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Polysomnography (PSG) a Diagnostic tool in Obstructive Sleep Apnea and Its Application in Treatment Planning in Orthodontic treatment - A Review Article

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Abstract

Polysomnography is a diagnostic tool and used to monitor the treatment response activity in obstructive sleep apnoea (OSA) and other related sleep disorders. This results in disjointed, no restful sleep that can lead to symptoms such as headache and daytime drowsiness. Obstructive sleep apnea interrupts the patients of all age group and most commonly among those 55 to 60 years, Obstructive spleep apnea (OSA) has an increased prevalence in the older patients. The prevalence rate is about OSA affects 1 to 6% of adults and 2% of children. Males are effected as twice compared to females. There are various health conditions

related with obstructive sleep apnea (OSA), including the history of hypertension, cardiac arrhythmias, coronary artery disease and Mental depression. The main clinical features includes Loud snoring, gasping during sleep, obesity, and puffy neck circumference area. The diagnostic stool for obstructive sleep apnea is nocturnal polysomnography in a sleep laboratory. Home sleep apnea tests can also be performed for certain orthodontic patients. Continuous positive airway pressure is the primary treatment; observance rates may vary and appear to improve with patient education and support for the test. Polysomnography (PSG) records your brain waves, oxygen level in your blood, heart rate and breathing, as well as eyes and leg movements during the study.

Keywords : Obstructive sleep apnea, polysomnography test, diagnosis, orthodontic treatment

Introduction

Polysomnography is the test performed on a person, who is completely asleep. It is also known as the sleep study. Polysomnography is basically done to detect sleeping disorders. Polysomnography records the following while a patient is asleep: Breathing cycle , Level of Heart rate, Level of oxygen in the blood, Brain waves activity. Muscle tone activity, Eye movements and Limb of Movements. This procedures employs the activities like electroencephalogram, electromyogram,electrocardiogram electrooculogram, and pulse oximetry, as well as airflow and respiratory effort, to evaluate for underlying causes of sleep disturbances[1] . Polysomography is considered as gold standard test for the obstructive sleep apnea and other sleep-related breathing disorders like central sleep apnea, and sleep-related hypoxia. Recent advanced technological developments has been revolution in medical. Home sleep apnea testing can be done to check the diagnosis of the patients with a high risk, moderate and severe Obstructive sleep apnea. Polysomography parameters such as the Hypnea-Hypopnea Index, Sleep Efficiency ,Oxygen Saturation levels and Different stages of sleep provides the comparisons over a time and recognizes the limitation of night to night variability that occurs in patients. Polysomography can be useful for documenting the changes in objective sleep parameters secondary to treatment intercession, It measures the changes and functioning in daytime of health related quality of life. Sleep studies are performed in a sleep laboratory or in the home can quantify the apnea-hypopnea index, which is required to diagnosis Obstructive sleep apnea (OSA). Apnea is a complete obstruction of airflow, and hypopnea is a partial obstruction of airflow; both must last a minimum of 10 seconds. Hypopneas are measured by oxygen desaturation of 3% or more or arousal from sleep. The apnea-hypopnea index is calculated by adding all apneas and hypopneas and then dividing by total sleep time. An apnea-hypopnea index of 15 or more events per hour, or five or more events per hour in the presence of symptoms or cardiovascular comorbidities, is diagnostic for Obstructive sleep apnea (OSA)[2] .

History

The roots of the modern-day polysomnogram (PSG) are credited to the work of Caton (1875), who discovered brain wave activity in animals in 1875. This very early finding led to the description of differences between wakefulness and sleep by Berger (1929), and ultimately contributed to the first continuous overnight EEG recording during sleep (Loomis et al., 1937). Further work by Aserinsky, Kleitman, Dement, and Jouvet in the 1950s established the utility of the combined use of electroencephalogram (EEG), electro-oculogram (EOG), and electromyogram (EMG) to determine various behavioural states in wakefulness and sleep, including rapid eye movement (REM) sleep (Aserinsky and Kleitman, 1953[3] ; Dement and Kleitman, 1957; Jouvet et

