Review Article

Airway-centric orthodontics: a review on oral appliance therapy as a simplified solution to obstructive sleep apnea

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Abstract: Obstructive sleep apnea (OSA) is a widespread sleep-related breathing disorder. However, a large proportion of cases go undiagnosed due to a deficit of knowledge regarding the genesis and management of the condition. We present an evolutionary cranio-skeletal basis to OSA, and collate current knowledge regarding OSA prevalence, biological effects and its management using oral appliance therapy (OAT). This review discusses the specific craniofacial and morphological factors that predispose the condition, obesity and narrow pharyngeal airway spaces being in the forefront. The primary diagnosis and recognition of this anomaly falls within the purview of the orthodontist, oral diagnosticians, surgeons as well as the general dentist as part of a multidisciplinary team, hence we discuss several risk factors and diagnostic modalities for OSA that can be realized on a simple oral examination and diligent oropharyngeal examination, questionnaires, radiological assessment, etc. The review also focuses on the use of cephalometric and diagnostic cast analysis in planning the management of OSA. The multisystemic effects beyond respiration with effects on vasculature and the central nervous system are also presented. Positive air pressure (PAP) devices have been the gold standard for OSA management; however, OAT has been found to be equally effective as PAP in management of OSA with proper case and appliance selection. Various OAT appliance designs and their benefits, efficacy rates, and alternative therapies such as surgical management have also been presented. The authors also discuss pediatric OSA and its unique diagnostic and management strategies.

Keywords: Obstructive sleep apnea (OSA); surgically assisted rapid palatal expansion (SARPE); oral appliance therapy (OAT); sleep-disordered breathing; continuous positive air pressure (CPAP)

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Introduction

Background

"*You that seek what life is in death, now find it air that once was breath*."—Baron Brooke Fulke Greville, "Caelica 83".

Air, breath, and life are synonymous. Breath sustains life and every cell of the several billion that constitute the human body's need to breathe. Surprising though, the intersection of evolutionary biology, function, and biomechanical modulation of the craniofacial skeleton struggles to find a central position in clinical orthodontics and oral health sciences.

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Any decrease in breath on the other hand has numerous dangerous and potentially dangerous effects for all life. Obstructive sleep apnea (OSA) is one such disease characterized by episodes of upper air passage collapse during sleep accompanied by hypoxia and sleep arousals. Patients with OSA may complain of various signs and symptoms such as daytime sleepiness (1), snoring and choking and gasping during sleep (2), nocturia (3), morning headaches (4), increased sedentary fatigue (5), unrefreshing sleep (6), and chronic insomnia (7) making a positive diagnosis of OSA difficult (8). Risk factors predisposing to OSA include obesity, large neck diameter, male sex, increasing age, post-menopausal status, and disturbances of the craniofacial region (6,9).

While polysomnography (PSG) remains the gold standard for testing for OSA, the use of home sleep apnea testing (HSAT) has emerged as a reasonable alternative with a sensitivity and specificity of 79% the use of several questionnaires such as the Stop Bang, Epworth Sleepiness Scale (ESS), and the Berlin Scale also have seen a wide acceptance in the clinical setting (6).

Rationale and knowledge gap

OSA prevalence is increasing, Benjafield *et al.* reported an OSA (mild to severe) prevalence of 936 million persons between 30 to 69 years, and 425 million persons between 30 and 69 years have OSA (moderate to severe) globally, according to the diagnostic criteria of the American Academy of Sleep Medicine (10). The prevalence rates of OSA in different regions vary with rates from 3% (females) to 10% (males) (11) to rates as high as 78% (females) to 90% (males) being reported making it one of the commonest sleep disorders (12). The rising challenge of obesity brings an increasing focus on OSA. There is a need to address the address the etiology, pathogenesis, and management strategies for OSA. The role craniofacial anomalies have been receiving much attention as contributors for OSA (6), with a lot of recent studies focusing on the role of malocclusion and craniofacial anomalies as contributory factors for OSA bringing to fore the role of dentists in early diagnosis and management of OSA (13,14).

There exist diverse modalities for the management of OSA with lifestyle modifications such as abstinence from alcohol, exercise, changes in sleep position to name a few being the least invasive (6). Skeletal and soft tissue surgeries have also been recommended as management strategies (15). Positive air pressure (PAP) has emerged as the mainstay in the treatment of OSA. Continuous PAP (CPAP) was first tried in 1981 and is the most common delivery in use subsequent modifications such as bilevel PAP (BPAP) have provided better results. Technological advancements such as auto CPAP (ACPAP) and Auto BPAP (ABPAP) have led to better results (16). However patient compliance with PAP devices have been challenging. There is also the emerging recognition that effective management of OSA needs an interdisciplinary approach (17).

Dentists often examine various structures such as the tongue, tonsils, soft palate and evaluate jaw position routinely thus making them an important part of the multidisciplinary team for the management of OSA (18). The use of oral appliances which reposition the jaws during sleep in the management of OSA is a promising field because of better tolerance in patients intolerant to PAP appliances (6) leading to the emergence of a new field in dentistry i.e., dental sleep medicine

Objective

This review presents an all-inclusive view of OSA in the context of evolutionary cranio-skeletal development, collates current knowledge regarding OSA prevalence in contrast to issue or subject specific reviews. The biologic effects of OSA have been added to ensure a holistic view of the condition. Special emphasis that has been placed on the recommendations on diagnosis of OSA using simple diagnostic aids routinely used by dentists and management of OSA using relatively simple oral appliance therapy (OAT) are deliberated.

OSA: cause & ramifications

The term "Pickwickian syndrome" that's sometimes used for the syndrome became coined by the famous early twentieth-century doctor, William Osler, who apparently was a reader of Charles Dickens. The description of Joe, "the fat boy" in the pickwick papers suits flawlessly with the clinical image of a person with OSA syndrome. The effect of OSA on overall health is also well established, 50% of cardiac patients have a varying degree of OSA and a causative link between OSA, stroke, and coronary artery disease is also well established in literature (19,20). Yet the underlying problems remain surprisingly undiagnosed. A systematic review and meta-analysis by Chen *et al.* in 2021 shows that 80–90% of cases go undiagnosed with a huge health liability and risk (21). There is flippancy and embarrassment over seeking help or

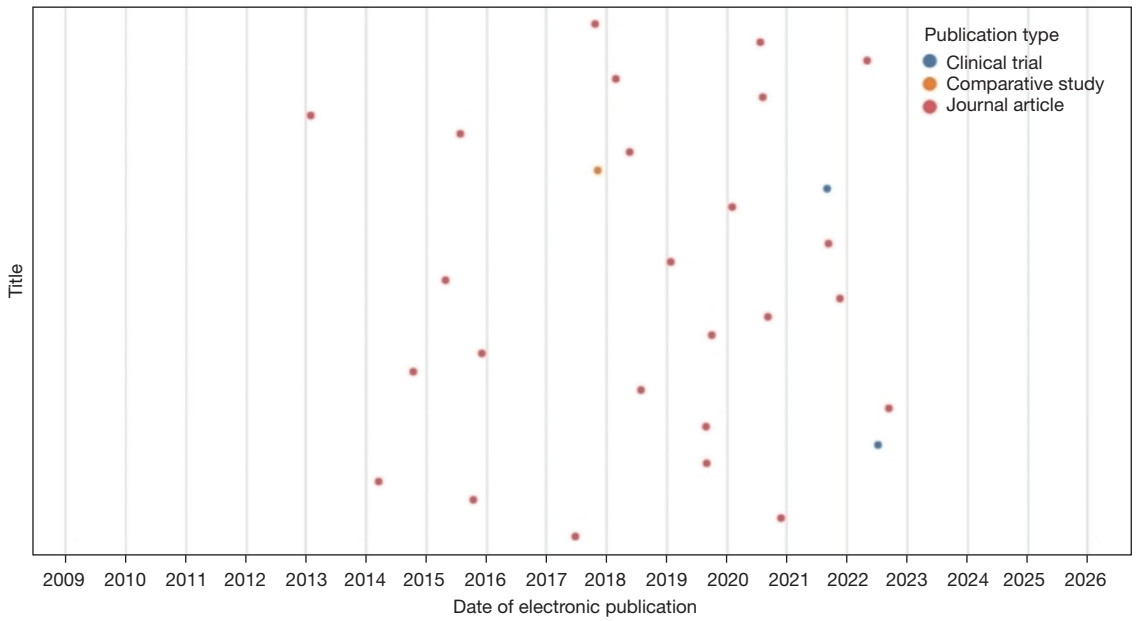

Figure 1 ArIS chart demonstrating distribution of articles from the AI search. ArIS, advanced research intelligence system; AI, artificial intelligence.

a consultation over sleep problems and snoring.

OSA is related to the enhanced crumpling of the upper air passage. The pharyngeal critical closing pressure (PCRIT) defines the point at which the air passage collapse occurs. Impaired muscle tone, mandibular and tongue position add to the collapse. The increased effort to maintain respiration in a compromized air passage is accompanied by an enhanced serum carbon dioxide and diminished oxygen levels (22,23). The respiratory distress is related to cortical arousal and an increase in sympathetic neural activity with spikes in blood pressure, heart rate and a predisposition towards cardiac arrythmias (8). Multiple sleep wake cycles complicate the issue with serious health consequences.

Search strategy

PubMed/Embase/Scopus/Web of Science databases were searched for studies that mentioned sleep apnea, obstructive sleep apnea, OSA in the title and mentioned oral appliance, myofunctional in the title or abstract. The following search strategy was put into the advanced research intelligence system (AriS) chart using python software (*Figure 1*). The articles were sub divided into clinical trials, controlled clinical trial comparative study and others. The following were the search terms used: (sleep apnea [Title] OR obstructive sleep apnea[Title] OR OSA[Title]) AND (appliance[Title/Abstract] OR oral appliance[Title/Abstract]) AND (systematic review[Title] OR meta-analysis[Title]).

OSA: an evolutionary basis

Evolutionary biology has been a serious contributor to this emerging silent epidemic as some have termed it (24). Bipedalism, an erect posture, a collapsible oropharynx, all led to a progressive set of factors where a minor variation could have unprecedented outcomes on the airway and breathing. Bipedalism of homo sapiens came at a price, the scaffolding had to support the weight of the cranium, brain posture became an issue and the larynx descended. Migration into the grasslands and the introduction of pursuit hunting led to an increased demand for oxygen in our ancestors which was provided by mouth breathing. The process of verbal communication and language affected tongue position and posture. If the tongue rested completely in the oral cavity, it would not impede the airway, but phonation and articulation would be a challenge, so the tongue came to lie in the oropharynx setting the stage for compromising airway with even small variations in position and posture (25).

