Cover Story

The enigma of sleep

Implications of sleep neuroscience for the dental clinician and patient

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ABSTRACT

Background. Sleep disturbances have been shown to result in considerable morbidity and mortality. It is important for dental clinicians to understand the neuroscience behind sleep disorders.

Types of Studies Reviewed. The authors conducted a search of the literature published from January 1990 through March 2024 of sleep medicine–related articles, with a focus on neuroscience. The authors prioritized articles about the science of sleep as related to dental medicine.

Results. The authors found a proliferation of articles related to sleep neuroscience along with its implications in dental medicine. The authors also found that the intricate neuroscientific principles of sleep medicine are being investigated robustly. The salient features of, and the differences between, central and obstructive sleep apneas have been elucidated. Sleep genes, such as *CRY*, *PER1*, *PER2*, and *CLOCK*, and their relationship to cancer and neurodegeneration are also additions to this rapidly developing science.

Conclusions and Practical Implications. The dental clinician has the potential to be the first to screen patients for possible sleep disorders and make prompt referrals to the appropriate medical professionals. This can be lifesaving as well as minimize potential future morbidity for the patient.

Key Words. Sleep; neuroscience; circadian rhythm; sleep neurotransmitters; sleep genes; insomnia; obstructive sleep apnea; melatonin.

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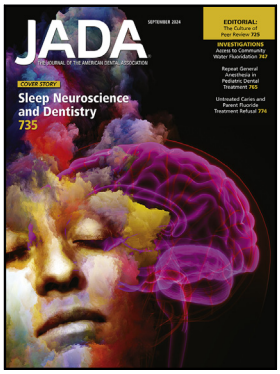

Sleep is a phenomenon that is ubiquitous in organisms. The physiology and importance of sleep, an entity that occupies almost one-third of human life, has baffled scientists for thousands of years. The interest in the physiology and neuroscience of sleep has led to a steep increase in related scientific articles over the past several decades. The importance of quality sleep and its various stages in homeostasis, memory consolidation, growth, repair, immunity, and other health and disease aspects are only beginning to be unraveled by science.

Sleep is defined as "a reversible behavioral state of perceptual disengagement from, and unresponsiveness to, the environment."[1] Over the past few decades, the science of sleep medicine and the literature associated with it have grown. Many branches of medicine have recognized the cardinal role sleep plays in health and disease. Consequently, dentistry is also seeing an exponential involvement in sleep medicine, with growth in the form of evolving principles of dental sleep medicine.

The objective of our narrative review is to create awareness in dental clinicians of the neuroscience of sleep and sleep disorders and their importance for patients as well as the clinician. Considering the vastness of this topic, this article is meant to provide only a basic foundation for the clinician.

We searched PubMed, Google Scholar, Web of Science, Embase, and Ovid MEDLINE for articles pertaining to the neuroscience of sleep. The time range was from January 1990 through March 2024. The search terms included sleep neuroscience, sleep and growth, circadian rhythms, sleep

This article has an accompanying online continuing education activity available at: http://jada.ada.org/ce/home.

Box 1. Classification of sleep disorders with examples (condensed version).[9]

Insomnia Disorders
- Chronic insomnia disorder
- Short-term insomnia disorder

Sleep-Related Breathing Disorders
- Obstructive sleep apnea
- Central sleep apnea syndromes
- Primary sleep apnea
- High altitude–related sleep apnea
- Sleep-related hypoventilation disorders

Central Disorders of Hypersomnolence
- Narcolepsy
- Hypersomnia due to medical or psychiatric disorders

Circadian Rhythm Sleep-Wake Disorders
- Shift work disorder
- Jet lag disorder

Parasomnias
- Confusional arousals
- Sleepwalking
- Sleep terrors
- Sleep-related eating disorder
- Rapid eye movement sleep behavior disorder
- Sleep enuresis
- Parasomnia due to a medication or substance use

Sleep-Related Movement Disorders
- Restless legs syndrome
- Periodic limb movement disorder
- Sleep-related leg cramps
- Sleep-related bruxism

physiology, and sleep disorders. We included articles published in the English language within the time range and excluded inconclusive, unfocused, limited, and duplicate studies.

