Obstructive sleep apnea etiology, diagnosis, management and dental considerations

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Abstract

It has been reported that 10% of men and 5% of women in the 30-40 year age group are habitual snorers, prevalence of which increases with age. Upper airway sleep disorders are becoming recognized common medical concerns. The management and treatment of obstructive sleep apnea patients have long since been addressed by medical personals. Recently, dental participation in management of the patients through oral devices has been accepted as a recommended treatment modality by the American Sleep Disorders Association. As dental professionals, we have significant role to play in the early diagnosis, management and care of patients suffering from sleep apnea. This article reviews the etiology, clinical features, management and dental perspective of obstructive sleep apnea.

Keywords: Obstructive sleep apnea, Sleep disorders, Snoring, Oral devices.

Introduction

Approximately 3% of the middle aged population suffer from excessive day time sleepiness that may be the result of frequent night time sleep interruptions caused by upper airway disorders.[1] Excessive sleep interruptions may interfere with the health and lifestyle of persons, causing them to be less productive in their work, to suffer an increased number of automobile and work related accidents and sometimes be associated with potentially life threatening medical conditions like pulmonary hypertension, acute pulmonary oedema and systemic hypertension etc.

Sleep disordered breathing (SDB) is a term which includes simple snoring, upper airway resistance syndrome (UARS) and sleep apnea.[2] Simple snoring is a common complaint affecting 45% of adults occasionally and 25% adults habitually and is a sign of upper airway obstruction. Snoring has also been identified as a possible risk factor for hypertension, ischemic heart disease and stroke.[3,4]

The role of dentistry in sleep disorders is becoming more significant, especially in co-managing patients with simple snoring and mild to moderate obstructive sleep apnea(OSA). The practicing dental professional has the opportunity to assist patients at a variety of levels, starting with the recognition of a sleep related disorder, referring them to a physician for evaluation and assisting in the management of sleep disorders especially during fabrication of oral devices. Almost every discipline in dentistry needs to be aware of sleep disorders and their potential impact.

In normal weight adults, when there is an increased inspiratory effort exerted during sleep, without the cessation of airflow that leads to brain or electroencephalogram (ECG) arousals, it is termed as UARS. Patients are described as 'arousing' when they shift from a deeper to a lighter stage of sleep or have an actual awakening.[5,6]

Sleep apnea syndrome is a sleep interference disorder characterized by apneic and possibly hpopneic events, resulting in low oxygen levels to the lungs (hypoxia), blood oxygen desaturaton and a sleep arousal or awakening.

Types of Apnea

Sleep apnea is probably the most prevalent of all the sleep disorders and is classified as central, obstructive, or mixed; it may be mild, moderate or severe. Apnea is defined as cessation of airflow that lasts for at least 10 seconds. Hypopnea is defined as a significant (30%) reduction in airflow lasting 10 seconds or more.[7 8,9]

The American Academy of Sleep Medicine (AASM) rates the average number of obstructive sleep apnea events per hour as respiratory distress index (RDI). An RDI of 0 to 5 is normal; 5 to 20 is mild; 20 to 40 is moderate and over 40 is considered severe.[9,10]

Central sleep apnea(CSA) occurs when the brain fails to send appropriate signals to the breathing muscles to initiate respiration. It is often secondary to central nervous system diseases such as infarction and infection involving the brain stem or due to neuromuscular diseases involving respiratory muscle.

Obstructive sleep apnea occurs due to obstruction caused by collapse of soft tissue structures in the oropharynx or hypopharynx. OSA when combined with the excessive day time sleepiness is termed obstructive apnea syndrome. A patient with a combination of CSA and OSA is said to have mixed sleep apnea. Mixed apnea occurs more often than central but less often than obstructive apnea.

Obstructive sleep apnea is still a poorly recognised medical condition that affects approximately 4% and

2% of middle aged males and females respectively.[11,12] The causes of OSA are multifaceted. Any obstruction condition coupled with assuming the supine position may cause a blockage of the upper airway.