A growing concern in evolutionary biology was the

Figure 2 Hypothetical correlation between OSA and evolution (14,25-27,30,34,35). OSA, obstructive sleep apnea.

possibility of a progressive reduction of the size of the human jaws, this is made out by comparisons of medieval skulls with modern skulls in which the medieval skulls have shown little or no evidence of malocclusion, had ample space for the tongue, and showed a minimal prevalence of mandibular third molar impactions, all of these traits are found compromized in modern human skulls. Craniofacial development was linked to changing dietary and chewing habits from coarse to more refined food (26) and anthropologists set about building a link with the reduction in the size of the jaws (27). Some experts in dental anthropology, infer that malocclusion has accelerated in the last 150 years or so in technologically advanced communities (28).

Observations on the effect on muscle posture modifying facial growth are present in published literature (29). Obstructions in the naso-respiratory passages have been found to promote a clockwise rotation in the growing mandible thereby leading to increase in anterior vertical facial height and decrease in posterior vertical height leading to retrognathia and open bites (30,31). Harvold has demonstrated the impact of impaired nasal breathing on craniofacial development. Obstructed airway leads to an extended cranio-cervical extension and a forward head posture to maintain patency of airway which unfortunately does not happen during sleep (32).

Dentists on the other hand have seen malocclusions from the prism of genetics only, ignoring an increasing body of evidence which focusses on the epigenetic/phenotypic events leading to malocclusions (33).

What Mew postulated in his philosophical paper suggesting the disruption of resting oral posture by environmental factors guiding skeletal growth patterns and genesis of a dental malocclusion which is defined by muscle patterns primarily of the tongue (34) has now found experimental evidence in the work of Engelke *et al.* who have demonstrated the formation at least two functional components in their bio-functional model reaffirming the role of muscle posture in oral skeletal development (35). These findings present an interesting evolutionary pathway for the development of OSA (*Figure 2*) and are summarized in *Table 1*.

Biologic burden of OSA

The complex interrelationship between sleep and health has been widely recognized. Disturbed sleep is in numerous studies found associated with diseases of cardiovascular and metabolic systems. There is also emerging evidence that sleep disorders increase the risk of breast, prostate and

Table 1 OSA an evolutionary basis

Author, year	Study type	Number of subjects	Outcome evaluated	Results and conclusion	Quality of evidence
Kahn, 2020	Expert opinion and literature review	–	–	OSA symptoms are phenotypic responses to a vast natural experiment—rapid and dramatic modifications of human physical and cultural environments	Low
Goose, 1962	Case control	403	Width and length of modern and historic skulls	Significant reduction in width of modern skulls leading to crowding	Low
Corruccini, 1984	Case control	2,152	Occlusal variations in overjet, overbite, crossbite and tooth displacement scores between urbanized and non-urban populations	Increased variations in overbite, crossbite and tooth displacement scores suggesting occlusal variations is an aberrancy of modern urbanized population	Low
Bresloin, 1983	Case control	45	Effects of abnormal breathing patterns on facial growth using cephalometric radiographic analysis	Increased facial height, larger gonial angles, retrognathic maxilla and mandible, greater overjet and reduced maxillary intermolar width leading to increase molar crossbite seen in mouth breathers Nasal airway obstruction is associated with aberrant facial growth	Moderate
Harari, 2010	Retrospective case control	116	Cephalometric analysis, and dental study models analysis for, arch form, tooth position, occlusion, and other normal parameters liable to undergo changes due to mouth breathing	The prevalence of a posterior cross bite was significantly more frequent in the mouth breathers group (49%) than nose breathers (26%) Abnormal lip-to-tongue anterior oral seal was significantly more frequent in the mouth breathers group (56%) than in the nose breathers group (30%) Naso-respiratory obstruction with mouth breathing during critical growth periods in children has a higher tendency for clockwise rotation of the growing mandible, with a disproportionate increase in anterior lower vertical face height and decreased posterior facial height	Moderate
D'Onofrio, 2019	Expert opinion and literature review	–	Effect of oral dysfunction on malocclusion	Malocclusions and their acquired craniofacial dysmorphology are the result of chronic oral dysfunction and OMD	Low
Harvold, 1981	Single center prospective	42	Relationship between mouth breathing and dental malocclusion by means of primate experiments	Increased facial height, larger gonial angle and steeper mandibular plane in mouth breathers	Moderate
Engelke, 2011	Single center prospective	20	Effect of oral posture on the development of malocclusion by atmospheric pressure monitoring using a digital manometer in the vestibular interocclusal space and palatal vault	Demonstration of malocclusion related intraoral pressure levels as a basis for malocclusion therapy	Low

OSA, obstructive sleep apnea; OMD, oral myofunctional disorder.

colorectal cancers (36-40).

OSA has also been found to be associated with several systemic diseases and the intermittent hypoxia caused by OSA has been consistently found to predispose patients to cardiovascular diseases, insulin resistance and neural damage (8).

Cardiovascular diseases

OSA contributes to cardiovascular disease by affecting various paths of the cardiovascular system. Episodes of OSA produce central hemodynamic effects such as hypercapnia, intrathoracic pressure oscillation and produce arterial oxygen desaturation in addition to causing sleep disruption. This causes a fall in cardiac flow rate, decreased stroke volume and diminutions in cardiac rate (41). The post apnea period is typified by a pronounced transitory increase in systemic arterial pressure. The peripheral circulation is also affected with vasoconstriction being observed in the forearm and finger (42).

The increased cerebral blood flow seen during periods of apnea is followed by a sudden decline in the post-apnea period leading to fluctuations in the partial pressure carbon dioxide ($PaCO_2$) and causing breathing disability during sleep (43). In the pulmonary circulation OSA produces cyclic patterns of vasoconstrictions and vasorelaxations leading to fluctuations in pulmonary arterial pressure (44).

Endothelial damage by induction of endothelial cell apoptosis (45), increased levels of cell death markers serum nucleosomes, double-stranded DNA (19) and the presence of increased levels of cellular adhesion molecules [intercellular adhesion molecule (ICAM), vascular cell adhesion molecule (VCAM), and E-selectin] all point to endothelial insult as a key event predisposing to the occurrence of other vascular events such as cardiovascular death, unstable angina and myocardial infarction with stratified hazard ratios as high as 6.01 for cardiovascular events occurring in OSA patients (46).

Insulin resistance

Knowledge that obesity is a factor in both OSA and insulin resistance leading to type 2 diabetes has led to postulations of relationships between OSA and insulin resistance (47), causal relationships between the two were however difficult to generate because of the presence of confounding factors such as smoking, body mass index (BMI), age, etc.

The nurses' health study cohort found a relative risk for diabetes of 1.48 between occasional snoring *vs.* non-snoring, adjusting for other diabetes risk factors attenuated to relative risk to 1.41 showing that snoring and by extension OSA being an independent risk factor for type II diabetes (48). while the complex interrelationship between OSA and type II diabetes gets slowly unraveled the results of various clinical trials point out to intermittent hypoxia as a factor in causing insulin resistance and glucose intolerance in OSA patients.

Increased levels of catecholamines, the increased sympathetic neural traffic and amplified levels of cortisol by the effects of OSA on hypothalamic-pituitary-adrenal axis are other possibilities by which OSA predisposes to insulin resistance (49).

Neural damage

Neurobehavioral impairments such as sleepiness, fatiguability, impaired memory and poor concentration are seen in most adults with OSA. While investigating reasons for these, Macey *et al.* (50), Morrell *et al.* (51) have found marked reductions in the gray matter of the hippocampus, cingulate cortex and Broca's area using magnetic resonance imaging (MRI).

Higher levels of brain infarctions (25%) in comparison to normal obese controls (6%) and increased levels of CD40 ligand (CD40L) and P-selectin markers for cerebrovascular disease have been demonstrated by Minoguchi *et al.* in persons with OSA (52).

In the peripheral nervous system consistent functional impairment, with demyelination of motoneurons has been found in OSA and a correlation between the oxyhemoglobin desaturation and the severity of peripheral nerve dysfunction have been observed (8).

OSA and the immune system

The sleep immune crosstalk has recently received much attention (53) and thus it would only be logical that OSA would lead to impairments in the immune system.

Increase in T helper cells and alteration in the T_{helper}/$T_{regulator}$ ratios are noted in patients with OSA. Significant reductions in the peripheral dendritic cell population and reductions in B lymphocytes have also been found in patients suffering from OSA pointing to the presence of immune impairment in OSA (54).

In addition to impairments in the immune system OSA has also been shown to cause a dysregulation of circulating

cytokines. Pro-inflammatory cytokines such as the interleukins 6, 12, 17, and 23, tumor necrosis factor alpha, and matrix metalloproteinase (MMP)3 were increased whereas MMP2 and tumor necrosis factor-like weak inducer of apoptosis (TWEAK) levels were decreased (55).

While the data on immune dysregulation in OSA patients is rather recent, immune dysregulation also seems to predispose OSA patients to certain types of cancers and influence oncological outcome (56,57).

The results of the quoted literature are consolidated in *Table 2*.

Malocclusion and its relation to OSA

Recent systematic reviews and metanalysis have found that the worldwide prevalence of malocclusion is 56% with no gender variances. Africa (81%) had the highest prevalence was seen in followed by Europe (72%), America (53%) lowest prevalence was seen in Asia (48%) with prevalence rates of class I (74.7%; range, 40–96%), class II (19.56%; range, 2–63%), and class III (5.93%; range, 1–20%) (58,59).

Craniofacial disharmony is reflected in cases of OSA. The most common features of disharmony seen in cases of OSA are bimaxillary retrusion, decreased mandibular length, reduced cranial base angle with a shortened cranial base and increased lower anterior facial height amongst these the decreased mandibular length has been found to dispose most to OSA (60,61). Multiple regression analysis have demonstrated increased overjet and a class II malocclusion as significant risk factors for OSA, however racial variations exist and lateral cross bite was the most prominent transverse dimension predisposing to OSA (13,61-63).

An elongated face with a dolichoprosopic pattern, steep mandibular plane angle, high arched narrow palate, also find a positive association with OSA (*Figure 3*) (64).

Considering all of these findings together, the classical pathogenesis begins to emerge. A narrow palate with a mouth breathing habit would imply increase nasal airway resistance and altered tongue posture. Increased overjet with crowding would prevent lip closure further aggravating the problem (65). The mandibular retrognathia associated with slackening of the genioglossus and mentalis muscles, hypotonia of the circumferent musculature would produce a fall back of the base of tongue in supine position with partial or complete airway obstruction (66). A skeletal class II pattern in patients with OSA would be associated with an underdeveloped/posteriorly positioned mandible with associated soft tissue and muscle attachments. The articles of this section are summarized in *Table 3*.

