candidate based on their airway anatomy [58]. Once OAs are delivered, some practitioners administer type 3 or 4 home sleep tests to assess the need for changes in titration. This can be useful in patients that never experienced subjective symptoms, such as snoring or daytime sleepiness. These sleep tests are not diagnostic but are solely to aid with adjustments to the OA.

2.4.7 Side Effects

Reported side effects of oral appliances included excessive salivation, mouth or tooth discomfort, occlusal change, pain in teeth, muscle stiffness, and symptoms of temporomandibular joint disorder. Custom OAs can be designed and adjusted to reduce pressure on the teeth and gums. The most frequent cause of poor compliance with OAs is discomfort. However, most of these side effects only last for the first few months of use [49]. Morning jaw exercises have been shown to improve compliance, reduce most of the side effects, as well as aid the mandible into returning to its normal position [59]. There are also morning repositioning devices available that patients wear for 20 min to assist with stretching after removing their OA [46]. Of note, one study also found patients taking statins experienced more myofascial pain initially with OA therapy [60].

Due to the anterior forces on the mandibular teeth, and the distal forces on the maxillary teeth, most patients can expect decrease in overbite and overjet during the first 5 years of treatment. Bite changes will continue to progress as long as treatment is continued, with median changes in overbite of −1.6 mm and −1.1 mm change to overjet after a 17-year period [61]. However, a majority of patients report they don't notice the change, likely because there is no loss of posterior occlusion or associated TMD [62]. Periodic re-evaluation will be needed because this forward movement of mandibular teeth can result in the device to produce less mandibular advancement and less treatment efficacy over time. Studies show that most patients need further titration over time to compensate for tooth movement [61].

2.4.8 Oral Appliances vs Continuous Positive Airway Pressure

Current first-line therapies for OSA include continuous positive airway pressure (CPAP), OAs, and modified sleep positioning. CPAP is frequently employed before OAs, but the adherence to this therapy is problematic. Overall acceptance rate is approximately 50%, and it has been found that true compliance is much lower than patient reported compliance [52]. Still, the variability in treatment response among

patients to OAs makes CPAP currently the most efficient therapy option. This is because even though OAs have proven to be effective, they are still less predictable than CPAP.

OAs can be used in combination with CPAP, either wearing both at the same time or alternating modalities nightly. Combination therapy has been proven effective for patients who cannot tolerate both OAs and CPAP, because patients can do less advancement with the OA and use lower pressures with CPAP, making the therapies more tolerable [63]. OAs can also be used as an adjunct in patients with partial success on CPAP or with positional therapy [63, 64].

2.4.9 Conclusion

OAs are indicated for the management of patients with mild-to-moderate severity OSA and can be considered in patients with severe OSA that are unable to tolerate CPAP. There are numerous OAs available on the market, all varying slightly in design; however there is no identified gold standard device to date. After referral from a sleep medicine physician, PSG, and through oral examination, it is recommended to fabricate a custom, adjustable, and titratable mandibular repositioning device, such as the dreamTAP™ (Airway Management, Carrollton, TX). Prefabricated devices are not recommended by the authors. Once the OA is fabricated and delivered, patients should use them nightly and titrate to effect. A repeat PSG can be conducted at 6 months. With prolonged use of OAs, most patients experience some changes in occlusion; however they are minor and often not recognized by the patient. Long-term studies have shown OAs can successfully treat OSA, but it is expected OAs effectiveness can decline long term due to progression of disease and patient compliance.

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