Recent publications indicate that other factors may also be important concerns in OSA patient. Studies have indicated that the genioglossus and tensor veli muscles may have increased activity in the awake OSA patients and thus help maintain the shape of the upper airway. However, when the patient assumes a supine position and goes to sleep there is a decrease in the activity of the genioglossus and tensor veli palatini muscles that results in a decreased airway space.[13,14] This decrease in airway size may result in an increase in the velocity of the air passing through the airway increasing the degree of sub atmospheric pressure. The combination of increased negative pressure and decrease in muscle activity allows the tongue and soft palate to move toward and often contact the posterior wall of the oropharynx, resulting in a decreased airway space ultimately causing snoring and /or OSA. The other possible causes of obstruction in this type of apnea are deviated nasal septum, polyps, enlarged adenoids, enlarged tonsils and uvula, enlarged base of tongue, tongue base falling into pharyngeal airway, submucosal fat or redundant mucosa. Davies et al found that men and women were at greater risk for OSA if they had neck circumferences of 17 and 16 inch or greater, respectively.[15] Pae et al also showed that the thickness of the soft palate increases and the oropharyngeal cross section area decreases when a patient changes form an upright to supine position.[16] Otherpredisposing factors of OSA include obesity, retropositioned maxilla and mandible, drugs, alcohol, sedative, smoking, hypothyroidism, acromegaly, vocal cord paralysis, nasal congestion etc.

Clinical Features

Patients with OSA may have memory problems, excessive day time sleepiness, difficulty in concentrating, night drooling of saliva, depression, irritability, xerostomia, gasping for breath at night, and witnessed apneas. Poor work performance, occupational accidents and a reduction in social interactions and other aspects of quality of life appear to be associated with untreated OSA. There have been reports of exacerbations of epilepsy, asthma, and hypertension in patients with untreated or undiagnosed OSA.

Diagnosis

Sleep disorders can be diagnosed and treatment planned only by physicians. Dentists must not assume the role of primary care provider for these patients, because most of the causes of sleep disorders are medical, not dental, in nature. Dentists should be able to recognize potential sleep-disorder patients, refer them to a physician, and assist the physician in treating these patients with oral appliances when requested. Diagnosis of OSA can be made on history, physical examination, polysomnography, limited channel testing, split night testing and oximetry.

Physical Examination

Physical examination is frequently normal in OSA other than the presence of obesity (defined as a body mass index greater than 28 kg/m^2) and neck diameter greater than 16 inches.[17] The upper airway should be evaluated in all patients, particularly in nonobese adults, for features associated with the presence of OSA such as:

- Narrowing of the lateral airway walls, which is an independent predictor of the presence of OSA in men but not women
- Enlarged tonsils
- Retrognathia or micrognathia
- Soft palate edema
- High, arched hard palate

Epworth sleepiness scale (ESS) is a validated questionnaire which indicates a patient's level of day time sleepiness. The Epworth sleepiness scale is calculated as the sum of chances of dozing off scores in various (total 8) situations. Scores range from 0 to 3, and measure the likelihood of the patient dozing off while watching television, driving, or reading: 0 = would never doze, 1 = slight chance of dozing, 2 = moderate chance of dozing, and 3 = high chance of dozing A score of more than 10 on the Epworth scale is considered pathological and indicates that a sleep specialist should be consulted. ESS is also useful in evaluating response to treatment. The score in ESS should decrease with effective treatment.[18]

Polysomnography

After a preliminary examination, the physician may refer the patient for an overnight polysomnography study in a sleep clinic. The polysomnogram (PSG) is used to evaluate the sleep and breathing patterns. The PSG can determine the existence, type (central, obstructive or mixed) and severity of any apnea disorders. The PSG is also used to later determine the effectiveness of any completed treatment.

Overnight polysomnography is considered the gold standard in diagnosis of sleep apnea. It features ECG graphy, brainwave electroencephalography (EEG) measurements, motor activity extremity measurements, diaphragmatic/chest movements, eye movements, pulse oximetry for oxygen desaturation measurements, and inhalation/exhalation oro-nasal flow characteristics.

