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# UPPER AIRWAY SLEEP DISORDERS AND DENTAL TREATMENT

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**Abstract**

*In recent years', about 3% of the middle-aged population suffers from daytime sleepiness and nighttime sleep interruptions, it may be due to upper airway sleep disorders (UASD). A UASD is the narrowing of the upper airway and results in disruptions of sleep, affects health and lifestyle, and less concentration in work. Most of the automobile and work accidents are due to sleeplessness. It can also cause critical medical conditions. Apnea is the complete cessation of breath and hypopnea is a reduction in the airflow. Obstructive sleep apnea (OSA) affects 4% of males and 2% of females. In a normal person, airway space is free for air passage, and in a disordered person, the airway space is compromised which makes it difficult for passage of air. There are multifactorial factors that can cause UASD. They are the position of muscles, anatomical alterations. In supine, the muscles tensor veli palatini and genioglossus have decreased activity. Anatomical alterations such as posteriorly positioned maxilla and mandible, over erupted anterior teeth, large gonial angle, and long tongue may reduce the upper airway space. There are various treatments for UASD. Dental treatment options such as tongue retaining device (TRD) and a mandibular advancement device. This study reviewed the dental treatment involved in the treatment of UASD, surgical methods involved, and also the failure of dental treatment. Many snoring and OSA patients were successfully treated using dental devices. UASD is treated successfully using oral devices. Dental treatments are successful to treat mild to moderate OSA.*

**KEYWORDS:** *Dental treatments, oral devices, tongue retaining device, mandibular advancement.*

## Introduction

Respiratory diseases are responsible for a large number of deaths and sufferings in humans. In recent years about 3% of the middle-aged population suffers from excessive sleepiness in the morning and nighttime sleep interruptions not only due to usage of gadgets, but it can also be due to upper airway sleep disorders (UASD) [1]. UASD is the narrowing of upper airway space making it difficult for the air passage which eventually

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requires extra effort to breathe and results in sleep interruptions. The UASD is categorized from moderate to severe. Sleep interruptions in the nighttime interfere with health causing tiredness and weakness, less attention at work. It is the major reason for increasing automobile accidents [2], due to less attention caused by sleep interruptions. People with UASD are more prone to accidents. UASD includes the terms apnea and hypopnea. Apnea is the complete cessation of airflow. Hypopnea is the 50% reduction in airflow which causes a fall in blood saturation. UASD diminishes sleep time and sleeps quality. Symptoms of UASD are hypertension, excessive daytime sleepiness [3], tiredness, memory, judgment impairment, irritability, sweating, fatigue, headache, depression. Its adverse effects are a lack of concentration in work and increased automobile accidents [4].

In children, it causes poor school performance and hyperactivity [5]. Snoring is a common symptom of UASD. UASD includes sleep apnea syndrome and upper airway resistance syndrome (UARS). Sleep apnea syndrome is sleep interference characterized by apnea and hypopnea events. The respiratory system is responsible for oxygen and carbon dioxide exchange between blood and the environment. Reduced airflow results in reduced oxygen levels which are called hypoxia, and results in a fall in blood oxygen saturation which in turn causes awakening in the sleep. Respiratory apnea syndrome is the clinical manifestation of sleep apnea syndrome without the events of apnea or hypopnea. UASD also results in severe medical conditions such as bradycardia, tachycardia, systemic hypertension, pulmonary hypertension, and acute pulmonary edema [6]. Previously our team had conducted numerous studies on online surveys [7], cancer biology [8] [9] [10] [11] [12] [13], research on natural medicine [14] [15] [16] [17], nanoparticles [18] [19] [20] [21]. This review is mainly focussed on upper airway sleep disorders and dental treatments. The main aim of the study is to review the dental treatments, surgical procedures, used for UASD.