ABBREVIATION KEY

AHI: Apnea-hypopnea index.
CSA: Central sleep apnea.
GABA: γ-aminobutyric acid.
GH: Growth hormone.
N2: Light sleep.
N3: Deep sleep.
NREM: Non–rapid eye movement.
OSA: Obstructive sleep apnea.
QOL: Quality of life.
REM: Rapid eye movement.
RHT: Retinohypothalamic tract.
SCN: Suprachiasmatic nucleus.

STAGES OF SLEEP

A major tool in determining sleep stages is polysomnography, of which the essential components include electroencephalogram, electro-oculogram, and electromyogram.[2] The electro-oculogram, measuring eyeball movements, is the cardinal one that differentiates between non–rapid eye movement (NREM) and rapid eye movement (REM) sleep. The 3 physiological systems involved in the regulation of sleep are the homeostatic system (managing the length, quantity, and intensity of sleep), the ultradian system (responsible for cyclic shifts between REM and NREM sleep), and the circadian system (governing the timing of sleep and wakefulness).[3] Stages N1 and N2 are called light sleep. N2 occupies approximately 50% of total sleep time.[4] Several poor sleep hygiene factors (eg, watching liquid crystal display screen) and pharmacologic agents (such as nicotine and caffeine) may increase the time spent in N2.[5] The N3 stage, also known as delta wave sleep, restorative sleep, slow wave sleep, and deep sleep, has been shown to be the most reparative stage. REM sleep is associated with learning and consolidation of memory.[6,7] It has been shown that sleep deprivation affects the retention of information, memory, and ability to focus, affecting the skills of the clinician, cognition, and recall of learned tasks and resulting in tiredness and depression.[8] A

Box 2. Centers for sleep.

Hypothalamus[13]
- The preoptic area of the hypothalamus is critical for both thermoregulation and sleep
- Sleep-active neurons have been identified in the preoptic area
- Their activity is linked to the amount and intensity of sleep

Suprachiasmatic Nucleus[14]
- Individual neuronal oscillators that are connected together to form a system of pacemakers make up the suprachiasmatic nucleus
- The main control center for circadian rhythms

Brainstem[15]
- Key wake-promoting area
- Contains glutamatergic and cholinergic neurons that promote wakefulness and arousal
- Plays a crucial role in transitions between non-REM* and REM sleep

Thalamus[16]
- Dual role in controlling both wakefulness and non-REM sleep
- Regulates cortical tone and arousal

Basal Forebrain[17]
- Contains cholinergic, GABAergic, and glutamatergic neurons, all of which project to the cortex and are involved in the control of cortical arousal and sleep-wake transitions

Amygdala[18]
- Plays a role in influencing the brainstem regions responsible for controlling wakefulness and regulating sleep

Pons[19]
- The primary brain region responsible for initiating REM sleep is located in the pons and neighboring areas of the midbrain

*REM: Rapid eye movement.

complete review of the crucial role played by sleep in health and disease is beyond the purview of this article. A condensed version of the latest classification of sleep disorders is given in Box 1.

BRAIN CENTERS FOR SLEEP AND WAKEFULNESS

Sleep involves multiple brain centers.[2] The forebrain and brainstem are considered cardinal centers for initiation and maintenance of sleep and wakefulness.[2,10] The reticular activating system, sometimes referred to as the ascending reticular activating system, with its associated projections, is considered to be paramount in the maintenance of wakefulness.[10,11] Humans are considered programmed to sleep. Pioneers of sleep medicine have opined that it is not sleep that needs to be explained but wakefulness that is a mystery.[12] A summary of the sleep and wakefulness centers of the brain is presented in Box 2.

SLEEP AND WAKE NEUROTRANSMITTERS

Neurotransmitters involved in the regulation of the sleep-wake cycle include, but are not limited to, histamine, norepinephrine, serotonin, orexin (hypocretin), glutamate, acetyl choline, and γ-aminobutyric acid (GABA) (Figure 1).

