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Prosthodontic Management of Obstructive Sleep Apnea

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Abstract

Obstructive sleep apnea (OSA) is a term used to describe the cession of breathing during sleep for not less than 10 seconds and repeated more than five times per hour of sleep. OSA is a common disorder that can adversely impact longevity and quality of life for adults and has also been linked to sudden infant death syndrome (SIDS). The frequency of snoring and sleep disorders among the population of Saudi Arabia is increasing, as the prevalence of obesity and smoking within the last few years. Patients with OSA are most often overweight, with associated peri-pharyngeal infiltration of fat and/or other anatomical alteration that may decrease the cross sectional area of the upper airway space. Smoking is widely known to impact upper airway physiology detrimentally. This sleep pattern can eventually leads to sudden death because of the continuous oxygen deprivation. Unfortunately, the number of patients who suffer from snoring and sleep apnea in Saudi Arabia is not well established. The treatment of OSA includes both surgical and conservative methods. Both treatment options aim at reducing the upper airway collapsibility which is considered the main cause of apneic attacks during sleep. It is well established as a thumb rule that the first line of OSA treatment should be directed towards the conservative approach owing to the questionable success rate achieved by surgical intervention. The conservative methods include; weight loss, change in sleep posture, drug therapy, nasal continuous positive airway pressure (CPAP) and oral devices. The oral devices in specific are gaining popularity among the medical profession owing to their diverse advantages and versatility. In this article, a review of the various prosthetic appliances used for management of OSA has been carried out.

Keywords: *Obstructive sleep apnea; Mandibular advancement prostheses; Mandibular repositioning appliances; Oral devices*

Introduction

By the late twentieth century, the medical community recognized that snoring and daytime sleepiness were signs of obstructive sleep apnea syndrome (OSAS). Parts of the sleep apnea syndrome complex were however, known many years earlier by an insightful few [1]. Nowadays, OSA is recognized to be a common potentially life threatening well defined medical entity. Its recognition has been ascribed essentially to the continuous growth in sleep research within the past three decades. Increased public awareness, more frequent detection by medical professions, and the use of a more sophisticated diagnostic tools, has led to an obvious increase in the number of diagnosed patients. The medical implications of this condition are significant. Specifically, frequent obstruction of the upper airway results in stoppage of breathing (apnea) in association with repeated arousals from sleep and blood de-oxygenation. The more frequent apneic attacks, the more severe hypoxemia results with more serious medical complications including; loss of energy, loss of concentration, loss of productivity, high blood pressure, heart attacks, strokes and even sudden death. The primary sequel that results in apnea has been shown to be the upper airway collapsibility [2,3]. There are three typical patterns of apnea. Obstructive apnea is the absence of airflow irrespective of the respiratory effort [4]. Central apnea is an absence of airflow with no respiratory effort. Mixed apnea includes both a central and an obstructive component. The most typical mixed apnea pattern is a central apnea followed by an obstructive one [5].

Epidemiology

Sleep-disorders were first detected in mid-1960s in advance with the polysomnographic studies of Gustout's on obese patients with increased carbon dioxide level [6]. These studies ensured that obesity is an important factor in initiating the OSA. However, further studies revealed that OSA can also occur in non-obese patients and that a direct link between both the cardio-vascular and cerebro-vascular complications and the consequences of OSA exists [7]. Although snoring is common in 25% of the adult population, the epidemiological data estimated that only 2-5% of the population meets the criteria for OSA when estimated with polysomnographic recordings [8,9]. The problem of OSA can affect all age groups and both sexes. Traditionally, OSA was recognized as a syndrome of the middle-aged adults and that the apneic event tends to decline in length with age [10]. Community based studies have shown that OSA is seen in 2% of women and 4% of men between the ages of 30 and 60 years [11,12]. The increased risk of OSA in males has been ascribed to gender differences in airway morphology and the protective effects of female hormones on upper airway patency [13].