**Diagnosis of upper airway sleep disorders**

The structures involved in the upper airway are hypopharynx, oropharynx, and nasopharynx. The upper airway space is nonrigid, soft tissue with minimal bony support. The diagnosis includes palpation of muscles of the head and neck to identify mass or tumor blocking the airway. Maintaining the shape of the airway also plays an important role in UASD. Patients with UASD have compromised airway space which occurs mostly in obese patients due to the deposition of fat in the upper airway [22]. Without obesity, in a normal weight person, the action of the genioglossus and tensor veli muscle is increased [23]. In the supine position of sleep, the activity of genioglossus and tensor veli palatini is decreased and decreases in airway space (figure 1) [24]. When the velocity of inspired air is high, it further increases the subatmospheric pressure which is caused by the diaphragm to pull the air [25]. This changes the shape of the airway.
Figure 5: Enlargement of adenoid in upper airway sleep disorder patient

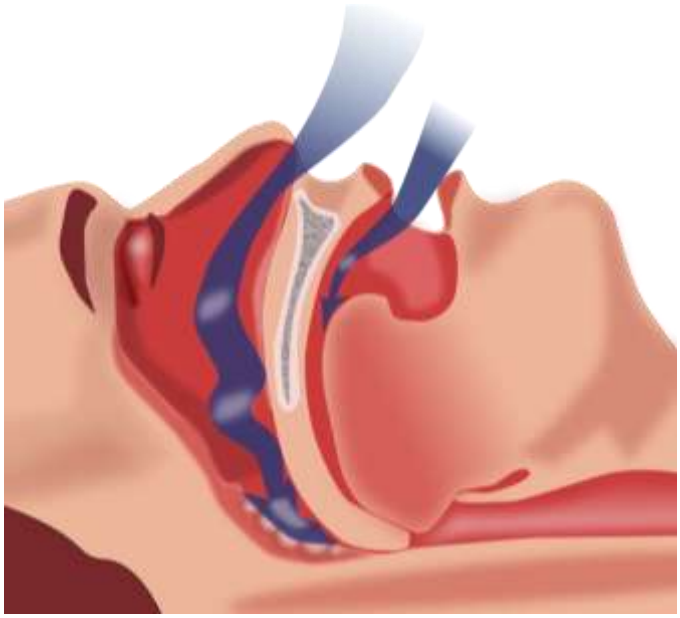

**Figure 1:** Obstruction of the upper airway in the supine position of sleep

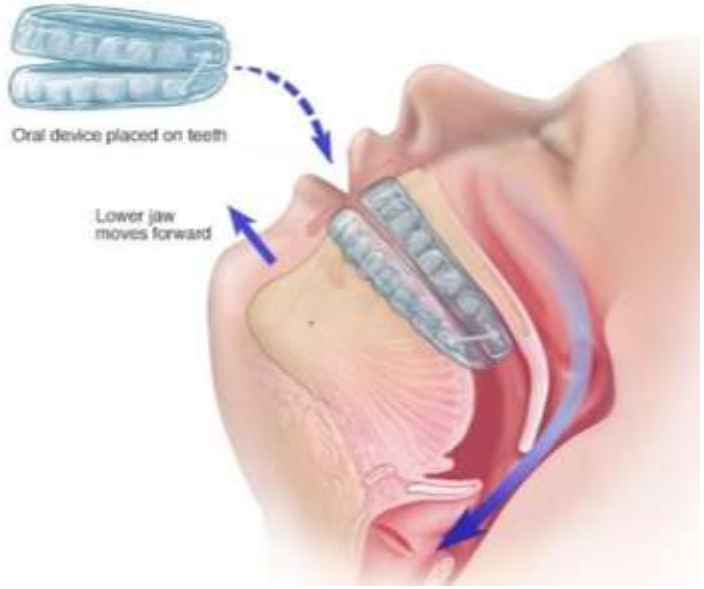


**Figure 2:** Insertion of Mandibular repositioner

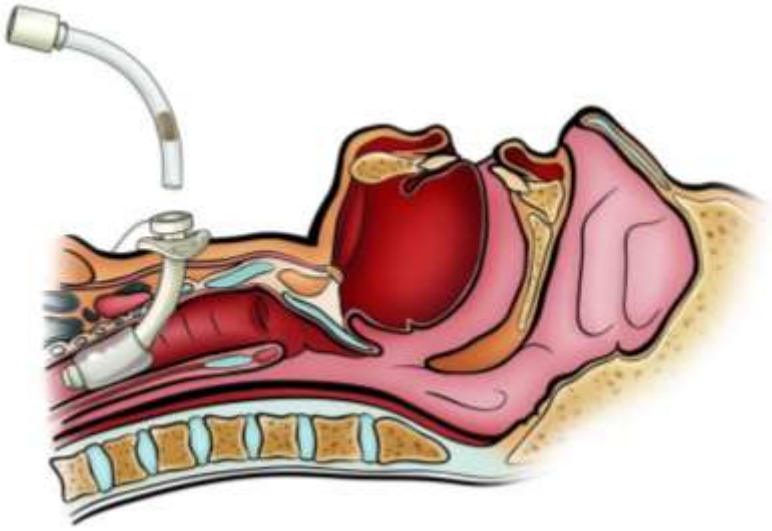

**Figure 3:** Tracheostomy surgical intervention

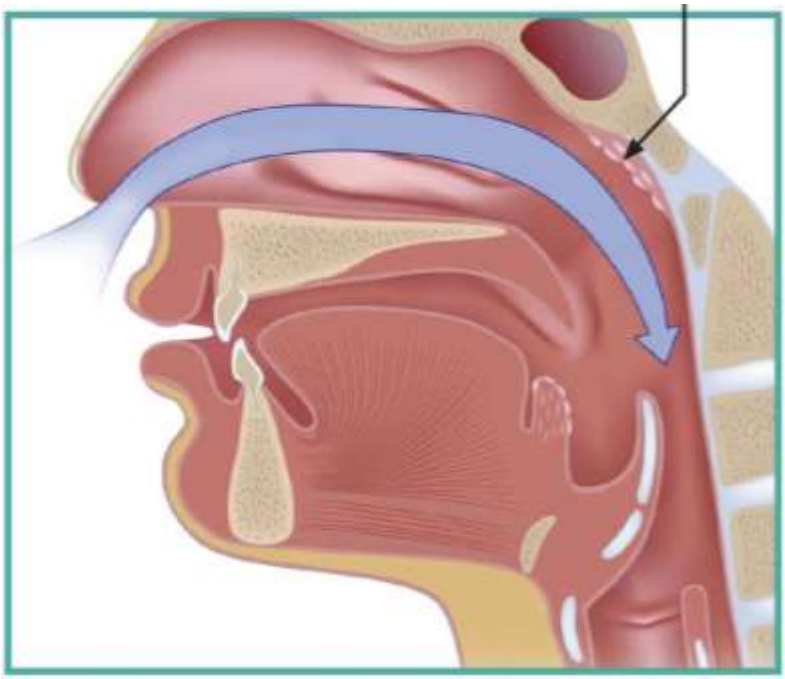

**Figure 4:** Normal development of adenoid in a normal person

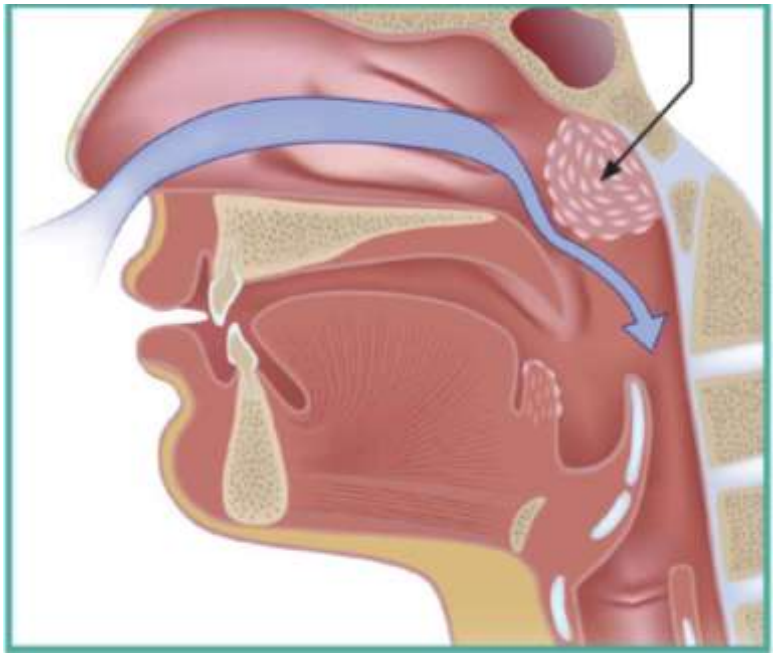

**Figure 5:** Enlargement of adenoid in upper airway sleep disorder patient

The tongue and soft palate move backward and come in contact with the posterior wall of the oropharynx and decrease the airway space. If the blockage is not complete the uvula & soft tissues vibrate. In complete blockage, snoring and OSA occurs. From upright to supine position the thickness of the soft palate increases [26]. The oropharyngeal cross-sectional area is decreased. Polysomnogram (PSG) an instrument used to evaluate, sleep, and breathing patterns. It determines the existence, type, and severity