Some of the neurotransmitters are primarily prosleep and some are prowake; others have a dual action.[21,24,26,32] These neurotransmitters also function in the modulation of alertness and motor activity and depth of sleep.[33] Acetylcholine, glutamate, and dopamine generally are considered dual-action neurotransmitters. Acetylcholine plays a role in both generation of REM sleep and wakefulness.[29] Dopamine has a similar action and is secreted primarily from the ventral tegmental area.[25] It acts via the mesolimbic pathway and is the cardinal neurotransmitter in the reward system

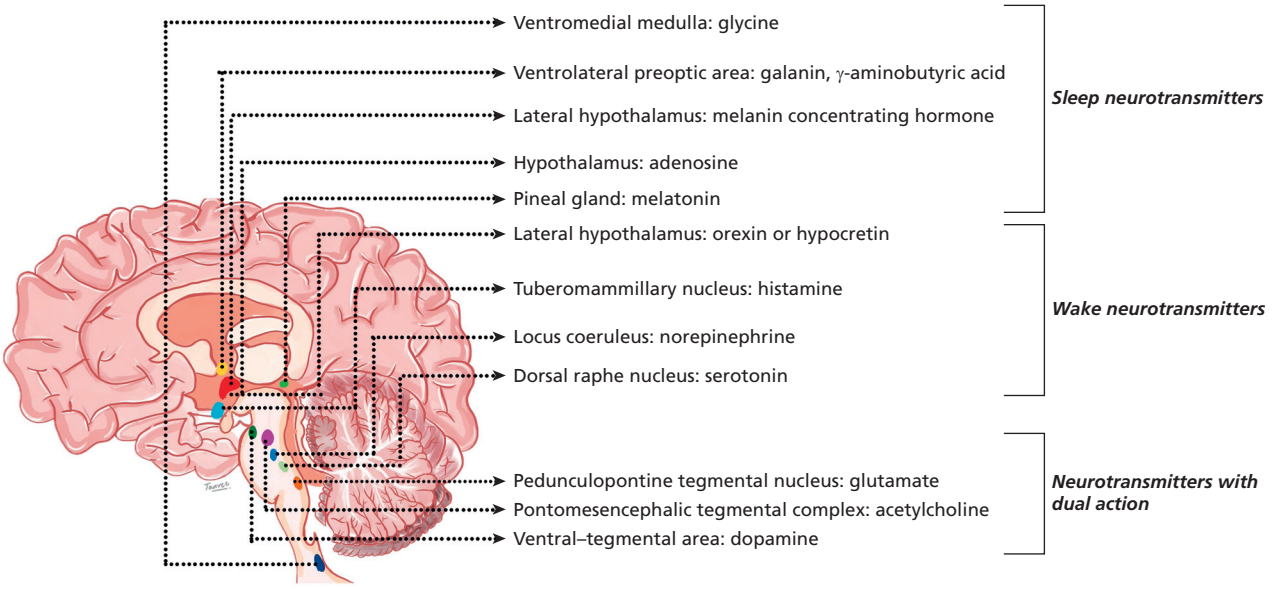

Figure 1. Neurotransmitters involved in the sleep-wake cycle.[20-31]

of the brain.[34] Glutamate is the most abundant excitatory neurotransmitter in the central nervous system and shows increased levels during waking and REM sleep.[26,32]

The neurotransmitters that primarily are involved in wakefulness include histamine, orexin (hypocretin), serotonin, and norepinephrine.[35,36] Histamine is secreted mainly by tuberomammillary nucleus neurons.[36] Orexin (hypocretin) is a neuropeptide and regulates wakefulness, emotions, and attention through stimulation of the basal forebrain and other structures.[22,37] Serotonin, produced by neurons in the dorsal raphae nucleus, inhibits REM sleep and facilitates wakefulness.[30] Norepinephrine is a wake neurotransmitter mainly secreted from locus coeruleus and primarily involved in wakefulness, attention, and response to stress.[24]

The neurotransmitters that are involved primarily in sleep include adenosine, GABA, glycine, galanin, and melatonin (neurohormone).[27-29,35] During wakefulness, adenosine gets accumulated in the basal forebrain, increasing the predisposition to fall asleep.[38] Adenosine keeps accumulating during wakefulness (as adenosine triphosphate is used up and broken down during daily activities) and is an important inducer of sleep. It acts on adenosine receptors in the brain and thus induces and modulates sleep.[23] GABA is the most abundant inhibitory neurotransmitter in the central nervous system and plays a role in REM sleep.[26] Glycine, the main inhibitory neurotransmitter in the spinal cord and the ventromedial medulla, causes REM-related skeletal muscle atonia and hypotonia (the paralysis during dreams).[27] Galanin, a sleep-promoting neuropeptide, is present in the ventrolateral preoptic area.[22,28] The other related biologically active entities include growth hormone (GH) releasing hormone,[31] cytokines,[39] vasoactive intestinal peptides,[22] melanin concentrating hormone,[22] and melatonin.