Split night polysomnography refers to a single night of attended sleep testing; in addition to aiding in diagnosis, it has a therapeutic component, namely the nasal continuous positive airway pressure (CPAP) titration, which helps in assessment of a positive airway pressure and also serves to maintain the patency of the patient's airway on the night of the test.[19,20,21]

The apnea-hypopnea index (AHI) is the average number of apneas and hypopneas per hour of sleep. The severity of OSA is classified on the basis of the patient's AHI index into three categories:

1. Mild OSA (5 to 15 events per hr),
2. Moderate OSA (15 to 30 events per hr)
3. Severe OSA (more than 30 events per hr).[22]

Oximetry

The only alternative to polysomnography at present is a procedure called overnight oximetry which measures a patient's oxygen saturations throughout the night. Oximetry is not valid in those receiving oxygen therapy. It can be used to screen before ordering a sleep study since it has a high negative predictive value and is inexpensive.[23]

Multiple Sleep Latency Test (MSLT)

MSLT measures the speed of falling asleep. A multiple sleep latency test may also be performed to assess the level of daytime sleepiness. The average adult requires 10 or more minutes to fall asleep during the day. A mean sleep latency of less than five minutes is considered abnormal. The MSLT may be useful to measure the degree of excessive daytime sleepiness and to rule out other types of sleep disorders.[24]

Other Investigations

The ideal upper airway imaging modality for patients with OSA should be non-invasive, inexpensive, permit supine imaging, allow for three-dimensional volumetric reconstructions of the upper airway and the surrounding tissues, and not expose the patient to ionizing radiation. A number of imaging modalities like acoustic reflexion, fluoroscopy, nasopharyngoscopy, cephalometry, MR imaging, and both conventional and electron-beam CT scanning have been used to assess the airway. When specific problems like TMJ dysfunction are present and an oral appliance is being planned, specific imaging of the TMJ should be done. Cephalometrics could be used if the practitioner wishes to evaluate the airway dimension, evaluate cranial or skeleted structures, or plan for orthognathic surgery.[25,26,27,28]

Management

Central sleep apnea is not treated by the dental profession. Dental treatment is indicated in conditions namely snoring and mild to moderate OSA. If the apnea is mixed, the dental profession cannot treat the central apnea. The ideal results of treating OSA patients would be increased life expectancy, and decreased health hazards and improved quality of life. Selection of treatment for individual OSA patients is based upon balanced consideration of disease severity and site of obstruction, subjective symptoms, risks of morbidity and mortality and patient's choice. Treatment effectiveness is variable and dependent on patient needs.

Non Specific Therapy

These measures should be included in the treatment of all patients with OSA but should be used exclusively only in patients with very mild apnea whose main complaint is snoring.

- Overweight persons can benefit from losing weight. Even a 10% weight loss can reduce the number of apneic events for most patients.[1,29]
- Behaviour modification suggestions include changing the sleep position from the supine position to the side position; this can be accomplished by placing a tennis ball in the centre of the back of their pyjamas or by positioning a pillow such that they cannot roll on to their back (positional training)[30]. The avoidance of alcohol and sedatives for 3 hr before sleep has been recommended, because these have a depressing effect on the central nervous system; these may also act as muscle relaxants, reducing airway patency.[31]

Specific Therapy

- Medications like thyroid hormone, progesterone, tricyclic antidepressants have been tried but shown little success.
- Physical or mechanical therapy- Patients with mild apnea have a wider variety of options, while those with moderate to severe apnea should be treated with nasal CPAP.
- Positive pressure therapy

Positive airway pressure is a very effective therapy for OSA. It has three forms:-

1. **Continuous positive airway pressure(CPAP):** Continuous positive airway pressure continues to be the standard, treating the symptoms of OSA in both adults and children, and it is regarded as being successful in approximately 62% of patients. Continuous positive airway pressure treats patients by continuously pumping room air under pressure through a sealed face or nose mask through the upper airway to the lungs. It has been reported that the success of this treatment lies in its ability to act as a splint in keeping the upper airway open, thereby preventing its collapse. To determine precisely the individual patients' optimum airway pressure, it is necessary to titrate the pressure to each individual patient during a polysomnogram. Approximately 55% of patients who use CPAP use it on a night basis for more than four hours. It is the most commonly prescribed treatment for OSA.