of disorders and also determines the effectiveness of completed treatment. ENT examinations and radiographs [27] used to find the cause of obstruction. PSG also provides a hypopnea index (HI), apnea sleep ratio, and respiratory disturbance index (RDI) [28]. For home studies, pulse oximetry devices are used for convenience purposes [29].

**Snoring**

Snoring is a common problem [30] affecting 25% of adult men [25]. It is the result of soft tissues in the upper airway vibrating during inspiration due to increased velocity of air, entering decreased airway space. The recent studies say that snoring is medically significant [31], and mostly is of loud snoring [32].

**Obstructive sleep apnea (OSA)**

Obstructive sleep apnea (OSA) is a poorly recognized medical condition that occurs due to upper airway occlusion during sleep. It is also defined as an apnea-hypopnea index of 5 events per hour. Mostly it affects 4% of males and 2% of the female population [33]. Patients with OSA are in danger of cardiac arrhythmias [34]. OSA is life-threatening for adults and it's linked with sudden infant death syndrome (SIDS) [35]. The different causes for OSA are, in supine position due to the blockage of the upper airway genioglossus muscle, which has altered timing of activity, thickening of lateral walls of the pharynx, increases pharyngeal length in the supine position.

**Cranial Morphology**

Craniofacial morphology and occlusal patterns are influenced by a variety of factors. Upper airway obstruction and craniofacial morphology have been considered over centuries. The structure of the face is also a cause for UASD [36]. Several studies have shown that there is a relationship between mouth breathing and the development of skeletal and dental abnormalities. The anatomic alterations reduce airway space [37]. Abnormality of nose, nasopharynx, oropharynx, oral cavity also causes a reduction of airway space. The different anatomical alterations are extended neck, posteriorly positioned maxilla and mandible, tongue, steep occlusal planes, over erupted anterior teeth, large gonial angles, anterior open bites, posterior pharyngeal wall, retrognathic mandibles, large tongue, soft palate, acromegaly and Down's syndrome [38]. Deviation of the nasal septum may also be the cause of UASD. The above-said conditions combined with supine position results in compromised airways.