SLEEP-WAKE CYCLE: THE CIRCADIAN RHYTHM

The word circadian means "around the day" (in Latin "circa" is around or about and "dies" is day). Circadian rhythms include endogenously regulated oscillations of (but not limited to) heart rate, cardiac output, core body temperature, respiratory rate, blood pressure, endocrine and exocrine secretions, and sleep-wake cycle. The biological clock, the central pacemaker of the sleep-wake cycle, is the suprachiasmatic nucleus (SCN), located in the inferior zone of the hypothalamus.[3,8] The retinohypothalamic tract (RHT) is a crucial anatomic structure involved in circadian rhythm and is influenced by light. The paired SCN contains a total of more than approximately 10,000 neurons regulating the sleep-wake cycle.[8,40] Although many genes may be involved in the sleep-wake cycle, the main ones are *CLOCK*, *PER*, *BMAL1*, *TIM*, and *CRY*.[40] The SCN molecular clock comprises 2 activators, namely CLOCK and BMAL1, and 3 repressor proteins, namely PER, TIM, and CRY. They are regulated by kinases and phosphatases.[40] TIM is known to be a repressor

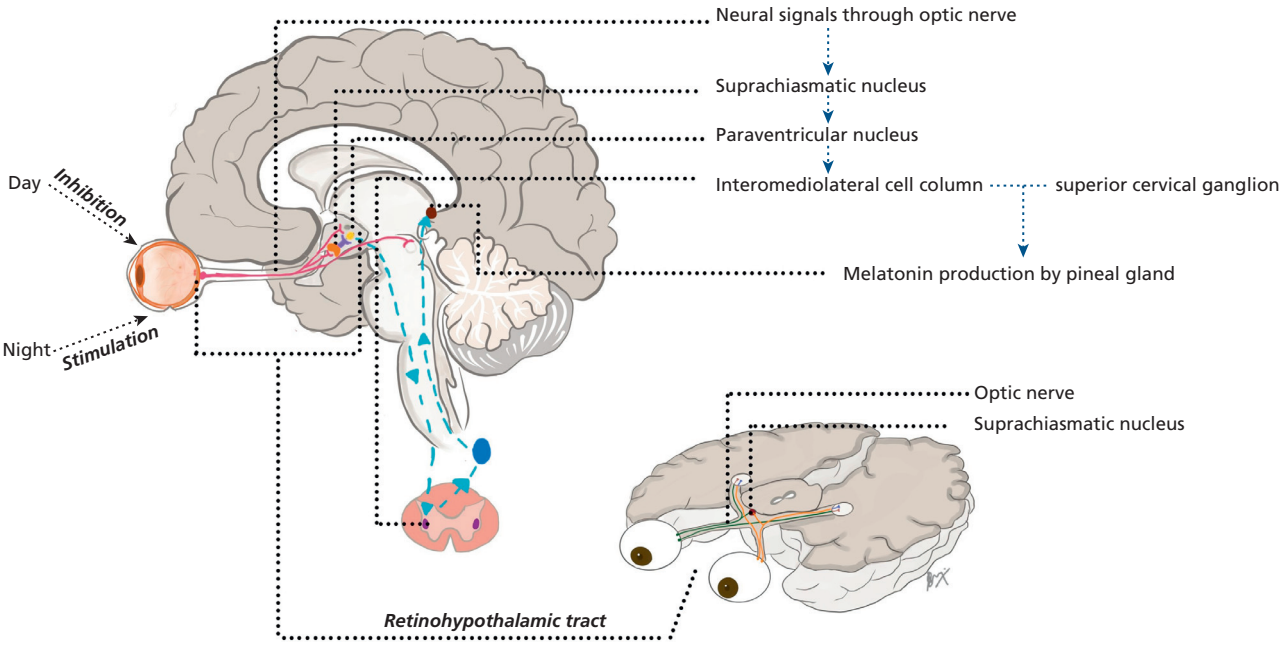

Figure 2. Retinohypothalamic tract.