Clinical implications

The fragmented and restless sleep cause common symptoms such as morning headaches, daytime sleepiness, fatigue, depression and mood alterations, libido as a result of hypoxemia, hearing loss, cognitive deficiencies, automatic behavior, reduced mental alertness and short-term memory loss. Children with sleep apnea may exhibit poor school performance and hyperactivity. Hypoxia resulting from apnea may lead to severe medical conditions that hypertension, cardiac arrhythmias, systemic and pulmonary hyperten¬sion, chronic hypercapnia and polycythemia, left ventricular dysfunction, myocardial infarction, stroke and even sudden death [14].

Predisposing factors

OSA is caused by repeated airway obstruction during sleep as a result of narrowing of the respiratory passages [15-17]. This narrowing is often attributed to obesity and anatomical alteration. Over two-thirds of the patients with OSA are most often overweight. Generally, obesity is also associated with larger neck size. If an individual's neck circumference is greater than 42.5 cm, the chance of apnea increases significantly [16-18]. Craniofacial as well as maxillofacial anomalies can also play an important role in OSA cases. These anatomical alterations include deviated nasal septum, enlarged nasal turbinate, increased size of soft palate and uvula, and bi-maxillary or mandibular retrognathism [16,17]. Micrognathia, acromegaly, and Down's syndrome may also be predisposing conditions [17]. Smoking is a detrimental factor to the physiology of the upper airways. The repeated use of an irritant such as smoking can significantly reduce the patency of the upper airway due to the irritation-inflammation-edema cycle [18]. The role of the genioglossus muscle in the pathogenesis of OSA has also been recently emphasized [19,20]. Decreased tone of this muscle during sleep as well as the pull of gravity in the supine position, further decrease airway size, and significantly contribute to airway obstruction [21].

Management of OSA

OSA can be managed by both surgical and non surgical methods. The conservative approaches to treatment include behavioural modification (weight loss, altered sleeping position, reduction in smoking and alcohol consumption), the use nasal continuous positive airway pressure (CPAP), medication, and/or oral devices [22]. It has been postulated that a 50% improvement in the apneic hypopneic index (AHI) or an AHI less than 10 indicates a treatment success [23,24]. Surgical treatment of snoring alone is much easier although there are no guarantees that they work for all or last forever. Several surgical procedures are available to correct the upper airway collapsibility with questionable prognosis. These include, nasal surgeries, such as septoplasty and inferior turbinate resection, uvulopalatopharyngoplasty, Laser-assisted uvuloplasty, Mandibular distraction osteogenesis, and tracheostomy [25-30]. Since 1981, continuous positive airway pres¬sure (CPAP) has been the most commonly prescribed nonsurgical method of treatment for obstructive sleep apnea. CPAP treatment is considered the most effective method to manage obstructive sleep apnea. The most significant effect is enlargement of the airway by dimensional changes of the lateral pharyngeal walls. In addition to structural changes, CPAP augments the tone of the upper airway dilator muscles thereby reducing susceptibility to collapse. Despite of its great efficacy it requires the use of a mask interface, sealed tubing, and a device connected to a power source. This complexity limits its acceptance by patients and leads to suboptimal treatment adherence [31-33].

Oral appliances

Oral appliances for treatment of OSA was first described by a French physician called Pierre Robin in 1902. With his monobloc appliance, Robin treated children who suffered from breathing difficulties and glossoptosis due to mandibular hypoplasia. The classical form of an oral appliance that repositioned the mandible in an adult patient with OSA was not reported until 1980 [34]. Treatment of obstructive sleep apnea in dentate patients with oral appliances (OAs) is well documented, the objective of oral appliances is to advance the mandible and tongue base, increasing the space between the base of the tongue and the posterior pharyngeal wall. The tongue may also be advanced with the use of a tongue-retaining device. These appliances improve upper airway collapsibility during sleep. Subsequently assist in reducing the obstruction [35,36]. Prosthodontists have recently become one of the general team in the field of sleep medicine. However, it is very important that the dentist should not provide the primary care of the patient; instead he has to work through a medical team work. Most of the treatment options are medical in nature, the problem often ranges far beyond that of a dental condition, and it often requires multiple medical studies. Consequently, the role of dentist in treating that case should be linked to a team which include a thoracic physician, oral and maxillofacial surgeon ear, nose, and throat surgeon, restorative dentist, and an orthodontist. Therefore, it is imperative that the patient be referred to a physician for examination, appropriate studies, diagnosis, and course of treatment [37,38].