**Medications using dental treatments**

Most of the people visit dental clinics after diagnosis of respiratory disorder with other specialists. So a dentist should provide the correct dental treatment by preparing and fitting dental devices. In 1996, the American sleep disorder association accepted dental treatments for UASD. Blockage of the airway due to apnea or hypopnea results in reduced airflow to the lungs. The treatment increases life expectancy, decreases health hazards, and improves the quality of life. The behavioral changes involved in UASD are weight loss, changes in sleep position. The most used dental treatment is the TRD and mandibular advancement device. There are 35 commercial devices available [39]. Figure 2 shows the usage of oral devices for the treatment of sleep apnea patients.

**Tongue retaining device**

The tongue retaining device (TRD), prevents the dropping of tongue posteriorly. A suction is created in the patient's mouth, it forces the tongue to fall in the hollow bulb in the device, to maintain the tongue in the bulb, for several hours placed between the anterior teeth. The advantage is it can be used for edentulous patients [29]. It reduces the number and duration of apnea [40]**.**

**Mandibular repositioner**

Some studies have shown that 27.6% of partial air volume is increased by using a mandibular repositioner [41]. Mandible repositioners can be a type of fixed or adjustable [42]. In a fixed mandibular repositioner there is a necessary for mandibular advancement. It stabilizes the mandible both horizontally and vertically, keeping the tongue away from, pharyngeal wall. Most of the oral devices decreased snoring from 73% to 98% in two different studies [43]. Dental devices are effective in treating snoring and mild to moderate OSA patients [29].