Defining airway centric orthodontics

Is health merely an absence of disease or infirmity? Could malocclusion fall into a definition of a disease? Orthodontics has struggled with its own identity of coming to terms with malocclusion and health (67). However, the 'tooth' paradigm has been centric to dentistry, the central focus being fixing crooked or diseased teeth and restoring an occlusion from a skill based and technique centric model using technology and materials. The industry has offered cookbook solutions with newer materials and a 'stepwise' methodology often dictating professional trends. In the 1940's the World Health Organization (WHO) proposed a larger definition of health correlating not just the absence of disease and infirmity but well-being and quality of life (68). Airway centric orthodontics brings into sharp focus the need for a link between orthodontics, oral medicine, sleep medicine, a concept of health with focus on cell anatomy, biology, physiology pathology and shifting a paradigm away from cosmetic or smile design which by association tend to diminish a specialty that is so deeply rooted in health and well-being. It brings a new paradigm of diagnosis and holistic treatment with appliances, techniques and technology being relegated to a secondary role (69). After all moving teeth and remodelling the craniofacial skeleton is a biologic and cellular phenomenon which could only work if all the cellular blocks are in harmony and alignment.

Diagnosis of OSA

OSA and sleep disordered breathing requires a joint workup with a physician to confirm the level of the problem. There has been a lot of debate over whether only sleep experts should be diagnosing and managing OSA, nevertheless OSA has been diagnosed and managed by confluence of specialties in dentistry and several studies have shown that the treatment outcomes do not vary on the type of expert diagnosing and managing OSA (70,71).

There is no physical examination that is specific for OSA, however the signs and symptoms (*Table 4*) that point out to the probability that a patient has OSA are as follows:

(I) Overweight/obese (72);
(II) Neck circumference (>17 male, >16 female) (72);
(III) Greater waist to height ratio (73);
(IV) Male (6);

Table 2 Biological burden of OSA

Author, year	Study type	Number of subjects	Outcome evaluated	Results and conclusion	Quality of evidence
Li, 2019	Single center prospective multicentric	622	Effect of OSA on DNA methylation-based marker of biological aging	Severe OSA was associated with epigenetic age accelerators with AHI and arousal index associated with greater aging. Effects are more prominent among males	Moderate
OSA and cancer					
Cao, 2022	Literature review and meta-analysis	22 articles	Relationship between OSA and cancer	Overall prevalence of OSA among cancer patients is 46 and occurrence of cancers among persons suffering from OSA is 1.53 times higher than non-OSA individuals	Moderate
Blask, 2009	Literature review	–	Lack of sleep and cancer risk	Shortened duration of nocturnal sleep associated with increased cancer risk	Low
Wong, 2021	Prospective multicentric study and meta-analysis	24,476	Sleep duration and breast cancer risk over a period of 14.3 years	No correlation between sleep duration and risk of breast cancer	High
Almendros, 2012	Single center prospective	15	Effect of high-rate intermittent hypoxia seen in OSA on tumor size in a murine melanoma model	Two-fold increase in tumor necrosis a size in the hypoxic rats Intermittent hypoxia enhances tumor growth	Low
Huppertz, 2021	Single center prospective	33	HSAT in patients with confirmed oropharyngeal carcinomas and comparison with primary tumor size	Significant correlation between primary tumor size and AHI	Low
Nieto, 2012	Multicenter retrospective cohort	1,522	Mortality data from Wisconsin sleep cohort to determine effect of OSA in cancer mortality	Adjusted relative hazards of cancer mortality: 1.1 for mild OSA, 2.0 for moderate OSA, 4.8 for severe OSA OSA is associated with increased cancer mortality	Moderate
Choi, 2014	Single center retrospective	45,699	Associations between OSA and breast cancer incidence using the Korea national health insurance service database	Increased risk of breast cancer in OSA patients with a HR 1.20 (1.04–1.29) and increasing to 1.72 (1.10–2.19) in patients >65 years of age	–
OSA and the CVS					
Shiomi, 1991	Single center prospective	10	Echocardiogram from parasternal long axis view in OSA patients	Left shift of the intraventricular septum with pulsus paradoxus which disappeared after CPAP treatment	Low
Leuenberger, 2001	Single center prospective	10	Heart rate, MAP, MSNA (peroneal microneurography), and VFA (Doppler) under hypoxia (10.5% inspiratory fraction of O_2), and hyperoxia (100% inspiratory fraction of O_2)	The transient apnea-induced surges of MSNA and arterial pressure are associated with transient peripheral vasoconstriction Hypoxia accentuates the sympathetic and vasoconstrictor responses to apnea	Low
Xie, 2006	Single center prospective	9	Oral indomethacin was used to reduce the cerebrovascular reactivity to CO_2 and the steady-state hypercapnic ventilatory response to CO_2 was tested and hyperoxia (50% O_2)	Reduced cerebrovascular reactivity will cause an increase in ventilatory responsiveness to CO_2, which is commonly seen during sleep in patients with central sleep apnea	Low
Weitzenblum, 2005	Literature review	–	Relation between pulmonary hypertension and OSA	Nocturnal hypoxia not sufficient to induce pulmonary hypertension	Low
Solh, 2007	Single center case control	24	Brachial artery flow-mediated dilation was determined in 14 subjects with documented OSA and 10 healthy control subjects at baseline and 8 weeks after CPAP therapy. Quantification of circulating apoptotic endothelial cells (CD146 Annexin V) was performed by flow cytometry	In patients with OSA, impairment of endothelial-dependent vasodilation correlated with the degree of endothelial cell apoptosis CPAP therapy led to significant decline in circulating apoptotic endothelial cells	Low
Peres, 2021	Single center cohort	418	Predictive value of ICAM-1, VCAM-1, E-selectin levels in identifying risk of cardiovascular events in OSA	Higher levels of ICAM-1 were associated with developing CVD (HR =3.65, 95% CI: 1.40–9.53, 2nd and 3rd tertiles *vs.* 1st tertile), including in patients with OSA (HR =3.1, 95% CI: 1.16–8.25) E-selectin was significantly associated with cardiovascular events in patients with moderate to severe OSA (HR =3.31, 95% CI: 0.94–1.00, 2nd and 3rd tertiles *vs.* 1st tertile) but not in patients without moderate to severe OSA (HR =0.67, 95% CI: 0.19–2.38), P value for interaction =0.07	Moderate

Table 2 (*continued*)

Table 2 (*continued*)

Author, year	Study type	Number of subjects	Outcome evaluated	Results and conclusion	Quality of evidence
OSA and diabetes					
Al-Delaimy, 2002	Prospective cohort	1,957	Association between snoring and type II diabetes	In analyses adjusted for age and BMI, snoring was associated with risk of diabetes [for occasional snoring *vs.* non-snoring, RR =1.48 (95% CI: 1.29, 1.70); for regular snoring *vs.* non-snoring, RR =2.25 (95% CI: 1.91, 2.66); P for trend <0.0001]	Moderate
				Further adjustment for other diabetes risk factors and sleeping-related covariates only slightly attenuated the risk [for occasional snoring, RR =1.41 (95% CI: 1.22, 1.63); for regular snoring, RR =2.03 (95% CI: 1.71, 2.40); P for trend <0.0001]	
Punjabi, 2004	Milticenter cohort	2,656	Comparisons of PSG and oral glucose tolerance tests	In comparison to controls subjects with mild SDB (5.0–14.9 events/h) and moderate to severe SDB (≥15 events/h) had adjusted odds ratios of 1.27 (95% CI: 0.98, 1.64) and 1.46 (95% CI: 1.09, 1.97), respectively, for fasting glucose intolerance (P for trend <0.01)	Moderate
				Sleep-related hypoxemia was also associated with glucose intolerance independently of age, gender, BMI, and waist circumference	
				The results of this study suggest that SDB is independently associated with glucose intolerance and insulin resistance and may lead to type 2 diabetes mellitus	
Brain changes in OSA					
Macey, 2002	Single center case control	42	Comparison of high-resolution T1-weighted MRI between 21 OSA patients and 21 controls	Diminished regional and often unilateral gray matter in multiple sites of the brain in patients with OSA	Low
				Unilateral loss in well-perfused structures suggests onset of neural deficits early in the OSA syndrome	
				The gray matter loss occurs within sites involved in motor regulation of the upper airway as well as in areas contributing to cognitive function	
Morrell, 2003	Single center case control	14	Voxel based morphometry comparison of structural changes in gray between patients diagnosed with OSA and non-OSA controls	Significantly lower gray matter concentration within the left hippocampus (P=0.004) in the apnoeic patients	Low
Minoguchi, 2007	Single center case control	89	Silent brain infarction in 50 cases and 15 controls compared by MRI with 3-month CPAP treated follow up in 24 OSA cases. Levels of sCD40L and sP-selectin	The percentage of silent brain infarction in patients with moderate to severe OSA (25.0%) was higher than that of obese control subjects (6.7%) or patients with mild OSA (7.7%)	Low
				Higher levels of serum markers in patients with moderate to severe OSA than in obese control subjects	
				Reduction of serum marker levels with CPAP therapy	
Effects of OSA on the immune system					
Besedovsky, 2019	Literature review		Relationship between sleep and immunity	Sleep affects innate and adaptive immunity	Low
Ludwig, 2022	Literature review		Relationship between OSA and cell mediated immunity	OSA has a significant impact on the cellular immune system	Low
OSA and markers of renal disease					
Wang, 2021	Single center prospective	46	Serum levels of MMP2, TWEAK, IL-6, and TNF-α (predictive markers of renal and cardiovascular diseases) using a BioPlex array in 19 cases of untreated OSA and 19 treated cases and 8 non-OSA controls	Treated OSA patients had a 5.4-fold higher median level of MMP2 ($P=9.1\times10^{-11}$), 1.4-fold higher level of TWEAK ($P=1.8\times10^{-7}$), 1.7-fold higher level of CD163 ($P=1.4\times10^{-6}$), in contrast to untreated patients	Low
				Treatment brought about a significant normalization in levels	

OSA, obstructive sleep apnea; AHI, apnea-hypopnea index; HSAT, home sleep apnea testing; CVS, cardiovascular system; CPAP, continuous positive air pressure; MAP, mean arterial pressure; MSNA, muscle sympathetic nerve activity; VFA, femoral artery blood velocity; ICAM, intercellular adhesion molecule; VCAM, vascular cell adhesion molecule; CVD, cardiovascular disease; HR, hazard ratio; CI, confidence interval; BMI, body mass index; RR, relative risk; PSG, polysomnography; SDB, sleep disordered breathing; MRI, magnetic resonance imaging; sCD40L, soluble CD40 ligand; sP, soluble P; MMP2, matrix metalloproteinase 2; TWEAK, tumor necrosis factor-like weak inducer of apoptosis; IL-6, interleukin-6; TNF-α, tumor necrosis factor-α.