gene of certain specific proteins in the nucleus. Together with the *PER* gene, TIM plays an important role in regulating the setting of the circadian pacemaker.[41] Aging results in a reduction in the circadian rhythm sleep activities.[42] Contrary to previous belief, a study from 2018 indicates that many parameters of sleep are affected minimally by aging.[43]

RHT

Melatonin is secreted by the pineal gland on receiving signals from the RHT. Stimulation of cells in the retina by light causes signals to be transmitted by the RHT to the SCN.[8,44] The neurophysiology of how RHT brings about a reduction in melatonin production on exposure to light is complex, involving multiple neural centers. The end result is either stoppage or reduction of melatonin secretion from the pineal gland.[8] A summary of this process is depicted in Figure 2.

Melatonin

Melatonin, a prosleep neurotransmitter secreted by the pineal gland, helps maintain the circadian rhythm.[20] Melatonin secretion is controlled primarily by light and follows a rather complex pathway. It acts at MT1 and MT2 receptors. Serum melatonin concentrations are maximum at ages 4 through 7 years, reduce in adulthood, and minimize at approximately ages 70 through 90 years.[20] Melatonin shows diurnal variation, maximizing between 2 and 4 AM and progressively reducing plasma concentrations during the waking hours.[45,46] Melatonin has been proposed to have antioxidant and anti-inflammatory properties.[20] Plant-derived melatonin usually is used for therapeutic purposes. Synthetic melatonin (such as ramelteon) is used for improving sleep quality in older adults and patients with neurodegenerative diseases. Oral melatonin usually is given 1 through 2 hours before routine bedtime.[8,20] A list of commonly prescribed sleep medications is summarized in Table 1.

SLEEP AND NEURODEGENERATIVE CONDITIONS

Neurodegenerative conditions such as Alzheimer disease, Parkinson disease, and tauopathies affect sleep parameters, including the secretion of melatonin, a sleep-promoting neurotransmitter.[52] Changes in the cells of the SCN are considered to be 1 of the causes of the sleep disorders associated with Alzheimer disease.[42] Sleep disturbances may be a symptom of the diseases or occur as a comorbidity or secondary to medications. The disturbance in the macro and micro architectures of sleep may be important in the pathophysiology and progression of these conditions.[44,53]

Table 1. Commonly prescribed medications for sleep disorders.[47-51]

DRUG	INDICATIONS AS RELATED TO SLEEP MEDICINE	MECHANISM OF ACTION	EFFECT ON SLEEP ARCHITECTURE
Benzodiazepines	Insomnia, anxiety	γ-Aminobutyric acid agonist	Increase in N2* stage
Zolpidem, Zaleplon, Zopiclone (Z-Drugs)	Insomnia	γ-Aminobutyric acid agonist	Increase in N2 stage
Agomelatine	Insomnia with comorbid disorders	Agonist at MT1 and MT2 receptors	Increase in N3† stage
Ramelteon	Sleep-onset insomnia, insomnia related to circadian disturbances	Dual agonist at MT1 and MT2 receptors	Increase in N2 stage
Suvorexant	Sleep maintenance insomnia	Dual orexin receptor antagonist	Increase in N2 and rapid eye movement sleep stages
Gabapentin and Pregabalin	Insomnia with comorbid disorders	Modulators of the $\alpha 2\delta$ subunit of voltage-sensitive calcium channels	Increase in N3 stage
Doxepin	Sleep maintenance insomnia	H1 antagonist	Increase in N2 stage
Amitriptyline (Tricyclic Antidepressant)	Insomnia with comorbid disorders	Histamine and serotonin receptor antagonists	Increase in N3 stage
Mirtazapine, Olanzapine (Hypnotic)	Insomnia	Serotonin receptor antagonists 5HT2A and 5HT2C	Increase in N3 stage, and possibly N2 and rapid eye movement
Quetiapine	Insomnia	Serotonin receptor antagonists 5HT2A and 5HT2C, 5HT1A partial agonist	Increase in N2 stage
Trazodone	Insomnia	5HT1A partial agonist, 5HT2A receptor antagonist	Increase in N3 stage
Caffeine	Sleepiness, narcolepsy	Adenosine (A2A) receptor antagonist	Promotes wakefulness
Modafinil	Daytime sleepiness and narcolepsy	Dopamine transporter antagonist	Promotes wakefulness

* N2: Light sleep. † N3: Deep sleep.