**Surgical treatment**

There are two phases of surgeries: phase 1 and phase 2. Some will perform phase 2 surgery initially and some will perform a combination of page 1 and phase 2 [44]. The different surgical treatments for UASD are tracheostomy, mandibular surgery, nasal septal survey, hyoid bone suspension, partial tongue resection,

maxillomandibular advancement osteotomy, inferior mandibular osteotomy, lingual plasty, genioglossal advancement with hyoid myotomy suspension, uvulopalatopharyngoplasty [45]. The surgical treatment for children is a tonsillectomy and adenoidectomy [46]. Tracheostomy is successful treatment and provides airway below obstruction (figure 3). Uvulopalatoplasty reduces snoring from 80% to 90% [38]. Nasal surgeries are effective at 20% [47]. The advancement of mandibles is successful at 33% [48] by moving the mandible forward with a 10% protrusion jaw position [49]. The gold standard treatment for OSA in adults is positive airway pressure (PAP). Figure 4 represents the normal adenoid development. In figure 5 the development of abnormal adenoid which blocks the upper airway making it difficult to breathe**.** The abnormal development of adenoids can be removed by adenoidectomy.

**Failure of dental treatments**

Tracheostomy has negative psychological and esthetic effects and indication limits [50]. Uvulopalatoplasty is not successful for the base of tongue obstructions [51]. Another study found that it can also cause mortality and morbidity [52]. In fixed mandibular repositioners to some extent, no further protrusion or regressive adjustment can be made, and also it shows no satisfactory results [43]. In some treatment, there is a loss of occlusion. Many dental materials are of small size when the patients are treated in a supine position, there is a chance of swallowing the materials. Surgical treatment has life-threatening complications such as fatal in the postoperative period due to upper airway collapse or surgical edema [43].

**Conclusion**

As 3% of the middle age population suffers from upper airway sleep disorders which further results in less concentration and more automobile accidents which may be life-threatening, Various treatment methods are employed for the treatment of UASD. Although surgical treatment has life-threatening complications, some studies have shown that it has a success rate of 70% to 99% in treating UASD. Dental treatments are also used, which has a success rate of 70 to 90%. Hence innovative procedures have to be explored for treating UASD.

**REFERENCES**

[1] Ivanhoe JR, Cibirka RM, Lefebvre CA, Parr GR. Dental considerations in upper airway sleep disorders: A review of the literature. The Journal of Prosthetic Dentistry 1999;82:685–98. https://doi.org/10.1016/s0022-3913(99)70010-7.

[2] Findley LJ, Unverzagt ME, Surratt PM. Automobile accidents involving patients with obstructive sleep apnea. Am Rev Respir Dis 1988;138:337–40. https://doi.org/10.1164/ajrccm/138.2.337.

[3] Guilleminault C, Stoohs R, Clerk A, Cetel M, Maistros P. A cause of excessive daytime sleepiness. The upper airway resistance syndrome. Chest 1993;104:781–7. https://doi.org/10.1378/chest.104.3.781.

[4] Noureddine SN. Sleep apnea: A challenge in critical care. Heart & Lung 1996;25:37–42. https://doi.org/10.1016/s0147-9563(96)80010-0.

[5] Rosen CL, D'Andrea L, Haddad GG. Adult criteria for obstructive sleep apnea do not identify children with serious obstruction. Am Rev Respir Dis 1992;146:1231–4. https://doi.org/10.1164/ajrccm/146.5_Pt_1.1231.

[6] Fletcher EC. The relationship between systemic hypertension and obstructive sleep apnea: facts and theory. Am J Med 1995;98:118–28. https://doi.org/10.1016/S0002-9343(99)80395-7.

[7] Shukri NMM, Vishnupriya V, Gayathri R, Mohan SK. Awareness in childhood obesity. Research Journal of Pharmacy and Technology 2016;9:1658. https://doi.org/10.5958/0974-360x.2016.00334.6.

[8] Rengasamy G, Venkataraman A, Veeraraghavan VP, Jainu M. Cytotoxic and apoptotic potential of Myristica fragrans Houtt. (mace) extract on human oral epidermal carcinoma KB cell lines. Brazilian Journal of Pharmaceutical Sciences 2018;54. https://doi.org/10.1590/s2175-97902018000318028.