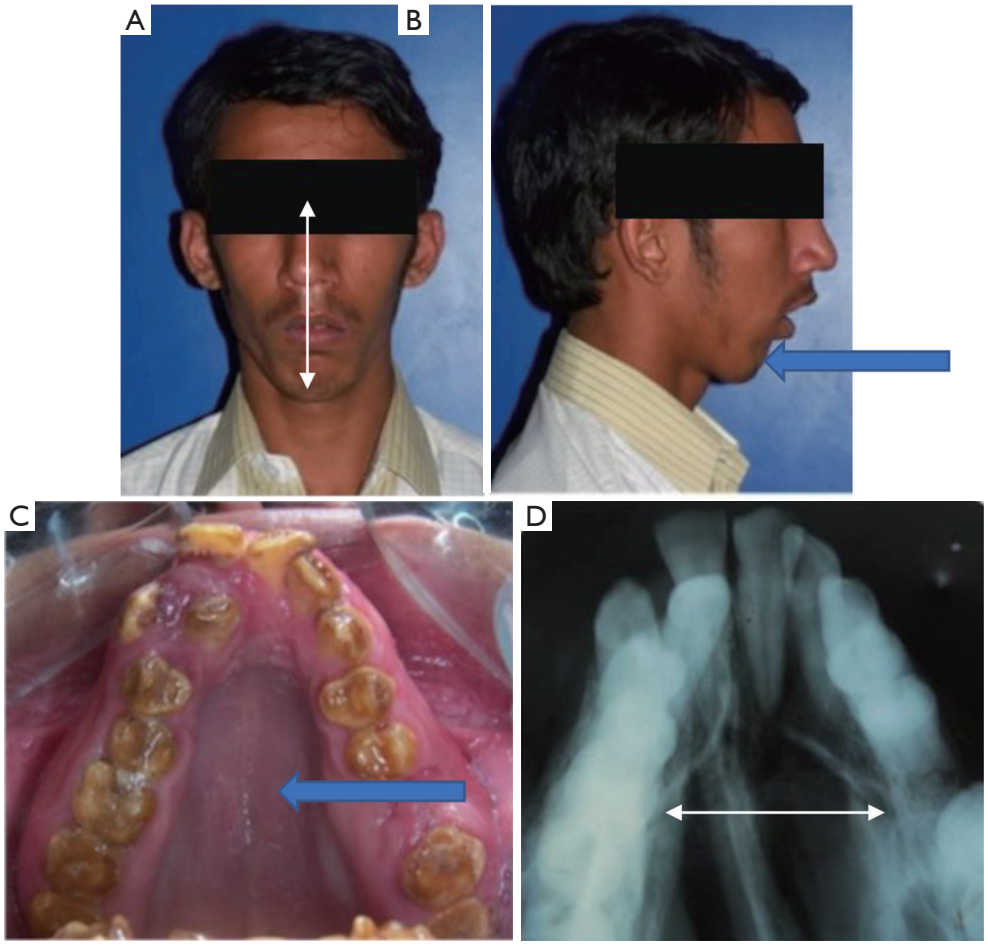

Figure 3 Patient with OSA demonstrating classical long narrow face with collapsed arch. (A) Frontal view demonstrating increased facial height with vertical maxillary excess (arrow). (B) Side profile demonstrating small and retrognathic mandible (arrow). (C) Intraorally a narrow palate with a high palatal vault (arrow) is seen. (D) Occlusal radiograph demonstrating reduced transverse maxillary dimension (arrow) and collapsed palate. These images are published with the patient's consent.

(V) Crowded oropharyngeal airway (74);
(VI) Elder age group (6);
(VII) Post menopausal status (6).

There exist several tools which would aid in assessment of OSA in a non-sleep clinical setting most sensitive among these is the Stop Bang questionnaire, essentially this looks at snoring (S), tiredness (T), observed pauses in breathing (O), blood pressure (P), the ESS (75) and the Berlin questionnaire are also used to predict OSA, however these alone should not be used to diagnose OSA (76,77).

Volumetric estimation of airway is possible by use of computed tomography (CT), MRI, acoustic imaging techniques and acoustic pharyngometry are in use today to estimate the degree and severity of OSA (78).

Home sleep testing/portable sleep testing reduce the necessity for patients to be tested in a sleep lab/hospital settings and recent introduction of devices such as Alice PDX, WatchPAT, etc. have provided results similar to lab PSG and are acceptable as alternatives to PSG in patients without comorbidities, home sleep testing devices report a respiratory event index (REI) in contrast to the PSG (79-82).

PSG however still remains the gold standard for identifying OSA and determining its severity (76,83). PSG provides an apnea-hypopnea index (AHI) (84). Based on AHI scores, OSA can be grouped into four categories:

- Normal (AHI <5 events/h);
- Mild OSA (AHI 5–15 events/h);
- Moderate OSA (AHI 16–30 events/h);

Table 3 Relationship between craniofacial abnormalities malocclusion and OSA

Author, year	Study type	Number of subjects	Outcome evaluated	Results and conclusion	Quality of evidence
Lombardo, 2020	Systematic review and meta-analysis	77 studies	Worldwide prevalence of malocclusion	Prevalence of malocclusion is 56% The highest prevalence was in Africa (81%) and Europe (72%), followed by America (53%) and Asia (48%)	High
Alhammadi, 2018	Systematic review	53 studies	Geographic and racial distribution of malocclusion and comparison between classes of malocclusion	The highest prevalence of class I was in Africa (89%), class II in Caucasian (23%) and class III in mongoloids	Moderate
Miles, 1996	Literature review and meta-analysis	143 studies	Etiological relevance of craniofacial structure to OSA	Only mandibular length, mandibular plane angle, and mandible to hyoid strongly correlated with OSA	Low
Banabilh, 2010	Observational	120	Comparison of facial profile shape, malocclusion and palatal morphology in Malay adults with and without OSA as determined by AHI	Convex profile (71%) and class II malocclusion (51%) was more common in the OSA group	Low
Lam, 2005	Observational case control	239	Whether craniofacial profile predicts presence of OSA as determined by AHI	Patients with OSA had higher thyromental angles and Mallampati scores than controls	Low
Johal, 2004	Observational case control	94	Comparison of maxillary morphology between OSA and non-OSA patients	The palatal angle was more obtuse in male OSA subjects Minimum palatal airway widths were significantly reduced In the comparison of study model measurements, palatal heights in OSA subjects were greater Maxillary morphological differences do exist between OSA and control subjects, supporting their role as an etiological factor	Low
Jamieson, 1987	Single center case control	196	Comparison of cephalometric radiographs and PSG of 155 cases and 41 controls to determine contribution of craniomandibular abnormalities to OSA	Retruded mandible, changed cranial base flexion and inferior hyoid bone displacement were commonly seen in OSA patients	Low

OSA, obstructive sleep apnea; AHI, apnea-hypopnea index; PSG, polysomnography.

- Severe OSA (AHI >30 events/h).

Mild to moderate OSA is amenable to OAT, severe and central apnea's need CPAP, nasal CPAP or oscillating positive airway pressure (OPAP) support apart from a detailed medical investigation (85,86).

Though dentists gather a vast array of records including a detailed personal and family history and perform cephalometric and model analysis, these have been with the defined purpose of estimating space to bring about an optimal occlusion with a consequent smile and/or an aesthetic facial outcome. While the utility of various cephalometric and model analysis in the diagnosis of OSA has been recognized quite early (87,88), the entire focus on cephalometric and model analysis in routine practice has been on creating metrics for tooth movement and adjusting teeth in a given occlusion (69). The assessment of skeletal disharmony is routine but so is the tendency for looking at a camouflage and compromise even before offering a more aggressive surgical correction of the jaw bases. This tendency has found favor and is promoted by

Table 4 Prevalence of symptoms of OSA

Symptom	Prevalence of symptom (%)
Daytime sleepiness	73–90
Snoring (loud and irregular)	50–60
Choking or gasping during sleep	10–15
Nocturia	30
Morning headaches	10–30
Insomnia	29
Lack of concentration/fatigue	18–23

OSA, obstructive sleep apnea.

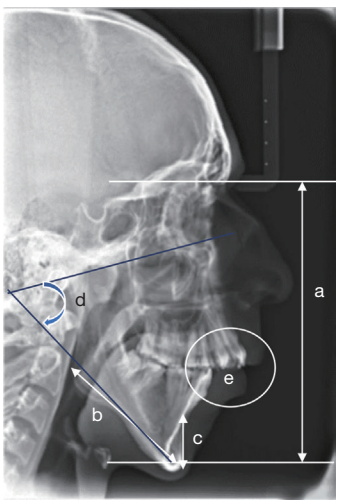

Figure 4 Lateral cephalogram of class 2 malocclusion with features predisposing to OSA. a: increased vertical height; b: small and retrognathic mandible; c: increased symphyseal length; d: clockwise rotation of mandible; e: skeletal open bite. OSA, obstructive sleep apnea.

the industry who tend to define extraction decisions related to a particular appliance. There is an inherent need to bring airway centric focus in the process of diagnosis.

Dental treatment goals need a redefinition beyond teeth and smiles. Improvement of upper airway patency and promotion of nasal breathing should be a primary objective (85). It is possible to outline a simple airway inclusive process in dental evaluation as proposed by Jayan and Kadu (89).

- Preliminary screening in all patients, adults or children, using an ESS or similar Stop Bang analysis;
- Distinctive clinical indicators for a compromized airway;
- Lip incompetency with oral breathing;
- Crumpling of chin;
- Adenotonsillitis;
- Airway grading of Mallampati more than grade III;
- Dark circles under the eye;
- Distended uvula;
- Severe clockwise rotation of the mandible;
- Tiny nares and high and narrow nose;
- Macroglossia and crenations.

It is also imperative for dentists to leverage the routine records that are collated for diagnostics and treatment planning. A lateral cephalogram in natural head position provides good information with a number of analysis being available for assessing risk and potential airway collapsibility along with mandibular position, tongue position (*Figure 4*) (90). The inherent disadvantage is that the cephalogram is recorded in an erect posture and is two-dimensional (2D). Cone beam CT (CBCT) evaluations offer three-dimensional (3D) airway assessments apart from a physical estimation of the skeletal structures (91). The results of various studies quoted in this section are summarized in *Table 5*.

Airway centric orthodontics: revising the clinical treatment paradigm

Much has been debated on early treatment, one phase or two-phase intervention. The reality remains that an essential amount of craniofacial growth is accomplished by 4 years of age. Almost complete development (90%) of the craniofacial complex is completed by 12 years of age and so it must follow that aberrant growth, morphologic features of sleep disordered breathing in adults may be a carryover from childhood issues that remain unaddressed both due to a lack of detail by the treating dentists and also the cognitive bias of treatment only once all the permanent teeth have erupted by a large segment of the lay population and the profession.

There is a need for orthodontists being sensitive to the reality of OSA as they play an important role in the diagnosis and management of OSA albeit as part of an interdisciplinary team.