SLEEP AND GROWTH

GH secretion follows a circadian rhythm and is dependent on the quality and quantity of sleep.[54,55] Increased GH levels are seen primarily during the N3 stage of sleep. Muscle and bone growth and tissue repairs occur during the N3 stage of sleep.[56-59] Reduction in GH that occurs during aging is considered to be related to that in the N3 stage of sleep and thought to result in disturbed sleep patterns as well as sleep-related cardiometabolic disturbances.[60] The secretion of GH-releasing hormone from the hypothalamus has been shown to promote NREM sleep, facilitating GH secretion.[31,61]

SLEEP AND THE PEDIATRIC POPULATION

The circadian rhythm in infants is less well defined than in adults.[62] Infant sleep patterns are sporadic, and the most extended single sleep session typically lasts from 2.5 through 4 hours, often aligning with feeding times.[62] Quiet sleep, active sleep, and indeterminate sleep are the 3 types of sleep observed in a newborn. Quiet sleep, which is similar to NREM, is defined by minimal muscle activity and regular breathing patterns, whereas active sleep is similar to REM but with a few distinct differences.[62] Approximately one-half of the sleep time in an infant is spent in REM sleep compared with approximately one-fifth of the sleep time observed in an adult. Furthermore, there is no actual delineation into various stages seen in the adult. By age 6 months, an infant's sleep closely resembles that of adults. Over the first year, nighttime sleep becomes more consolidated into a single continuous block, whereas daytime sleep gradually decreases over the first 3 years. By age 4 years, most children no longer need daytime naps. Nighttime sleep requirements decrease gradually and become similar to adults' needs during adolescence.[62,63]

Sleep disturbances in children and adolescents

A child's proper growth, physical and mental development, and general health depend greatly on how well they sleep.[64] Common childhood sleep disorders encompass behavior-related insomnia

(due to parental limit-setting and sleep associations), obstructive sleep apnea (OSA), restless legs syndrome, parasomnias, and delayed sleep phase syndrome in adolescence.[65,66] Sleep deprivation is a growing concern among high school students.[65] Sleep disorders can have distinct manifestations in children compared with in adults. Whereas adults typically show symptoms such as fatigue and daytime sleepiness, children may exhibit behavioral issues such as irritability, hyperactivity, and academic underperformance. Teenagers with sleep disturbances might be more prone to experience motor vehicle accidents caused by drowsy driving.[65] Approximately one-half of children may encounter sleep-related problems but only approximately 5% receive an official diagnosis of a sleep disorder.[65,67] The role of liquid crystal display screens in causing sleep disturbances in children and adolescents is well known.[68] The mechanisms proposed include time displacement (bedtime shortens), increased arousal, and suppression of melatonin.[68,69]

EFFECTS OF SLEEP DEPRIVATION IN ADULTS

Sleep deprivation impairs ability to make decisions, memory consolidation, cognition, concentration, and attentiveness.[70,71] Sleep deprivation was shown to result in disrupted attention span, resulting in errors in medical examinations and surgeries and increased patient mortality.[72] Impaired neurocognition and perception are observed in people who are chronically sleep deprived.[72] Poor sleep quality in dental students has been shown to affect adversely their clinical and didactic performance.[73,74]