[9] Menon A, V VP, Gayathri R. PRELIMINARY PHYTOCHEMICAL ANALYSIS AND CYTOTOXICITY POTENTIAL OF PINEAPPLE EXTRACT ON ORAL CANCER CELL LINES. Asian Journal of Pharmaceutical and Clinical Research 2016:140. https://doi.org/10.22159/ajpcr.2016.v9s2.13313.

[10] Priya VV, Jainu M, Mohan SK. Biochemical Evidence for the Antitumor Potential of Linn. On Diethylnitrosamine-Induced Hepatic Carcinoma. Pharmacogn Mag 2018;14:186–90. https://doi.org/10.4103/pm.pm_213_17.

[11] Ma Y, Karunakaran T, Veeraraghavan VP, Mohan SK, Li S. Sesame Inhibits Cell Proliferation and Induces Apoptosis through Inhibition of STAT-3 Translocation in Thyroid Cancer Cell Lines (FTC-133). Biotechnology and Bioprocess Engineering 2019;24:646–52. https://doi.org/10.1007/s12257-019-0151-1.

[12] Gan H, Zhang Y, Zhou Q, Zheng L, Xie X, Veeraraghavan VP, et al. Zingerone induced caspase-

dependent apoptosis in MCF-7 cells and prevents 7,12-dimethylbenz(a)anthracene-induced mammary carcinogenesis in experimental rats. J Biochem Mol Toxicol 2019;33:e22387. https://doi.org/10.1002/jbt.22387.

[13] G R, Ramya G, V VP, Gayathri R. CYTOTOXICITY OF STRAWBERRY EXTRACT ON ORAL CANCER CELL LINE. Asian Journal of Pharmaceutical and Clinical Research 2018;11:353. https://doi.org/10.22159/ajpcr.2018.v11i9.25955.

[14] Ponnulakshmi R, Shyamala Devi B, Vijayalakshmi P, Selvaraj J. In silico and in vivo analysis to identify the antidiabetic activity of beta-sitosterol in adipose tissue of high-fat diet and sucrose induced type-2 diabetic experimental rats. Toxicol Mech Methods 2019;29:276–90. https://doi.org/10.1080/15376516.2018.1545815.

[15] Rengasamy, G., Jebaraj, D.M., Veeraraghavan, V.P., Mohan, S.K. Characterization, partial purification of alkaline protease from the intestinal waste of Scomberomorus guttatus and production of laundry detergent with alkaline protease additive. Indian Journal of Pharmaceutical Education and Research 2016. https://doi.org/10.5530/ijper.50.2.19.

[16] Chen F, Tang Y, Sun Y, Veeraraghavan VP, Mohan SK, Cui C. 6-shogaol, and an active constituent of ginger prevents UVB radiation mediated inflammation and oxidative stress through modulating NrF2 signaling in human epidermal keratinocytes (HaCaT cells). J Photochem Photobiol B 2019;197:111518. https://doi.org/10.1016/j.jphotobiol.2019.111518.

[17] SURAPANENI KRISHNA MOHAN, VISHNU PRIYA VERRARAGHAVAN, MALLIKA JAINU. EFFECT OF PIOGLITAZONE, QUERCETIN, AND HYDROXYCITRIC ACID ON EXTRACELLULAR MATRIX COMPONENTS IN EXPERIMENTALLY INDUCED NONALCOHOLIC STEATOHEPATITIS. Iran J Basic Med Sci 2015;18:832–6.

[18] Ke Y, Al Aboody MS, Al Turaiki W, Alsagaby SA, Alfaiz FA, Veeraraghavan VP, et al. Photosynthesized gold nanoparticles from Catharanthus roseus induces caspase-mediated apoptosis in cervical cancer cells (HeLa). Artif Cells Nanomed Biotechnol 2019;47:1938–46. https://doi.org/10.1080/21691401.2019.1614017.

[19] Wu F, Zhu J, Li G, Wang J, Veeraraghavan VP, Mohan SK, et al. Biologically synthesized green gold nanoparticles from Siberian ginseng induce a growth-inhibitory effect on melanoma cells (B16). Artificial Cells, Nanomedicine, and Biotechnology 2019;47:3297–305. https://doi.org/10.1080/21691401.2019.1647224.