Oral appliance therapy for treatment of OSA can be categorized into; (a) those that hold the tongue forward and (b) those that reposition the mandible and the attached tongue forward during sleep [38]. Although rarely used because of poor results and patient tolerance; palatal lifting devices (which contact the soft palate directly, they seldom employed, most likely because of gag, discomfort, and the success of laser and radio frequency soft palate procedures). Tongue posture trainers, and labial shields are also oral appliances that claim to improve snoring and OSA [39]. Each of the oral appliances has a primary effect on either the tongue or the tongue and mandible together. Several appliances move the mandible anteriorly, for example, mandibular repositioner, PM Positioner, Herbst, Klearway, Snore Guard, and TheraSnore. The tongue is affected by all the appliances either by direct forward movement of the muscle itself or by changes secondary to an altered mandibular rest position. The tongue retaining device (TRD) is the most commonly used oral appliance that has a direct affect on tongue posture [40].

Tongue Retaining Device (TRD)

TRD was first described by Carwright and Samelson [41]. The TRD appliance is especially useful in patients who have macroglossia. Because the TRD does not depend in its retention on the presence of good healthy natural dentition, it is considered an effective alternate to mandibular advancement prostheses in edentulous patients or in patients with compromised dentition. Moreover, OSA patients who are not capable of advancing the mandible for whatever reason can use the TRD safely [42]. The TRD is a custom-made appliance with a flange which fits between lips and teeth and an anterior soft plastic bulb that by means of negative pressure holds the tongue forward during sleep [43]. For those patients with blocked nasal passages, a modified TRD with lateral airway tubes to permit mouth breathing is also available. However, the use of TRD poses many disadvantages as it forces the nasal breathing and it locks the jaw in a single position which is not usually tolerated by the patients [44]. The TRD appears useful either alone or in conjunction with other treatments to improve patients with a wide range of apnea severity provided that the apnea is more severe in the supine position and the patient's weight is not greater than 50% above the ideal [38]. The effects of the TRD on baseline tongue muscle activity have been studied. Ono., *et al.* [45] found that the TRD has different effects on the awake genioglossus muscle activity in control subjects and OSA patients. In awake OSA patients, the TRD reduces genioglossus muscle activity and corrects the delayed timing of the muscle before an apneic period during sleep. The TRD may counteract fatigue in the tongue muscles and fluctuations in the activity of the genioglossus muscle. In addition, the TRD may provide a pneumatic splint to enlarge the upper airway similar to that seen with nasal CPAP [45].

Mandibular repositioning appliances (MRAs)

In the last decade there has been an explosion of interest in using oral appliances especially the MRAsto treat OSA. The development of this prosthetic treatment option represents an important step in the management of this disease. They are generally appealing because they are simple to use, reversible, portable, and appear to be quite safe [46-48]. Randomized controlled clinical trials [49-51] have shown oral appliances to be an effective and well-established treatment option for patients with mild or moderate OSA and for patients with severe OSA who are unable to tolerate nasal CPAP. MRA is a removable dental prosthesis that creates a different, yet temporary,