Although it has the highest percentages of successful treatment, CPAP-suffers from severely poor patient compliance because of portability problems, pump noise, dryness of the airway passage, and mask discomfort. Patients prefer CPAP to a placebo, but they

prefer oral appliances to CPAP because of quality-of-life issues.

2. **Autotitration:** Devices are designed to provide the minimum necessary pressure at any given time and change that pressure as the needs of the patient change.
3. **Bi level positive airway pressure:** Bi level positive airway pressure machines are designed to sense when the patient is inhaling and exhaling and to reduce the pressure to a preset level on exhalation because the air pressure required for preventing respiratory obstruction is typically less on expiration than on inspiration.[32,33,34]

- **Surgical therapy:** Upper airway surgical approaches for the treatment of OSAS fall into three categories: (1) classic procedures that directly enlarge the upper airway, (2) specialized procedures that enlarge the upper airway by modifying soft tissue elements and/or the skeletal anatomy, and (3) tracheotomy for control of OSA by means of bypassing the pharyngeal portion of the upper airway.

The pain and expense of surgery and the relatively poor long term success rates, surgery is not the preferred treatment of choice and is indicated only in patients who cannot comply with or are not appropriate candidates for conservative therapies. Various surgical procedures include nasal, septal and adenoid surgeries, tonsillectomy, genioglossus tongue advancements, reduction glossectomies, uvulopalatopharyngoplasty procedures, laser assisted uvulopalatoplasty, maxillomandibular advancement, radiofrequency tissue volume reduction or somnoplasty, hyoid suspension and tracheostomy.[35,36,37]

- **Oral appliances:** Oral appliances were used by Robin to treat glossoptosis in infants with micrognathia as early as 1905. In 1990, adjustable mandible- advancing oral appliances became the predominant form of dental therapy for SDB, signalling the entry of dentistry into mainstream sleep medicine.[38]

Of the several appliances available in the market today, more than 34 have been accepted by the American Food and Drug Administration for intraoral use in the treatment of obstructive sleep apnea. These appliances are indicated in mild to moderate OSA, where other treatment modalities have failed, patients who are at poor surgical risk, medically compromised, or elderly and non compliant with CPAP. Oral devices are basically thermoplastic materials with retainers and supports and are usually custom made.

The appliances can be broadly classified into:

- Tongue repositioning devices, such as the tongue retaining device
- Mandibular advancement devices (MAD) which work by holding the lower jaw and the tongue forward during sleep
- Devices designed to lift the soft palate or reposition the uvula
- Uvula lifters, which are not in use now due to discomfort.

Tongue-Retaining Devices

Tongue-retaining devices were first described in 1982. They consist of a hollow bulb supported by trays that fit over the maxillary and mandibular teeth or edentulous ridges. To prevent the tongue from approaching the posterior wall of the pharynx, the patient projects the tip of the tongue into a hollow bulb, thereby creating a suction which retains the tongue in an anterior position.

Advantages

- TRDs can be used on edentulous patients, whereas MADs need dentition for retention purposes.
- TRDs will not loosen restorations because they do not require the retention that MADs need.
- TRDs require minimal or no adjustments,
- TRDs cause minimal sensitivity in teeth or in the temporomandibular joint.
- Tongue-retaining devices are effective in offsetting fluctuation of genioglossal muscle activity and in treating patients with OAS.