[20] Wang Y, Zhang Y, Guo Y, Lu J, Veeraraghavan VP, Mohan SK, et al. Synthesis of Zinc oxide nanoparticles from Marsdenia tenacissima inhibits the cell proliferation and induces apoptosis in laryngeal cancer cells (Hep-2). J Photochem Photobiol B 2019;201:111624. https://doi.org/10.1016/j.jphotobiol.2019.111624.

[21] Li Z, Veeraraghavan VP, Mohan SK, Bolla SR, Lakshmanan H, Kumaran S, et al. Apoptotic induction and anti-metastatic activity of eugenol encapsulated chitosan nanopolymer on rat glioma C6 cells via alleviating the MMP signaling pathway. J Photochem Photobiol B 2020;203:111773. https://doi.org/10.1016/j.jphotobiol.2019.111773.

[22] Stadler DL, Doug McEvoy R, Bradley J, Paul D, Catcheside PG. Changes in lung volume and diaphragm muscle activity at sleep onset in obese obstructive sleep apnea patients vs. healthy-weight controls. Journal of Applied Physiology 2010;109:1027–36. https://doi.org/10.1152/japplphysiol.01397.2009.

[23] Mezzanotte WS, Tangel DJ, White DP. Waking genioglossal electromyogram in sleep apnea patients versus normal controls (a neuromuscular compensatory mechanism). J Clin Invest 1992;89:1571–9. https://doi.org/10.1172/JCI115751.

[24] Adachi S, Lowe AA, Tsuchiya M, Ryan CF, Fleetham JA. Genioglossus muscle activity and inspiratory timing in obstructive sleep apnea. Am J Orthod Dentofacial Orthop 1993;104:138–45. https://doi.org/10.1016/S0889-5406(05)81003-0.

[25] Waldhorn RE. Sleep apnea syndrome. Am Fam Physician 1985;32:149–66.

[26] Pae EK, Lowe AA, Sasaki K, Price C, Tsuchiya M, Fleetham JA. A cephalometric and electromyographic study of upper airway structures in the upright and supine positions. Am J Orthod Dentofacial Orthop 1994;106:52–9. https://doi.org/10.1016/S0889-5406(94)70021-4.

[27] Sériès F. Evaluation of treatment efficacy in sleep apnea-hypopnea syndrome. Sleep 1996;19:S71–6. https://doi.org/10.1093/sleep/19.suppl_9.s71.

[28] The International Classification of Sleep Disorders. By the American Sleep Disorders Association. (Pp. 396; 59.95 hb, 49.95 PB.) American Sleep Disorders Association: Rochester, MN. 1990. Psychological Medicine 1991;21:1079–1079. https://doi.org/10.1017/s0033291700030117.

[29] Ferguson KA, Ono T, Lowe AA, Keenan SP, Fleetham JA. A randomized crossover study of an oral appliance vs nasal-continuous positive airway pressure in the treatment of mild-moderate obstructive sleep apnea. Chest 1996;109:1269–75. https://doi.org/10.1378/chest.109.5.1269.

[30] Man GC. Obstructive sleep apnea. Diagnosis and treatment. Med Clin North Am 1996;80:803–20. https://doi.org/10.1016/s0025-7125(05)70468-5.