SLEEP DISORDERS AND THE DENTAL CLINICIAN

OSA

The dental clinician has the ability to screen for sleep disorders such as snoring, OSA, and insomnia by means of using simple screening techniques such as the Epworth Sleepiness Scale, Pittsburgh Sleep Quality Index Scale, Mallampatti Score, STOP-BANG questionnaire, and a clinical sleep apnea and oral screening. In the OSA screening, additional parameters that the clinician looks for include signs of bruxism, prominent linea alba bucca, neck circumference, scalloping of the tongue, and oropharyngeal crowding.[75,76] One connection is the link between OSA and certain oral and facial characteristics.[77] Orthodontic factors such as a constricted palate, a retrognathic mandible, or decreased arch length discrepancy potentially can contribute to airway constriction and increase the risk of developing OSA.[78] Orthodontic interventions such as palatal expansion and functional appliances can help create more oropharyngeal space, potentially improving airflow and reducing the severity of OSA in the pediatric and adolescent populations.[79,80] In the adult population, modalities such as mandibular advancement devices and orthognathic surgery may be indicated.[81,82] Although myofunctional therapy (exercises) for OSA seems to indicate reduction in the apnea-hypopnea index (AHI) both in children and adults,[83] high-quality robust studies are lacking.[83] Furthermore, other studies, although reporting improvement in AHI, showed lack of improvement or lack of efficacy with regard to the OSA-related indexes.[84] Any recommendations for myofunctional therapies, as an adjunct to other treatment modalities for OSA, need further studies.[85,86] Rapid palatal expansion has shown moderate to good evidence of improvement of AHI in the pediatric and adult populations.[80,87] The exact mechanism and neuroscience principles behind the efficacy of these procedures are yet to be elucidated.

Sleep bruxism

Sleep bruxism has been one of the most discussed entities in the past 3 decades of scientific literature. The effects of sleep bruxism on dental structures and restorations is well published in the literature.[88] However, the exact neurophysiology of how the motor activity in sleep bruxism happens is yet to be determined, and a genetic predilection has been proposed in the pathogenesis.[89] Contrary to older literature, the evidence seems to suggest a lack of causal relationship between sleep bruxism and periodontal damage.[90] The effects of bruxism on dental structures and restorations remain somewhat controversial and, therefore, need further studies.[91-93] Dental splints may be used to protect the teeth and supporting structures from the possible effects of bruxism and provide temporary relief from bruxism episodes.[88]

Table 2. The salient features of, and difference between, CSA* and obstructive sleep apnea.

DESCRIPTION	CSA	OBSTRUCTIVE SLEEP APNEA
Definition	Cessation of air flow due to the lack of respiratory effort during sleep[112,113]	Cessation of airflow with concomitant continued respiratory effort[113]
Etiology	• Brainstem lesions[114] • Opioid, narcotic, or drug induced[115] • Neuromuscular diseases: amyotrophic lateral sclerosis, brainstem stroke, multiple system atrophy[115] • Chest wall syndromes[114] • Cheyne-Stokes breathing[112,115] • Idiopathic[115] • High altitude[115]	• Anatomic factors such as increased neck circumference; narrowing of pharynx[116] • Upper airway collapse[117] • Reduced airway space[118] • Repetitive total or partial airway collapses[119]
Epidemiology	• Prevalence is approximately 1%[120] • Prevalence higher in males than in females[120,121] • Increases with age[120,121]	• Age, 30-69 y[122] • Prevalence higher in males than in females[123] • Prevalence increases with age[124] • More prevalent in Hispanics and Asians[125]
Pathophysiology (Centers Involved)	• Unstable ventilatory control, hypoventilation during rapid eye movement[126,127]	• Negative pressure causing collapse during inhalation[128] • Narrowing of the airway in the retropalatal area[129,130] • Often correlates with body mass index[131] • Centers of the brain involved: right basolateral amygdala, hippocampus, and right insular cortex[132]
Clinical Features	• Daytime sleepiness, snoring, apnea episodes causing nocturnal awakenings, increased sleep latency, poor sleep quality, morning headaches[127,133]	• Daytime drowsiness; loud snoring and episodes of gasping, choking, or temporary cessation of breathing during sleep; fatigue; morning headaches; self-reported insomnia and nocturia[134,135]
Risk Factors and Predisposing Factors	• Male sex, congestive heart failure, other heart diseases, geriatric population[126]	• Obesity[136] • Alcohol, smoking, sedative and hypnotics usage[137,138] • Menopause[139]
QOL†	• CSA with congestive heart failure leads to poor QOL[140]	• QOL is poor[141,142]
Management	• Adaptive servo ventilation device[120,126] • Oxygen therapy[120] • Continuous positive airway pressure, bilevel positive airway pressure[120] • Carbon dioxide inhalation[120] • Acetazolamide[127] • Phrenic nerve stimulation[143] • Reduction or withdrawal of opioids if possible[113] • Hypnotic therapy[113] • Reassurance[113] • Sleep hygiene improvement[113]	• Positive airway pressure[144] • Oral appliances: tongue retaining device, mandibular advancement devices[144] • Surgical[144] • Adjunct: weight loss, etc.[144]
Prognosis	• Patients with congestive heart failure have worse prognosis with regard to CSA[145]	• Short-term good prognosis • Long-term prognosis uncertain[146]
Complications	• Mild cognitive impairment[133] • Dementia[133] • Cardiac arrhythmias[133] • Respiratory failure[114] • Death[133]	• Hypertension[147] • Cardiovascular disease[128] • Cerebrovascular accident[148] • Depression[149] • Sleeplessness-related accidents[150]