OAT has emerged as one of the accepted modalities of management of OSA especially so in patients who do not tolerate the PAP devices (16), while early research has focused on OAT in patients with mild and moderate

Table 5 Diagnosis of OSA

Author, year	Study type	Number of subjects	Outcome evaluated	Results and conclusion	Quality of evidence
Ken, 2018	Systematic review	9 articles	To assess OSA case-finding accuracy and comparative effectiveness of care by non–sleep specialists and sleep specialists	Similar outcomes of care by non–sleep specialists and sleep specialists.	Low
Tarraubella, 2018	Multicenter RCT	302	Assessment of effectiveness and cost-effectiveness of primary care and sleep unit models for the management of subjects with suspected OSA	Similar outcomes in primary care and sleep unit models	Moderate
Epstein, 2009	Expert opinion and clinical practice guidelines	–	Guidelines for the evaluation, management and long-term care of adult patients with OSA	Questions regarding OSA should be incorporated into routine health evaluations Suspicion of OSA should trigger a comprehensive sleep evaluation The diagnostic strategy includes a sleep-oriented history and physical examination, PSG and education of the patient	High
Unal, 2019	Retrospective case control	437	Association between OSA syndrome and waist-to-height ratio	Cutoff values for OSAs were 95.5 cm for waist circumference, 0.595 for waist-to-height ratio Higher waist circumference and waist to height ratio associated with presence and severity of OSA	Low
Ito, 2016	Single center prospective	703	Correlations between cephalometric readings of tongue size, lower face cage and tongue size/lower face cage ratio with AHI	Tongue size/lower face cage ratio correlated with AHI	Low
Kapur, 2017	Metanalysis and evidence-based task force clinical practice guideline	–	Systematic review was conducted to identify studies, and the GRADE process was used to assess the evidence. The task force developed recommendations and assigned strengths based on the quality of evidence. In addition, the task force adopted foundational recommendations from prior guidelines as “good practice statements”, that establish the basis for appropriate and effective diagnosis of OSA	The use of other clinical tools in the absence of PSG for OSA diagnosis contraindicated (strong) PSG or HSAT is recommended for diagnosis moderate to severe OSA (strong) If HSAT results are negative or inconclusive a repeat PSG is recommended (strong)	High
Chiu, 2017	Bi variate meta-analysis	100 studies	Comparison of the summary sensitivity, specificity, and diagnostic odds ratio among the Berlin, Stop Bang, Stop, and ESS according to the severity of OSA	The Stop Bang questionnaire is a better tool for detecting OSA when compared to other questionnaires	Moderate
Kendzerska, 2016	Single center cohort	576	Comparison of UA-XSA and other clinical predictors of OSA using regression analysis	Mean UA-XSA was a predictor for OSA with an odds ratio of 1.62, but a regression analysis did not demonstrate and differences with other clinical predictors	Moderate
Ghegan, 2006	Meta-analysis	27 studies	Comparison of diagnostic of HAST *vs.* laboratory PSG	HSAT gave a 10% less RDI values odds ratio 0.90 HAST while providing similar diagnostic information underestimate OSA severity	Moderate
Gao, 2021	Systematic review and meta-analysis using QUADAS-2 rating	20	Comparison of portable monitors and PSG in OSA diagnosis	Portable monitors showed a sensitivity of 74% and specificity of 90% when compared to PSG determined AHI Portable monitors provide an effective alternative to PSG	Low
Withers, 2022	Single center prospective	81	Comparison of HSAT type 2 portable monitoring devices with type 1 PSG	Excellent correlation between the number of arousals, RDI, and sleep in both devices Type 2 devices are excellent for HSAT	Low
Cagle, 2023	Meta- analysis	24 studies	Comparison of AHI, ODI, RDI, O_2 sat, and LSAT measured by PSSDs compared to PSG	Significant correlations between two devices of AHI, O_2 sat, and LSAT Significant predictive correlation for AHI, RDI, and LSAT but not for O_2 sat	Moderate
Borowiecki, 1988	Observational case control	42	Comparison of cephalometric findings between patients with OSA and non-OSA controls	Patients with OSA had the following findings on cephalometric analysis: (I) enlarged tongue and soft palate; (II) the hyoid bone is displaced interiorly; (III) the mandible is normal in size and position (no micrognathia or malocclusion), and an elongated face caused by an inferior displacement of the mandibular body; (IV) retropositioned maxilla and elongated hard palate; (V) the nasopharynx is normal, but the oropharyngeal and hypopharyngeal airway is reduced in area by an average of 25% Cephalometric evaluation could be useful when used with head and neck examination, polysomnographic and endoscopic studies to evaluate OSA patients, and to assist with the planning/surgical treatment for improvement of upper airway patency	Low
Scannone, 2017	Observational case control bi-variate analysis	126	Features of craniofacial and dental phenotype associated with high suspicion of OSA in adults using lateral cephalograms and study casts	Subjects with class II malocclusion more prone to OSA No other parameters showed any significant differences	Low
Kumar, 2007	Observational	10	Comparison of orthogonal and prospective CBCT lateral projections	Orthogonal CBCT projections provided more accurate midsagittal skull measurements than prospective CBCT or conventional cephalometric radiographs	Low

OSA, obstructive sleep apnea; AHI, apnea-hypopnea index; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; PSG, polysomnography; HSAT, home sleep apnea testing; ESS, Epworth Sleepiness Scale; UA-XSA, upper airway cross-sectional area; RDI, respiratory disturbance index; QUADAS, Quality Assessment of Diagnostic Accuracy Studies; ODI, oxygen desaturation index; O_2 sat, oxygen saturation; LSAT, lowest oxyhemoglobin saturation; PSSD, portable sleep study device; CBCT, cone beam computed tomography.

Table 6 Drug and behavior modification therapy for OSA

Author, year	Study type	Number of subjects	Outcome evaluated	Results and conclusion	Quality of evidence
Mason, 2013	Systematic review	30 trials	Efficacy of drug therapy in OSA management	Insufficient evidence for the use of drugs in the therapy of OSA	High
Papandreou, 2012	Randomized trial	940	Effect of Mediterranean diet *vs.* prudent diet with exercise in obese OSA patients	Reduction in AHI during rapid eye movement sleep	Low
Johansson, 2011	Single center prospective	63	To evaluate whether the initial effects of a low energy diet in OSA patients persist even after 1 year of the diet	Patients with severe OSA demonstrated marked reduction in AHI (reduction of 25/h) 30/63 did not require PAP after 1 year and 6/63 achieved complete remission	Low
Igelström, 2018	Two arm RCT	86	Effect of behavioral sleep medicine on moderate and severe OSA	40% of experimental group achieved improvement in OSA status	Moderate
Aiello, 2016	Systematic review and meta-analysis	8 articles	Efficacy of exercise in reducing AHI	Exercise as sole intervention led to better clinical outcomes	Low

OSA, obstructive sleep apnea; AHI, apnea-hypopnea index; PAP, positive air pressure; RCT, randomized control trial.

OSA (92) emerging evidence indicates that these devices could be beneficial to patients with severe OSA also especially in cases where CPAP has not been successful (93,94).

Comparisons of OAT with PAP devices have largely focused on the improvement in the AHI scores and thus OAT are often reported to be less efficacious in comparison to PAP for PSG parameters (95). In clinical practice, irrespective of the comparative measures used the better compliance and better health benefits achieved by OAT offset the inability of OAT to match the PAP devices in reducing apneic events (96).

Management of OSA in adults

Broadly OSA can be managed using three stratagems of behavioral modification, treatment devices and surgical intervention.

Drug therapy and behavioral modification

Drugs such as eszopiclone, acetazolamide, naltrexone, physostigmine, donepezil, and fluticasone have been tried out in the therapy of OSA, however there is insufficient scientific evidence to recommend the long-term use of these drugs in the Treatment of OSA (97).

Behavioral modification including diet modifications (98) low energy diet (99) diet and exercise (100,101) have all been found to be beneficial in reducing the severity of OSA and achieving reduction of AHI scores (102). The findings of the articles quoted in this section are summarized in *Table 6*.

Treatment with devices

The benchmark treatment for OSA continues to be CPAP and modifications such as BPAP, auto-titrating PAP (APAP), and humidified PAP (103). However, poor compliance is reported in around two-thirds of patients on PAP devices (6) and thus recent devices come with modifiable pressure profiles that result in greater patient compliance, however the compliance rates still continue to be an area of concern (16,104).

OAT

The oral cavity is an important component of the airway, the anterior boundary of the upper airway is formed by the upper and lower incisors and the piriform rim. The superior boundary is formed by the cranial base, the posterior boundary by the cervical vertebrae, and the inferior boundary is formed by the hyoid bone. The width of the palate, the separation between the ascending rami,

and the middle cranial fossa are lateral determinants of airway size. The pharyngeal muscles, turbinates, tonsils, soft palate, tongue, adenoids, and nares line these structures which define the bony skeletal limits (67), Thus providing the dentists and orthodontists with opportunities to leverage these factors for the management of OSA. The challenge for the orthodontists is to address any craniofacial structural deformity that could directly or indirectly influence the airway and to look at the possibility of OAT in addressing OSA.

The first documented use of an oral appliance to improve respiration comes from Pierre Robin who in 1921 demonstrated the use of a monoblock appliance for a case of the Pierre Robin syndrome which essentially led to mandibular advancement with tongue and hyoid repositioning for the management of the Pierre Robin sequence (105).

There are over 100 types of oral appliances available for the treatment of OSA differing in terms of mechanism of action, location and materials used (106). These appliances can be grouped as follows:

(I) Palatal lift appliances/soft palate liners;
(II) Tongue retaining devices/tongue stabilizing devices (TRDs/TSDs);
(III) Mandibular advancement devices (MADs)/mandibular repositioning devices (MRDs)/mandibular advancing appliances (MAAs).

Drug-induced sleep endoscopy (DISE) a procedure fist recommended in 1991 to accurately locate the position of upper airway collapse during induced sleep is now being used to discern the value of OAT in patients who have failed CPAP or previous surgery (107,108).

Palatal lift appliances or soft palate liners

These were initially used for the treatment of snoring by applying pressure on both the soft palate and uvula thereby reducing palatal vibrations, this was also found to increase airway space and hence were also used for OSA treatment (105,109). However, these appliances are rarely seen in clinical use exclusively for the management of OSA (106). Several devices such as the Tübingen palatal plate used for the management of the Robin Sequence also improve OSA parameters (110).

TRDs/TSDs

TRD/TSDs work on the principle of clasping the tongue in a forward position and not allowing it to proceed downward because of negative inspiratory pressure thus maintaining airway patency. A variety of TRD designs are available and have shown to significantly reduce the AHI scores in over 71% of patients (111,112) and TRDs are ideal for use in edentulous patients and patients with unhealthy dentition in whom other OAT is precluded (113).

MADs

The American academy of dental sleep medicine in 2014 gave an evidence-based definition for an effective appliance in the treatment of OSA and snoring and have constructed the definition for MAD as they are the most effective and clinically widely used OAT appliance (114).