[31] Chaudhary BA, Smith JK. Obstructive sleep apnea syndrome. J Med Assoc Ga 1991;80:541–5.
[32] Schwab RJ. Properties of tissues surrounding the upper airway. Sleep 1996;19:S170–4. https://doi.org/10.1093/sleep/19.suppl_10.170.
[33] 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. https://doi.org/10.1056/NEJM199304293281704.
[34] Clark GT, Nakano M. Dental appliances for the treatment of obstructive sleep apnea. The Journal of the American Dental Association 1989;118:611–9. https://doi.org/10.14219/jada.archive.1989.0086.
[35] Boudewyns AN, Van de Heyning PH. Obstructive sleep apnea syndrome in children: an overview. Acta Otorhinolaryngol Belg 1995;49:275–9.
[36] Lowe AA, Santamaria JD, Fleetham JA, Price C. Facial morphology, and obstructive sleep apnea. Am J Orthod Dentofacial Orthop 1986;90:484–91. https://doi.org/10.1016/0889-5406(86)90108-3.
[37] Lowe AA, Fleetham JA, Adachi S, Ryan CF. Cephalometric and computed tomographic predictors of obstructive sleep apnea severity. Am J Orthod Dentofacial Orthop 1995;107:589–95. https://doi.org/10.1016/s0889-5406(95)70101-x.
[38] Ryan CF, Lowe AA, Li D, Fleetham JA. Three-dimensional upper airway computed tomography in obstructive sleep apnea. A prospective study in patients treated by uvulopalatopharyngoplasty. Am Rev Respir Dis 1991;144:428–32. https://doi.org/10.1164/ajrccm/144.2.428.
[39] Barsh LI. Responsibilities of the dental profession in recognizing and treating sleep breathing disorders. Compend Contin Educ Dent 1996;17:490–4, 496 passim; quiz 502.
[40] Cartwright RD, Samelson CF. The effects of a nonsurgical treatment for obstructive sleep apnea. The tongue-retaining device. JAMA 1982;248:705–9.
[41] Ryan CF, Love LL, Peat D, Fleetham JA, Lowe AA. Mandibular advancement oral appliance therapy for obstructive sleep apnoea: effect on the awake caliber of the velopharynx. Thorax 1999;54:972–7. https://doi.org/10.1136/thx.54.11.972.
[42] Robin P. GLOSSOPTOSIS DUE TO ATRESIA AND HYPOTROPHY OF THE MANDIBLE. Archives of Pediatrics & Adolescent Medicine 1934;48:541. https://doi.org/10.1001/archpedi.1934.01960160063005.
[43] Schmidt-Nowara W, Lowe A, Wiegand L, Cartwright R, Perez-Guerra F, Men's. Oral appliances for the treatment of snoring and obstructive sleep apnea: a review. Sleep 1995;18:501–10. https://doi.org/10.1093/sleep/18.6.501.
[44] Mohan SK, Veeraraghavan VP, Jainu M. Effect of pioglitazone, quercetin, and hydroxy citric acid on extracellular matrix components in experimentally induced non-alcoholic steatohepatitis. Iran J Basic Med Sci 2015;18:832–6.
[45] Practice parameters for the treatment of obstructive sleep apnea in adults: the efficacy of surgical modifications of the upper airway. Report of the American Sleep Disorders Association. Sleep 1996;19:152–5.
[46] Deutsch ES. Tonsillectomy and adenoidectomy. Changing indications. Pediatr Clin North Am 1996;43:1319–38. https://doi.org/10.1016/s0031-3955(05)70521-6.
[47] Sériès F, St. Pierre S, Carrier G. Effects of Surgical Correction of Nasal Obstruction in the Treatment of Obstructive Sleep Apnea. American Review of Respiratory Disease 1992;146:1261–5. https://doi.org/10.1164/ajrccm/146.5_pt_1.1261.
[48] Bear SE, Priest JH. Sleep apnea syndrome: correction with surgical advancement of the mandible. J Oral Surg 1980;38:543–9.
[49] Masumi S, Nishizawa K, Williams AJ, Yan-Go FL, Clark GT. Effect of jaw position and posture on forced inspiratory airflow in normal subjects and patients with obstructive sleep apnea. Chest 1996;109:1484–9. https://doi.org/10.1378/chest.109.6.1484.
[50] Riley RW, Powell NB, Guilleminault C, Nino-Murcia G. Maxillary, mandibular, and hyoid advancement: an alternative to tracheostomy in obstructive sleep apnea syndrome. Otolaryngol Head Neck Surg 1986;94:584–8. https://doi.org/10.1177/019459988609400509.
[51] Riley RW, Powell NB, Guilleminault C. Maxillofacial surgery and nasal CPAP. A comparison of treatment for obstructive sleep apnea syndrome. Chest 1990;98:1421–5. https://doi.org/10.1378/chest.98.6.1421.
[52] Lee WC, Skinner DW, Prichard AJN. Complications of palatoplasty for snoring or sleep apnoea. The Journal of Laryngology & Otology 1997;111:1151–4. https://doi.org/10.1017/s002221510013957x.