Mandibular Advancement Device(MAD)

Mandibular advancement devices were first described by Robin in 1934. MADs consist of form-fitting trays that fit over the maxillary and mandibular teeth. Mandibular advancement devices may be fixed-position, with no allowance for adjustability for advancement or retrusion of the mandible, or adjustable. Almost all MADs require that the patient have a sufficient number of teeth so the device will be highly retentive, generally on both arches but at least on the maxillary arch.

Oral appliance therapy that involves advancement of the mandible shown to significantly decrease AHI in mild to moderate cases and in some cases with moderate to severe AHI.

Adjustable oral appliances are generally preferred because they can be adjusted in an anteroposterior direction until an acceptable level of symptom improvement has occurred, while teeth or temporomandibular joint sensitivity is controlled.[39,40,41]

Rationale of oral appliances and their efficacy

Oral appliances enlarge and stabilize the oro-and hypopharyngeal airway space by advancing the mandible and stretching the attached soft tissue, particularly the tongue. It is hypothesized that these appliances may also affect upper airway muscle tone and thus decrease their collapsibility. Oral appliances improve the blood oxygen saturation levels as they relieve apnea in 20-75% of patients. They reduce AHI

to < 10 events per hr or bring about 50% reductions in AHI. Oral appliances also reduce the AHI to normal in 50-60% of patients[42,43].

- **Alternative treatments:** A 2005 study in the British Medical Journal found that learning and practicing the didgeridoo (a wind instrument) helped reduce snoring and sleep apnea as well as daytime sleepiness. This appears to work by strengthening muscles in the upper airway, thus reducing their tendency to collapse during sleep.
- **Other dental considerations:** Surgical extractions which may involve reflecting a mucoperiosteal flap may predispose the patient to developing subcutaneous emphysema on using CPAP during the first two postoperative nights. Hence surgical procedures involving reflecting mucoperiosteal flaps may best be avoided in OSA patients using CPAP[44]. Patients with OSA may have an impaired swallowing reflex which may affect recording of the centric relation accurately. Medications used in weight loss therapy, e.g., sibutramine, are associated with xerostomia and have sympathomimetic properties likely to cause an increase in blood pressure or heart rate. Xerostomia is a potential side effect of several medications such as antidepressants, antihypertensives, and anticholinergics. These patients should be prescribed artificial saliva to help in complete denture retention, should have fluoride applications to avoid the incidence of caries, and must maintain good oral hygiene. Maxillary occlusal splints have been found to aggravate respiratory disturbances and hence clinicians should question patients about snoring and sleep apnea before fabricating night guards / splints for TMJ disorders.[45]

Conclusion

Upper airway sleep disorders are becoming recognized as common medical concerns. Recently dental participation in management of the OSA patients through oral prosthesis therapy has been accepted as an appropriate treatment modality by the American Sleep Disorders Association. Dental treatment has been showed to be a successful and conservative method to treat mild to moderate OSA. It should be considered by the medical profession over more invasive treatment modalities or in patients who do not respond to behavioural modifications.