Titratable functional appliances have been the precursors to the MADs for adults, MADs as the name suggest reposition or advance the mandible and base of tongue leading to tightening of the supra hyoid, infrahyoid, genioglossus, and geniohyoid muscles causing an increase in pharyngeal airway space and resultant decrease in the PCRIT (115) an important consideration in MAD therapy is the amount of mandibular advancement possible since devices in which advancement is not beyond centric occlusion do not effect airway size and in general the degree of mandibular attachment dictates the efficacy of MAD devices (105). MADs have generally shown optimum results at a 50% protrusion and protrusion beyond 50% has not shown any added benefits, the effect of less than 50% protrusion is not yet clearly documented (116,117).

Boil and bite devices

The simplest MAD device available are the boil and bite devices such as the Sleep Pro 1 and SnoreRx consist of a thermoplastic material which can be heated and the patient bites on these blocks and allows the material to set. The boil and bite devices suffer from improper fit and fall out easily, nevertheless these devices have also been found to improve AHI scores (118).

Customized MADs

Customized MADs are better tolerated than the prefabricated boil and bite (119), devices and come in two models, the one piece or monobloc appliances and the two piece or duo bloc appliances which consist of two blocks connected to each other, the two piece appliances come with the added benefit of being adjustable serially titrable i.e., the mandibular protrusion in these devices can be adjusted gradually allowing the patient to slowly adjust to

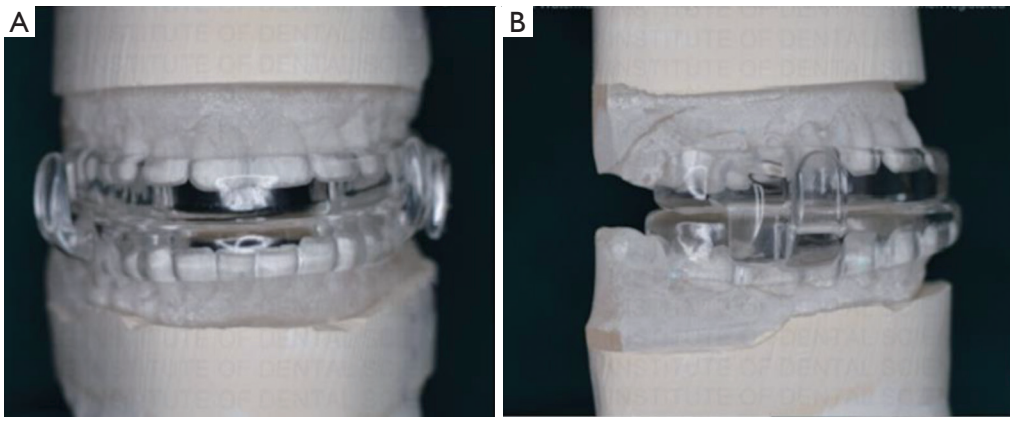

Figure 5 Mandibular advancement using the Micro 2 device demonstrated on casts. (A) Frontal view. (B) Lateral view.

maximum protrusion in contrast to the monobloc devices. Isacsson *et al.* have reported similar efficacy rates in their multicentric trial and Ishiyama *et al.* found better results for the monoblock devices in their meta-analysis (120-122).

The advent of digital impressions, computer-aided design (CAD)/computer-aided manufacturing (CAM) and 3D printing have led to the emergence of several Food and Drug Administration (FDA) approved MAD appliances such as Narval, Pantera, and Somnodent avant which are 3D printed and the Prosomnus Micro2 which is a CAD/CAM milled appliance (*Figure 5*) (123), these come with the benefits of being less bulky and have a better fit and have also shown a good response in severe cases of OSA (117,124).

The MAD appliances are usually delivered with the mandible obtruded to two-thirds of its maximal protrusion (*Figure 6*). A second sleep study after the patient is well accommodated and has some relief would be an indicator of success of the therapy. Monitoring every 6 months and then annually after the first year is recommended in various guidelines (113).

Selection of patients for OAT

The key to successful management of OSA by OAT would be appropriate patient selection. A stable dentition, minimum of 6–8 teeth/arch, good oral and periodontal health are prerequisites for a patient to be subjected to MAD appliances, though no absolute contraindications exist the presence of loose crowns, pre-existing temporomandibular disorders (TMDs), bruxism, micrognathia are relative contraindications (106,120).

Patients likely to benefit from MAD appliances are likely to be younger females, patients with a lower BMI and smaller neck circumference (120).

Efficacy of OAT

In consonance with the WHO definition of health the authors believe that the efficacy of OAT should be assessed on the basis of improvement in the quality of life indicators. Narratives of OSA efficacy have largely been affected by comparisons to CPAP and physiological indicators and the AHI index (106).

There exist ample evidence from several randomized control trials (RCTs) for the use of OAT in OSA especially in patients not compliant with PAP devices (97,98,107,112,125-131), this evidence is further supplemented by several systematic reviews and meta-analysis (112,116,117,122,130-133). all of these have reflected on the fact that OAT and PAP devices provide comparable health outcomes, with PAP devices showing a greater reduction in OSA severity as assessed by PSG.

The systemic effects of OAT have also been widely studied for over 2–8 years with OAT bringing about modest but significant benefits on cardiovascular outcomes, blood pressure, cognitive function, depressive symptoms, headache and quality of life (93,126,134-138).

Adverse effects of OAT

Temporomandibular joint (TMJ) discomfort or pain is the most common complaint of patients being treated with MADs occurring in over 37% of patients after a year of use according to a questionnaire study (139).

Increased salivation, dry mouth, bad taste in the mouth and occlusal changes have also been reported (118,140).

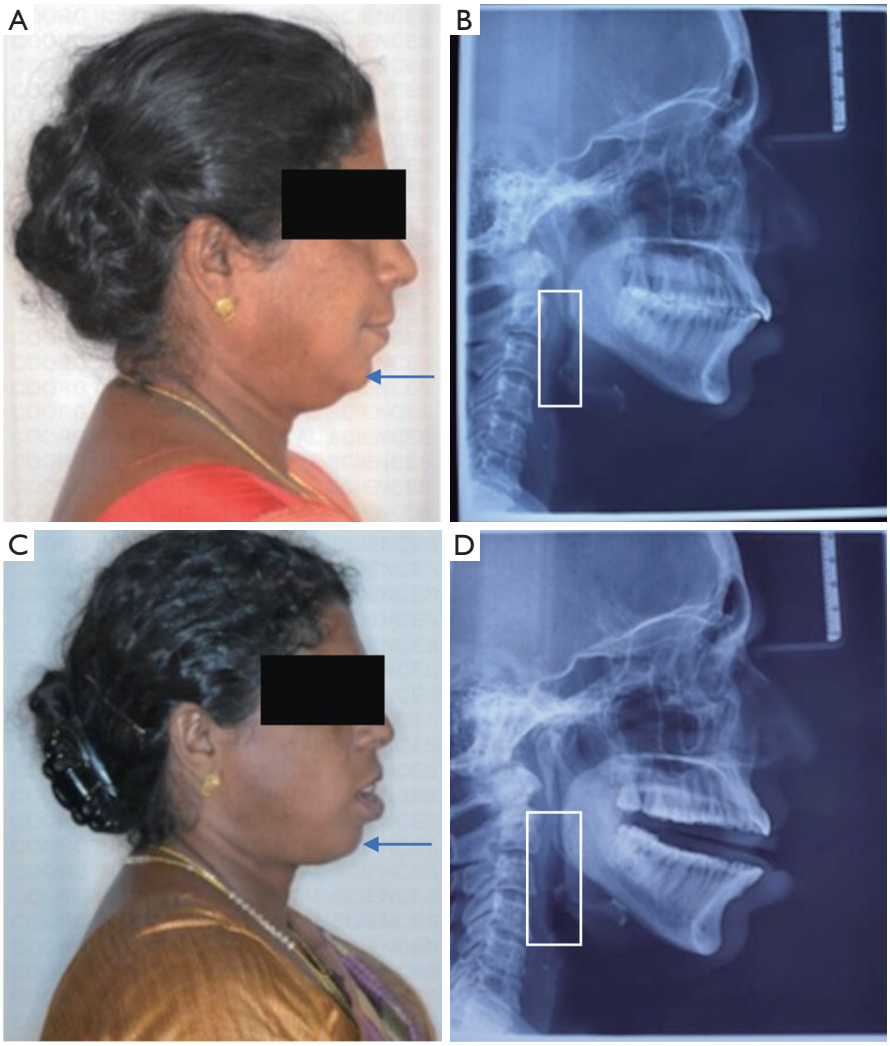

Figure 6 Mandibular advancement using the Micro 2 device in an adult patient with radiographs showing marked increase in airspace. (A) Pre appliance insertion showing retruded mandible (arrow). (B) Lateral cephalogram showing collapsed airway (box). (C) Post appliance insertion with mandibular advancement (arrow). (D) Lateral cephalogram showing increased airway space (box). These images are published with the patient's consent.

Alterations in cephalometric measurements have also been found post use of MAD devices (141,142). The results of various studies quoted in this section are summarized in *Table* 7.

Surgical management

Surgical interventions in adult OSA are never the first line of treatment and are only considered after other modalities have failed or cannot be implemented (143). The cases need careful evaluation and possible impact on airway and alleviation of symptoms.

Nasal surgeries such as septoplasty (with or without turbinate reduction) have been found to reduce sleepiness in a RCT (144). Tonsillectomies are recommended for adults with tonsillar hyperplasia although evidence of contribution of tonsillar hyperplasia to adult OSA is still unclear (145).