* CSA: Central sleep apnea. † QOL: Quality of life.

The diagnosis of sleep bruxism is based on parental report, bed partner report, self-report, clinical examination, medical history, and possible polysomnographic recordings. However, the exact value of these parameters in the assessment of bruxism is only beginning to be elucidated.[88,89,94] Sleep bruxism usually is observed in N1 and N2 stages of sleep. Sleep bruxism in REM sleep is not a usual clinical manifestation but may be attributed to cortical brain activity and possible microarousals.[95] Drugs such as anticonvulsants, selective serotonin reuptake inhibitors, serotonin norepinephrine reuptake inhibitors, and phenethylamines, among others, have been implicated in inducing sleep bruxism.[88,96] A multidisciplinary approach for management of sleep bruxism may involve a general dentist, neurologist, physical therapist, pain management specialist, and psychologist.[97,98]

Insomnia

Research that shows that insomnia is highly prevalent in patients being treated by dentists with symptoms of oral and facial pain.[99] Insomnia may often co-occur with various sleep disturbances such as sleep-related breathing disorders, both in adult[100] and pediatric populations.[101] A relatively newer concept of chronotype profiling of patients for management as well as procedures has evolved.[102] The concept originated from the proposal that human physiological functions, metabolism, and repair are modulated by the circadian clock. This emerging science has the potential to select customized appointment timings for a patient on the basis of their chronotype to facilitate better healing and pain control.[102] Cognitive behavioral therapy is considered as a first line of management for primary insomnia.[103]

Sleep and pain

Sleep and pain traditionally have been described in literature as having a "bidirectional relationship."[104] Impaired sleep can result in increased pain experience; acute and chronic pain can impair sleep as well.[105-107] Sleep disturbances also negatively affect the long-term prognosis of headaches, orofacial pain, temporomandibular disorders, and other chronic pain.[94,108,109] Management of orofacial pain should include a component of improving the patient's sleep parameters.

SNORING TO OSA: THE NEUROSCIENCE OF CONVERSION

The paradigm that snoring almost always is a prelude to OSA seems to be supported by emerging literature. Chronic snoring induces inflammation of the upper airway and the pharynx.[110] This results in local small fiber neuropathy and pathologic changes in the pharyngeal muscle fibers, leading to a collapse of the upper airway.[110,111] The pathogenesis of central sleep apnea appears to be different from that of snoring and OSA. The salient features of, and difference between, central sleep apnea and OSA are summarized in Table 2.

CONCLUSIONS

Dental clinicians should familiarize themselves with sleep disorders that may manifest in their patients. The dentist has the potential for being the first clinician to screen patients for possible sleep disorders and make prompt referrals to the appropriate medical professional. This can be lifesaving as well as instrumental in minimizing potential future morbidity for the patient. Furthermore, the importance of good-quality sleep both for the clinician and the patient is clear. Dental management modalities, including mandibular advancement devices and planned preventive and interceptive orthodontics, may play a crucial role in management of sleep disorders. A good understanding of the neuroscience behind sleep disorders will help dentists facilitate optimal care for their patients. ■

DISCLOSURES

None of the authors reported any disclosures.

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