dental occlusal position that guides the mandible to close into a predetermined and altered position [52]. A great deal of studies have paid attention to the horizontal relation between the mandible and maxilla produced by the appliance and consequently, the optimum amount of mandibular protrusion required to achieve better results which was estimated to be approximately 60% of maximum protrusion [53]. However, the optimum vertical dimension of an oral appliance required to achieve a successful treatment outcome in patients with OSA has been an issue of debate. Some authors [54] believe that the vertical dimension should be determined according to the individual patient tolerance and acceptance. Others [55] believe that acceptable treatment outcome cannot be obtained without increasing the vertical dimension by the appliance. In a randomized, controlled crossover study, Bloch., *et al*. [56] compared two groups of patients who received oral appliances with identical amount of mandibular protrusion and different amount of vertical opening. The authors reported better improvement with the group of patients who received an oral appliance with greater amount of vertical opening. However, possible contributors to this result are the difference in the appliance design itself between the two groups since one group received a Herbst appliance while the other received a Monobloc fixed device. Furthermore, the results of this study may be also questionable because of the between-subject variability due to the parallel group study design. In another trial, Pitsis., *et al*. [57] tried to systematically evaluate two predetermined specific levels of mouth opening among patients who received the same oral appliance and with identical protrusion level. However, the evaluation parameters were not sufficient to draw a conclusive result. A more recent study [58] suggests that the fabrication of oral appliances used to treat the OSA should be made with the minimal vertical opening required to accommodate those appliances since increasing the vertical dimension does not markedly affect the treatment outcome.

MRAs are of either a one-piece (Monobloc) or a two piece design (Bibloc). The one piece design fixes the mandible rigidly in an anterior position, whereas the two piece MRA usually allows for some freedom of mandibular movement (i.e., lateral, vertical and/or anterior). This latter feature has been suggested to decrease the chance of temporomandibular disorders, increase the retention and improve patient comfort (particularly for those patients who suffer from sleep bruxism) [59,60]. But in another study where the prevalence of side effects were identified for Monobloc and Bibloc appliances, the effects could not be relieved by switching from one appliance to the other, in contrast there are some patients experienced transient mild mucosal erosions exclusively during use of the Bibloc appliance, caused by its lateral attachments [61]. Conversely, fixation of mandible with a one-piece appliance is suggested to prevent suppression of tongue protruding muscles resulting in a less collapsible upper airway [60,61]. Most two-piece appliances are sagittally adjustable, thereby allowing for individual titration and possibly greater mandibular advancement [62]. While single jaw position or nonadjustable appliances often need to be remade if the initial jaw position proves to be inadequate [59]. In addition, MRAs are either custom-made (e.g. Herbst, Klearway appliances) or pre-fabricated (e.g. Snore Guard) [59,60]. A prefabricated MRA generally requires only an individual molding of a thermolabile material, while a custom-made appliance usually requires dental impressions, bite registration, and fabrication by a dental laboratory [59]. Retention of the MRA is usually provided by wrought wire clasps. Appliances made of thermoplastic material necessitates that the patient softens the material in hot water before insertion. These materials were found to have considerable more retention than traditionally designed cold cure acrylic appliances [60].

Several exclusion criteria should be taken into account when MRA therapy is considered. These include insufficient number of teeth, (extensive) periodontal disease or dental decay, active temporomandibular joint disorders, and restrictions in mandibular opening or protrusion [58]. However, although some consider a minimum of ten sound teeth in each of the maxillary and mandibular arches a requisite in MRA treatment, the location rather than the number of teeth may be more important (i.e., posterior teeth provide more adequate retention) [59].

Efficacy of oral appliances

Despite the effectiveness of surgical intervention in the treatment of some cases of OSA, there may be contraindications for such techniques as in medically unfit patients for general anaesthesia, and patient's refusal. Therefore attempts have been made to employ oral appliances alternatively. The aim of such modality is to advance the mandible and subsequently enlarges the antero-posterior diameter of the retro-glossal space thus reduces the pharyngeal collapsibility. Of particular interest in this context are the mandibular advancement prostheses, which are capable of advancing the lower jaw [38]. There are other possible mechanisms of oral appliances

in reducing OSA. The forward jaw position is said to induce stretching and increased stiffness of the lateral pharyngeal walls and pillars. Movement of the tongue forward can also prevent any likelihood of seal forming between the tongue/soft palate/pharyngeal wall. Moreover stabilization of the mandible and hyoid bone prevent posterior rotation of the jaw and retro-lapse of the tongue during sleep. Eventually, the altered anatomic relationship induces a stretch-induced neurosensory stimulation that influences the motor tone and collapsibility of the airway [63,64]. Three dimensional imaging and (supine) cephalometric studies demonstrated that mandibular repositioning increases oropharyngeal, hypopharyngeal and velopharyngeal dimensions [65]. Endoscopic studies have demonstrated that mandibular advancement results in, particularly, an increased cross-section of the lateral dimension of the velopharynx [66].