Oropharyngeal surgeries such as uvulopalatopharyngoplasty and modifications such as laser-assisted uvulopalatopharyngoplasty, radiofrequency palatoplasty, Z palatoplasty involve reduction of palatal bulk by removal of uvula, part of soft palate and tonsil and closure of tonsillar pillars (146). These

Table 7 OAT in the management of OSA

Author, year	Study type	Number of subjects	Outcome evaluated	Results and conclusion	Quality of evidence
Marklund, 2017	Literature review	102 articles	Evidence for OAT in the treatment of OSA	High level of evidence shows that OTA is effective in the treatment of OSA, but CPAP is more efficient. Higher adherence with OTAs may compensate for this difference	Low
Gjerde, 2016	Single center retrospective 2007–2013	116	To test the efficacy of MADs in 116 patients with moderate and severe OSA who were non-compliant with CPAP	No significant difference between the AHI reductions achieved by MADs in moderate and severe OSA	High
Sutherland, 2015	Multicentric retrospective	425	Comparison of a large cohort of MAS treated patients (I) to compare efficacy across patients with different phenotypes of OSA and (II) to assess demographic, anthropometric, and PSG variables	Lower MAS treatment response rates were observed in supine and REM sleep Demographic and anthropometric and PSG variables weakly inform about MAD efficiency	Moderate
Barthlen, 2000	Single center prospective	24	Comparison of MAD, TRD and soft palate lift appliance in OSA management	8/8 complied with MAD therapy whereas only 5/8 and 2/8 with TRD and soft palate lift respectively	Low
Lazard, 2009	Retrospective single center	84	Efficacy and tolerance of TRDs in patients with OSA	TRDs show similar efficacy and tolerance as MADs	Low
Ferguson, 1998	Single center prospective	19	videoendoscopic measurement of upper-airway cross-sectional area shape in the hypopharynx, oropharynx, and velopharynx during various stages of active mandibular and tongue protrusion	Both protrusions increased upper-airway cross section with tongue protrusion causing more oropharynx and velopharyngeal increase and mandibular protrusion causing increase in hypopharynx	Low
Quinell, 2019	Randomized control crossover trial	90	To compare clinical- and cost-effectiveness of a range of MADs against no treatment in mild to moderate OSA	All MAD devices used reduced AHI Non-adjustable MADs achieve clinically important improvements in mild to moderate OSA and are cost-effective The semi customized MAD is an appropriate first choice	High
Isacsson, 2019	Multicenter randomized trial	302	The Patients were randomized to monobloc and bibloc devices and effect on reduction of AHI was compared	Both devices achieved a mean reduction of 12–14 AHI events/h	High
Aziz, 2021	Single center prospective	10	Efficacy of CAD/CAM milled appliance in management of OSA as assed by cephalometric measurements and ESS	Increase in pharyngeal airway width, velum dimension and anterosuperior repositioning of mandible All patients demonstrated decreased ESS scores	Low
Comparison of OAT with CPAP					
Schütz, 2013	Single center prospective	25	Effect of CPAP, OAT and continuous exercise training on OSA	Only CPAP and OAT were able to bring about significant reductions in AHI (P=0.01) with only CPAP bringing about normalization of AHI	Low
Doff, 2013	Cohort study [2002–2005]	103	Comparison of objective (PSG) and objective (ESS, short form health survey-36, functional outcomes of sleep questionnaire)	No significant difference was found between OAT and CPAP in treating mild to severe OSAs in a 2-year follow up Both therapies showed significant improvements in PSG and neurobehavioral outcomes CPAP more effective in reducing AHI (P<0.05) OAT is a viable alternative to CPAP in mild to moderate OSA. For severe OSA CPAP is the first line of treatment	High
Ferguson, 1996	Randomized, prospective, cross over	25	To compare efficacy, side effects, patient compliance, and preference between OAT and CPAP	AHI reduction with CPAP (3.5) was better in comparison with OAT (9.7) (P<0.05) Of the seven patients who were treatment success with both treatments 6 preferred OAT as long-term therapy OAT is effective and is associated with lesser side effects and has greater patient satisfaction than CPAP	Moderate

Table 7 (*continued*)

Table 7 (*continued*)

Author, year	Study type	Number of subjects	Outcome evaluated	Results and conclusion	Quality of evidence
Nikolopoulou, 2017	Randomized, placebo-controlled trial	64	Comparison the effects of a MAD with those of CPAP on self-reported symptoms of common sleep disorders and sleep-related problems in mild and moderate OSA patients	The three groups (MAD, CPAP, and placebo) showed significant improvements over time in symptoms corresponding with 'insomnia', 'excessive daytime sleepiness', 'psychiatric sleep disorder', 'periodic limb movements', 'sleep apnoea', 'sleep paralysis', 'daytime dysfunction', 'hypnagogic hallucinations/ dreaming', 'restless sleep', 'negative conditioning' and 'automatic behaviour' (range of P values: 0.090–0.897)	Moderate
Dort, 2008	Randomized controlled crossover	38	Evaluation of a non-customized TRD compared to a control device as assessed by a reduction in RDI	The customized TRD brought about a significant reduction in RDI (P=0.06) The customized TRD was better preferred by 54% patients	Low
Comparison of OAT with CPAP literature reviews and meta-analysis					
Poets, 2019	Literature review	–	Efficacy of Tübingen plate in the management of Robin sequence and resultant upper airway obstruction	The Tübingen plate was superior to a sham procedure in reducing upper airway obstruction on patients with Robin sequence	Low
Chang, 2017	Systematic review and meta-analysis	16 studies and 242 patients	TRD outcomes as a treatment of OSA	Current international literature demonstrates that TRDs reduce AHI by 53%, increase lowest oxygen saturation by 4.1 oxygen saturation points, decrease oxygen desaturation index by 56% and decrease ESS scores by 2.8 points TRDs provide a statistically effective alternative treatment option for OSA	Moderate
Bartolucci, 2016	Systematic review and meta-regression analysis	13 RCTs	Effectiveness of different MADs in reducing AHI in OSA patients	Mandibular advancements from 50–89% Advancement amounts greater than 50% do not significantly increase success rates (P=0.541) AHI improvement not proportional to mandibular advancement	Moderate
Li, 2020	Systematic review and meta-analysis	14 RCTs 249 patients	Efficacy of CPAP *vs.* MAD in the treatment of OSA	CPAP was significant in reducing AHI (7.09/h) CPAP has better therapeutic efficacy	Moderate
Rangarajan, 2022	Systematic review and meta-analysis	25 studies	Impact of OAT on quality of life in patients with OSA assessed by functional outcomes of sleep questionnaire	With a mean difference of 1.8 points between pre and post therapy scores OAT treatment led to significant improvement in quality of life	Low
Ilea, 2019	Systematic review	15	Effectiveness of MAD for OSA by improvement of AHI	92% of subjects successfully treated with OAT	Low
Ishiyama, 2019	Systematic review and meta-analysis	7 RCTs	efficacy of device designs (monoblock or biblock) in MAD for OSA patients	Monoblock significantly reduced AHI in comparison to bi block (P=0.0006) and had better patient preference (P=0.0001)	Moderate
MAD effects on systemic health					
Kim, 2022	Literature review	41 articles	To present an overview of the cur-rent evidence regarding the overall multisystemic effects of MAD in OSA patients	MAD reduce diastolic blood pressure, heart rate and heart rate variability Levels of cardiovascular markers IL-6 and TNF-α MAD brings about significant improvements in glycated hemoglobin levels in moderate OSA but not severe OSA patients Improvement in vigilance and psychomotor speed	Low
Yoshida, 2006	Single center prospective	194	Evaluation the effect of individually prescribed oral appliances for the treatment of OSA syndrome	OAT resulted in a reduction of mean blood pressure 3.7 mmHg with maximum effect seen in the diastolic of 4.5 mmHg (P<0.001) The reduction was more in responders to OAT (higher reduction in AHI)	Low
Trzepiur, 2009	Single center prospective case control	33	Impact of CPAP and MAD on microvascular endothelial function using laser doppler flowmetry	Significant increase in acetylcholine induced dilatations (P=0.016) ensuring better nocturnal oxygenation	Low
Galic, 2016	Single center prospective	18	effect of MAD treatment on arterial stiffness, glucose metabolism, and certain inflammatory markers as predictors of cardiometabolic risk in mild to moderate OSA patients	MAD resulted in reduced plasma fasting glucose levels after 1 year (P<0.01) Reduction in inflammatory marker plasma fibrinogen after 1 year (P<005)	Low

Table 7 (*continued*)

Table 7 (*continued*)

Author, year	Study type	Number of subjects	Outcome evaluated	Results and conclusion	Quality of evidence
Long-term effects of MAD					
Haviv, 2014	Single center retrospective 2006–2012	52	Evaluation of medium long-term outcome and success rates of oral appliances in patients with severe OSA by second PSG 2 years after initiation of MAD therapy	A significant reduction (P<0.0001) in the AHI was demonstrated between the initial somnography (55.25) and follow up (10.79)	
Marklund, 2007	Single center retrospective 2004–2007	260	Questionnaire based study with mean follow-up of 5.4 years	Frequent use (P=0.001), few night-time awakenings before start of treatment (P=0.02), and effective apnea reduction during treatment of more severe cases (P=0.02) correlated with a good subjective effect at long-term follow-up	Moderate
Doff, 2013	Cohort study [2002–2005]	103	Comparison of objective (PSG) and objective (ESS, short form health survey-36, functional outcomes of sleep questionnaire)	No significant difference was found between OAT and CPAP in treating mild to severe OSAs in a 2-year follow up	High
Adverse effects of MAD					
Pliska, 2014	Single center retrospective 10-year follow-up	77	Evaluate the magnitude and progression of dental changes associated with long-term MAS treatment	Significant (P<0.001) reduction in the overbite (2.3±1.6 mm), overjet (1.9±1.9 mm), and mandibular crowding (1.3±1.8 mm) A corresponding significant (P<0.001) increase of mandibular intercanine (0.7±1.5 mm) and intermolar (1.1±1.4 mm) width as well as incidence of anterior crossbite and posterior open bite was observed	High
McGown, 2001	Questionnaire survey	166	To collect subjective and objective information concerning long-term effects, compliance and side effects of MAD devices	TMJ pain was the most common adverse effect (26/69), discomfort (25/69), sleep disturbance (12/69), excessive salivation (7/69), and altered bite (9/69) were noted as adverse effects	Low
Marklund, 2006	Single center prospective questionnaire survey 5.4-year follow up	450	find predictors of dental side effects from monoblock MADs after a 5.4-year follow-up using questionnaire and cast measurements	Median reductions of overjet and overbite of 0.6 mm after 5 years of MAD use	Moderate
De Almeida, 2006	Single center prospective	71	Patients were evaluated for adverse effects using lateral cephalometric measurements after 7.3±2.1 years of MAD use	Significant (P<0.01) in the following variables: increase in mandibular plane and ANB angles; decrease in overbite and overjet; retroclined maxillary incisors; proclined mandibular incisors; increased lower facial height; and distally tipped maxillary molars with mesially tipped and erupted mandibular molars	Moderate
			Patients were evaluated for adverse effects using model analysis after 7.3±2.1 years of MAD use	14.3% had no occlusal changes, of the 85.7% who had changes 41.4% had favorable changes, and 44.3% had unfavorable changes Class II malocclusions are likely to have favorable changes	

OAT, oral appliance therapy; OSA, obstructive sleep apnea; CPAP, continuous positive air pressure; MAD, mandibular advancement device; AHI, apnea-hypopnea index; MAS, macrophage activation syndrome; PSG, polysomnography; REM, rapid eye movement; TRD, tongue retaining device; CAD, computer-aided design; CAM, computer-aided manufacturing; ESS, Epworth Sleepiness Scale; RDI, respiratory disturbance index; RCT, randomized control trial; IL-6, interleukin-6; TNF-α, tumor necrosis factor-α; TMJ, temporomandibular joint; ANB, A-point-nasion-B-point.

are the commonest surgical procedures being performed for adult OSA with success rates of 50% and cure rates of 16% (147).

Procedures on the tongue such as reduction glossectomies have been found to improve quality of life while reducing daytime sleepiness (147), and have provided variable success rates, ranging from 35% to 62% (148).