References

1. Smith PL, Gold AR, Meyers DA, Haponik EF, Bleecker ER. Weight loss in mildly to moderately obese patients with obstructive sleep apnea. Ann Intern Med 1985;103:850-5.
2. Brown LK. Sleep apnea syndromes overview and diagnostic approach: Mt. Sinai J Med 1994;61,99-112.
3. Palomaki H. Snoring and the risk ischaemic myocardial or brain infarction. Stroke 1991;22:1021-5.
4. Waller PC, Bhopal RS. Is snoring a cause of vascular disease: An epidemiological review. Lancet 1989;1:143-6.
5. Caples SM, Gami AS, Somers VK. Obstructive sleep apnea. Ann Intern Med 2005:142:187-97.
6. Strohl KP, Redline S. Recognition of obstructive sleep apnea. Am J Respir Crit Care Med 1996:154:279-89.
7. Lowe AA, Ozbek MM, Miyamoto K, Pae EK, Fleetham JA. Cephalometric and demographic characteristics of obstructive sleep apnea: An evaluation with partial least squares analysis. Angle Orthod 1997:2:143-53.
8. Peker Y, Hedner J, Kraiczi H, Löth S. Respiratory disturbance index: An independent predictor of mortality in coronary artery disease. Am J Respir Crit Care Med 2000:162:81-6.
9. He J, Kryger MH, Zorick FJ, Conway W, Roth T. Mortality and apnea index in obstructive sleep apnea: Experience in 385 male patients. Chest 1988:94:9-14.
10. Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep disordered breathing among middle aged adults. N Engl J Med 1993;328:1230-5.
11. Swedish Medical Research Council, Diagnosis and management of obstructive sleep apnea syndrome. A State of the Art conference in Stockholm 1994.
12. Gula LJ, Krahn AD, Skares AC, Yee R, Hein GJ. Clinical relevance of arrythmias daily sleep - Guidance for clinicians. Heart 2004;90:347-52.
13. Schwab RJ, Gupta KB, Gefter WB, Metzger LJ, Hoffman EA, Pack AI. Upper airway soft tissue anatomy in normal and patients with sleep disordered breathing: Significance of the lateral pharyngeal walls. Am J Respir Crit Care Med 1995;152:1673-89.
14. Tangugsorn V, Skatvedt O, Krogstad O, Lyberg T. Obstructive sleep apnoea: A cephalometric study. Part II. Uvulo-glossopharyngeal morphology. Eur J Orthod 1995:17:57-67.
15. Davies RJ, Stradling JR. The relationship between neck circumference, radiographic pharyngeal anatomy, and the obstructive sleep apnoea syndrome. Eur Respir J 1990;3:509-14.
16. Pae EK, Lowe AA. A Cephalometric and electromypgraphic study of upper airway structures in the upright and supine positions. Am J Orthod Dentofacial Orthop 1994;106:52-9.
17. Tsai HH, Ho CY, Lee PL, Tan CT. Cephalometric analysis of nonobese snorers either with or without obstructive sleep apnea syndrome. Angle Orthod 2007:77:1054-61.
18. Johns MW. The Epworth Sleepiness Scale. Sleep 1991:14:540-5.
19. Chervin RD, Murman DL, Malow BA, Totten V. Cost-utility of three approaches to the diagnosis of sleep apnea: Polysomnography, home testing and empirical therapy. Ann Intern Med 1999:130:496-505.
20. Bohadana AB, Hannhart B, Teculescu DB. Nocturnal worsening of asthma and sleep-disordered breathing. J Asthma 2002;39:85-100. Raphaelson MA, Alpher EJ, Bakker KW, Perlstrom JR. Oral appliance therapy for obstructive sleep apnea syndrome: Progressive mandibular advancement during polysomnography. Cranio 1998;16:44-50.
21. Sleep-related breathing disorders in adults: Recommendations for syndrome definition and measurement techniques in clinical research-the report of an American Academy of Sleep Medicine task force. Sleep 1999;22:667-89.