Based on its effectiveness and patient compliance, oral appliances seem appropriate for the treatment of upper airway resistance syndrome, as well as sleep apnea syndrome or snoring [67]. Based on subjective reports of patients and their bed partners, MRA therapy generally results in improvements of snoring in a high proportion of patients. Other reported benefits of MRA treatment include substantial decreases of daytime sleepiness, improvements in work performance, and improved sleep quality of both patient and bed partner. Sleep registration generally confirms the patient-perceived benefits by demonstrating a decrease in snoring frequency and intensity, AHI or RDI, oxygen desaturation frequency and intensity, and number of arousals [68]. Moreover, MRA treatment has been associated with significant increases in slow-wave and REM sleep. Although the initial effect of the MRA has been reported to be stable over a five-year period [69], there are studies suggesting a gradual decline in treatment effect in both the short (i.e., six weeks) and long term (i.e., four years). Despite an unsatisfactory change in the number of breathing events, patients may report fewer symptoms. Moreover, an increased AHI after MRA therapy has been reported in approximately 13% of patients. Because of this risk of an increased or suboptimal AHI, a follow-up sleep study should always be conducted in MRA treatment [70].

Complications and compliance of MRA

Although side-effects are frequently reported with MRA therapy, these are usually mild and acceptable, with most symptoms subsiding when treatment is continued. Tenderness of the teeth and jaws, myofacial pain, gum irritation, excessive salivation, and xerostomia are commonly reported in the initial period of use. In exceptional cases, treatment may be complicated by involuntary removal of the device, an exaggerated gag reflex, periodontal damage, or fractured teeth and fillings [71]. It has been suggested that advancement of the mandible for considerable periods may have adverse effects on the stomatognathic system. Mild complaints of pain and strain of the masticatory muscles and the temporomandibular joint frequently occur at the initiation of treatment [72]. Some studies have observed an increase in bruxism in response to MRA therapy. In the long term, MRA treatment has been suggested to initiate or aggravate temporomandibular joint disease in individual patients [73]. A temporary bite change in the morning after removal of the appliance occurs in almost all patients. In individual cases, permanent occlusal alterations have been observed after long-term treatment periods [74].

Mandibular repositioning appliances for edentulous patients

The splint consists of maxillary and mandibular vacuum formed splints over which heat polymerized clear acrylic resin blocks were attached (vent holes in middle of acrylic resin blocks were placed). The blocks were attached together by auto-polymerizing acrylic resin [75]. This splint is fabricated to achieve protrusion of the mandible (75% of maximum protrusion) without increasing the vertical dimension of occlusion. Therefore, there is no difficulty in inserting and removing the splint from the mouth, and the patient does not find the splint formidable to wear. This assists in improving patient compliance. It is indicated in patients with well formed ridges. Adequate retention could be obtained by making a mandibular impression with a properly extended lingual flange [75].

Conclusions

Sleep apnea syndrome is a relatively common yet potentially fatal syndrome that is characterized by the transitory cessation of the breathing impulse. The most prevalent type is obstructive sleep apnea (OSA), which results from a collapse or obstruction in the oropharyngeal region of the upper airway. Mandibular advancement devices (MADs) are the class of appliances most commonly prescribed at this time to manage cases with OSA. The actual appliance that is chosen is often determined by the interaction of the patient and dentist. Those mandibular advancement devices that permit some degree of jaw movement (both lateral and vertical) may potentially

minimize TMJ problems and improve patient acceptance. However, many functional and anatomic factors that influence the syndrome make diagnosis or selection of therapy very difficult, so there is limited agreement on the effectiveness of specific methods. Therefore, patients must be carefully examined to ensure selection of the most suitable treatment. Further longitudinal studies on a relatively large number of patients are still needed to identify the long term efficacy and side effects of mandibular advancement prostheses.

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