Maxillomandibular advancement (MMA) surgeries involve osteotomies (Le Fort 1 and bilateral mandibular ramus sagittal split) of the maxilla and mandible followed by counter clockwise advancement of the inferior portion of the maxilla and anterior mandible leading to a forward displacement of attached soft tissues, tensioning the pharynx with resultant increase of the pharyngeal air space (146,149). These procedures also lead to better facial aesthetics (150,151). MMA surgeries demonstrate a high success rate (86–90%) and are the only treatment modalities demonstrating cure rates similar to CPAP (152). MMA surgeries are usually done as part of a multilevel or staged surgeries with stage 1 consisting of soft tissue surgeries and MMA as stage 2 surgeries (143).

Surgically assisted rapid palatal expansion (SARPE) and micro implant assisted rapid palatal expansion (MARPE) are modalities for increasing the transverse maxillary dimensions in individuals with transverse deficiency (153). This expansion has the secondary effect of decreasing airway resistance and increasing airway space. Both modalities have been found to decrease rate of respiratory disturbances in OSA (154).

Genial advancement, tracheostomy and surgical implantation of a hypoglossal nerve stimulation device that has been deemed safe, feasible and efficacious in two trials are the other surgical procedures used in adult OSA (155,156). *Table 8* summarizes this section.

OSA in children

Pediatric OSA is pathogenetically different from adult OSA because of the role played by multiple risk factors such as airway collapse, impaired neuromuscular tone, hyperplasia of tonsils and surrounding lymphoid tissue and growth-related changes contribute to pediatric OSA. Childhood obesity is a growing concern, and any screening must consider this essential aspect (157). According to the International Classification of Sleep Disorders (ICSD)3 (158), OSA can be diagnosed by either of two sets of diagnostic criteria. The first set of criteria for OSA includes the presence of at least one of the following: (I) snoring; (II) labored, paradoxical, or obstructed breathing during the child's sleep; or (III) sleepiness, hyperactivity, behavioral problems, or learning problems. The PSG criterion for diagnosis requires either (I) one or more obstructive events (obstructive or mixed apnea or obstructive hypopnea) per hour of sleep or (II) obstructive hypoventilation, manifested by $PaCO_2$ >50 mmHg for >25% of sleep time, coupled with snoring, paradoxical thoracoabdominal movement, or flattening of the nasal airway pressure waveform. It would be necessary to emphasize that these criteria are for use only in children under 18 years, though for ages 13–18 years the adult criteria may also be used (17). The pediatric sleep questionnaire is recommended as an adjunct to PSG analysis (159). In addition, HSATs with oximetry, DISE and dynamic MRI are used in diagnosis of pediatric OSA (160).

Management of pediatric OSA

Management of pediatric OSA differs from adult OSA in a multitude of ways, surgical management gains primary importance with adenotonsillectomy becoming the gold standard surgical treatment, with a metanalysis demonstrating resolution of PSG findings in 83% of patients (161). In children with deficient jaw size or with syndromes such as Pierre Robin sequence and trencher Collin syndrome MMA surgeries have proven to be beneficial (157). In cases where MMA surgeries cannot provide the desired increase in space, distraction osteogenesis is emerging as a viable alternative as the gradual maxillary/mandibular advancement provides for better soft tissue adaptation. The decreased PSG parameters are stable in the long run (17,161).

MAD appliances are when used in children will stimulate cartilaginous growth at the condyles and a recent metanalysis has found MAD devices in children to be most effective when used before the pubertal peak (162). In cases of transverse nasomaxillary deficiency the use of rapid maxillary expansion (RME) or MARPE has been found to reduce AHI scores in the short-term while there is insufficient long-term data. These devices bring about a transverse expansion of the palate, maxillary base and nasal floor with a downward shift of the nasomaxillary complex thereby decreasing airway resistance and increasing airway space (163,164).

Increased vertical face dimension is one of the classic findings in patients with OSA, this is largely caused by a clockwise rotational growth of the, to counteract this

Table 8 Surgical management of OSA

Author, year	Study type	Number of subjects	Outcome evaluated	Results and conclusion	Quality of evidence
Koutsourelakis, 2008	Single center randomized trial	49	Post surgical increase in nasal epoch leading to AHI change in comparison with a sham surgery assessed via breathing route examination	14.8% of surgical group responded to surgery with considerable increase in nasal epochs Nasal surgery rarely treats OSA effectively	Low
Kezirian, 2006	Literature review	36 articles	evidence-based medicine review of the literature describing outcomes of hypopharyngeal surgery in OSA	Improvements in respiratory physiology during sleep, daytime somnolence, and quality of life	Low
Vicini, 2010	Single center RCT	56	Random allocation of 50 consecutive patients to APAP or surgical management (MMA) and comparison of demographics, biometric parameters, ESS, and AHI	Significant improvement of AHI and ESS scores No differences between the two groups (P=0.20)	Moderate
Oliveira, 2021	Single center prospective	17	Comparison of skeletal and dental changes of MARPE *vs.* SARPE using CBCT	MARPE showed an increase in skeletal transverse maxillary expansion at the palate and basal bone compared with SARPE, especially at the posterior region. No difference was found in the expansion of the alveolar process between the two methods MARPE presented a more parallel expansion in both the coronal and axial view, whereas SARPE resulted in a more triangular and V-shaped opening A greater buccal inclination of the alveolar process and supporting teeth was observed in the SARPE group	Low
Vinha, 2016	Single center prospective study	16	Effects of SARPE on PSG parameters in patients with transverse maxillary deficiency	A RDI reduction of 54.6% (P=0.0013) A 56.2% (P=0.001) decrease was found in the AHI, in addition to decreases in the desaturation and microarousal rates, among other parameters The ESS scores improved from 12.5±5.3 to 7.2±3.5	Low
Oliven, 2011	Literature review	–	Review of hypoglossal nerve stimulation in OSA management	50% reduction in AHI score achieved by hypoglossal nerve stimulation devices Hypoglossal nerve stimulation devices likely to be available as a treatment option soon	Low
Kezirian, 2006	Single center prospective study	31	Examine the safety, feasibility, and efficacy of a novel HGNS system (HGNS®, Apnex Medical, Inc., St. Paul, MN, USA) in treating OSA at 12 months following implantation	Significant improvement (P<0·001) from baseline to 12 months in AHI (45.4±17.5 to 25.3±20.6 events/h) No major adverse effects alluding to the safety of HGNS	Low

OSA, obstructive sleep apnea; AHI, apnea-hypopnea index; RCT, randomized control trial; APAP, auto-titrating positive air pressure; MMA, maxillomandibular advancement; ESS, Epworth Sleepiness Scale; MARPE, micro implant assisted rapid palatal expansion; SARPE, surgically assisted rapid palatal expansion; CBCT, cone beam computed tomography; PSG, polysomnography; RDI, respiratory disturbance index; HGNS, hypoglossal nerve stimulation.

Table 9 Pediatric OSA

Author, year	Study type	Number of subjects	Outcome evaluated	Results and conclusion	Quality of evidence
Brietzke, 2006	Meta-analysis	14 studies	Effectiveness of adenotonsillectomy in treating obstructive sleep OSA in uncomplicated pediatric patients	The mean sample size was 28 Reduction of 13.92 AHI events/h (P=0.001) Success rate of procedure was 82.9%	Moderate
Yanyan, 2019	Systematic review and meta-analysis	7 studies	Evaluation of the effect of MAA in pediatric OSA	Mean reduction of 1.75 AHI events/h (P=0.0001) noted MAA can be effective for mild to severe patients before the end of the pubertal peak Long-term treatment (at least 6 months) may be more effective than short-term treatment	Moderate
Bucci, 2023	Systematic review and meta-analysis	25 studies	The effect of the following five interventions: RME, MAA, MT, and RME combined with MAA in bringing about changes in AHI and SaO_2	Significant reductions of AHI achieved by RME and MAA at 6 months to 1 year after start of therapy Myofunctional therapy cannot be suggested as an elective treatment because of lack of quality evidence	Moderate
Comacho, 2016	Systematic review and meta-analysis	17 studies	Analysis of sleep study outcomes in children who have undergone RME as treatment for OSA	70% of patients showed decreased in AHI (reduction of 6 events/h) Increase of oxygen saturation from 87 to 96 Improvements marked in patients who have undergone adenotonsillectomy	Moderate
Shavakhi, 2019	Systematic review and meta-analysis	7 studies	Effect of headgear on airway dimensions in patients with class II malocclusion	Low quality of evidence Conclusions of articles differed from each other	Low

OSA, obstructive sleep apnea; AHI, apnea-hypopnea index; MAA, mandibular advancement; RME, rapid maxillary expansion; MT, myofunctional therapy; SaO_2, arterial oxygen saturation.

a vertical pull headgear with intraoral maxillary micro implants favoring a counter clockwise mandibular growth with concomitant reduction in vertical facial height (165) has also been tried with mixed results precluding any recommendations (166).

The findings of this review on pediatric OSA are summarized in *Table 9*.

Strengths

This review charts the spectrum of OSA from its evolutionary basis to the biological effects, diagnosis and treatment of the condition from the perspective of orthodontists.

Limitations

Being a literature review in the context of OSA and orthodontics not all aspects of OSA have been discussed. The review has utilized literature published in the English language only and hence data from other language articles are not included. The literature search may have missed out on a few relevant publications.

Conclusions

Airway centric orthodontics underlines a major shift from the tooth paradigm to a larger definition of health and well-being. OSA is major medical disorder that can have serious health consequences in both children and adults.

An anthropologic predisposition consequent to bipedalism, phonetics, and the erect posture of homo sapiens has been further compounded by a progressive reduction in the size of the jaws, malocclusions, altered dietary patterns, obesity and societal change. There exists a need to screen all pediatric and adult patients for OSA in an orthodontic setting, a simple questionnaire procedure can be incorporated into the initial history taking and record keeping. Though diagnosis of OSA is based on PSG/HSAT parameters, the orthodontist would be able to identify the altered skeletal morphology which could impede the airway. OAT therapy achieves the alteration of mandibular/tongue position affecting airway dynamics and lowering the PCRIT. Surgical correction of maxillomandibular bases becomes essential in extreme cases. Maxillary expansion by SARPE/MARPE/RME/distraction osteogenesis could alter the nasal airway volume and the resistance to airflow.

OAT has emerged as a treatment of choice in the management of OSAs with several RCTs demonstrating the utility of OAT. This is especially in patients who are not amenable to PAP devices with MADs being the most common and effective devices available to orthodontists to manage OSA.

Slowly but surely a bridge is being built between orthodontics, oral medicine, oral, surgery and sleep medicine leading to the creation of multidisciplinary teams which will serve the specialty of dentistry well in enhancing its image rather than being relegated to a niche segment of cosmetics and aesthetics alone. It's time to redefine the paradigm.

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