22. Tsuchiya M, Lowe AA, Pae EK, Fleetham JA. Obstructive sleep apnea subtypes by cluster analysis. Am J Orthod Dentofacial Orthop 1992:101:533-42.
23. Chiner E, Signes-Costa J, Arriero JM, Marco J, Fuentes I, Sergado A. Nocturnal oximetry for the diagnosis of the sleep apnoea hypopnoea syndrome: A method to reduce the number of polysomnographies. Thorax 1999:54:968-71.
24. Chervin RD, Aldrich MS. Sleep onset REM periods during multiple sleep latency tests in patients evaluated for sleep apnea. Am J Respir Crit Care Med 2000:161:426-31.
25. Pépin JL, Lévy P, Veale D, Ferretti G. Evaluation of the upper airway in sleep apnea syndrome. Sleep 1992:15:S50-5.
26. Frohberg U, Naples RJ, Jones DL. Cephalometric comparison of characteristics in chronically snoring patients with and without sleep apnea syndrome. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995:80:28-33.
27. Stein MG, Gamsu G, de Geer G, Golden JA, Crumley RL, Webb WR. Cine CT in obstructive sleep apnea. AJR Am J Roentgenol 1987:148:1069-74.
28. Suto Y, Matsuo T, Kato T, Hori I, Inoue Y, Ogawa S, et al. Evaluation of the pharyngeal airway in patients with sleep apnea: Value of ultrafast MR Imaging. AJR Am J Roentgenol 1993:160:311-4.
29. Smith PL, Gold AR, Meyers DA, Haponik EF, Bleecker ER. Weight loss in mildly to moderately obese patients with obstructive sleep apnea. Ann Intern Med 1985;103:850-5.
30. Thornton WK, Roberts DH. Nonsurgical management of the obstructive sleep apnea patient. J Oral Maxillofac Surg 1996; 54:1103-8.
31. Tuomilehto HP, Seppδ JM, Partinen MM, Peltonen M, Gylling H, Tuomilehto JO, *et al*. Lifestyle intervention with weight reduction: First-line treatment in mild obstructive sleep apnea. Am J Respir Crit Care Med 2009;179:320-7.
32. Engleman HM, Asgari-Jirhandeh N, McLeod AL, Ramsay CF, Deary IJ, Douglas NJ. Self-reported use of CPAP and benefits of CPAP therapy. Chest 1996;109:1470-6.
33. Martvnez-Garcva MA, Galiano-Blancart R, Soler-Cataluρa JJ, Cabero-Salt L, Romαn-Sαnchez P. Improvement in nocturnal disordered breathing after first-ever ischemic stroke. Chest 2006;129:238-45.
34. Reeves-Hochι MK, Hudgel DW, Meck R, Witteman R, Ross A, Zwillich CW. Continuous versus bilevel positive airway pressure for obstructive sleep apnea. Am J Respir Crit Care Med 1995;151:443-9.
35. Mehra P, Wolford LM. Surgical management of obstructive sleep apnea. Proc (Bayl Univ Med Cent) 2000;13:338-42.
36. Tiner BD. Surgical management of obstructive sleep apnea. J Oral Maxillofac Surg 1996;54:1109-14.
37. Fujita S, Conway W, Zorick F, Roth T. Surgical correction of anatomic abnormalities in obstructive sleep apnea syndrome: Uvulopalatopharyngoplasty. Otolaryngol Head Neck Surg 1981;89:923-34.
38. Meyer-Ewert K, Brosik B. Treatment of sleep apnea by prosthetic mandibular advancement. Sleep related disorders and internal medicine. Berlin: Springer-Verlag; p. 341-5 as cited in Rose E, Staats R, Virchow C, Jonas IE. A comparative study of two mandibular advancement appliances for the treatment of obstructive sleep apnea. Eur J Orthod 2002;24:191-8.
39. George PT. A modified functional appliance for treatment of obstructive sleep apnea. J Clin Orthod 1987;21:171-5.
40. Schmidt-Nowara WW, Meade TE, Hays MB. Treatment of snoring and obstructive sleep apnea with a dental orthosis. Chest 1991;99:1378-85.
41. Wade PS. Oral appliance therapy for snoring and sleep apnea: Preliminary report on 86 patients fitted with an anterior mandibular positioning device, the Silencer. J Otolaryngol 2003;32:110-3.
42. Ferguson KA, Love LL, Ryan CF. Effect of mandibular and tongue protrusion on upper airway size during wakefulness. Am J Respir Crit Care Med 1997;155:1748-54.
43. Lowe AA. Titratable oral appliances for the treatment of snoring and obstructive sleep apnea. J Can Dent Assoc 1999;65:571-4.
44. Kramer NR, Fine MD, McRae RG, Millman RP. Unusual complication of nasal CPAP - subcutaneous emphysema following facial trauma. Sleep 1997;20:895-7.
45. Gagnon Y, Mayer P, Morisson F, Romprι PH, Lavigne GJ. Aggravation of respiratory disturbances by the use of an occlusal splint in apneic patients: A pilot study. Int J Prosthodont 2004;17:447-53.