al., 1959). Dement and Kleitman proposed formal nomenclature for various stages of sleep in 1957. Gastaut et al. (1965) published data on respiratory disturbances during sleep. A standardized manual for terminology, techniques, sleep staging, and respiratory event scoring was published in 1968, known as the Rechtschaffen and Kales (R and K) manual (Kales and Rechtschaffen, 1968). The R and K manual remained as the standard PSG staging and scoring system till 2007, American Academy of Sleep Medicine (AASM) published its own manual, which is now it is considered and used as the required standardized system for all AASM-accredited sleep centers and sleep labs. The AASM manual is revised every few years, with the latest edition being version 2.4 by Berry in 2017 [4] . Polysomnogram is utilized for the evaluation of a number of sleep disorders, it is considered and mainly aids as the gold standard for the diagnosis of obstructive sleep apnea.

Overview

A monotonous needs a complete monitoring system to record sleep stages, limb movements, airflow, respiratory exertion, heart rate and its rhythm, oxygen saturation, and body position. This type of study is also known as a Type I or Level I sleep study, it is prepared in a sleep lab with a skilled sleep technician. (PSGs) are principally used in diagnosis of sleep related breathing disorders including obstructive sleep apnea , central sleep apnea, and sleep-related hypoxia. (PAP) titration sleep studies have been modified. Polysomnogram (PSGs) evaluates the effectiveness of Positive airway pressure (PAP) therapy in treating sleep related breathing disorders. Additionally, PSGs may be used to diagnose sleep-related seizures, periodic limb movement (PLM) disorder, parasomnias, and central hypersomnias (Kushida et al., 2005).

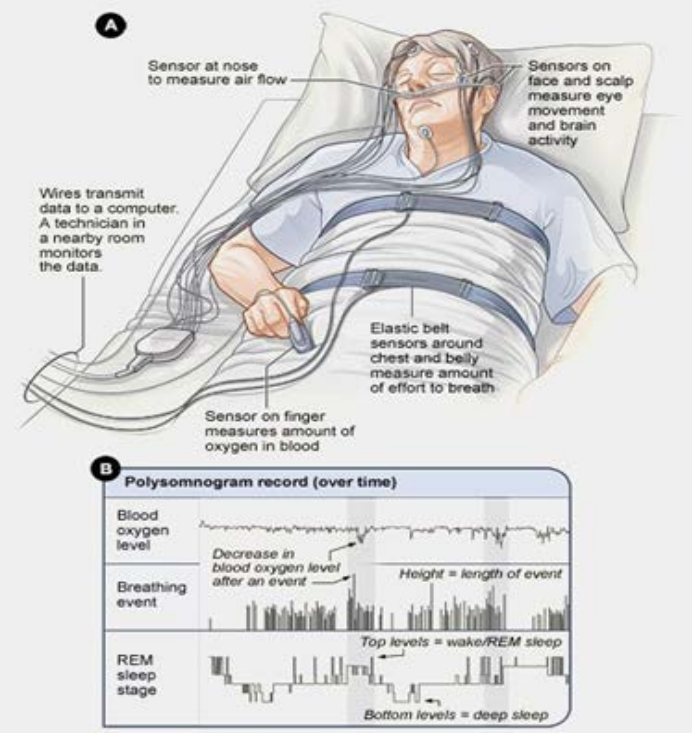

Figure 1: In Adults a) Polysomnography b) Polysomnogram

PSG or sleep study can directly monitor and quantify the number of respiratory events (ie, obstructive, central, or complex) and the resultant hypoxemia and arousals related to the respiratory events or even independent of the respiratory events[6] .A single-night PSG is usually adequate to determine if OSAS is present and the degree of the disorder. However, night-tonight variability may exist in adult and children patients who have a high probability but a low apnea index (Fig 1). In addition, variability in laboratory equipment, scoring technique, and interscorer reliability may also play roles. As is well known, PSG scoring also usually varies from laboratory to laboratory (Fig 2). PSG is used to evaluate abnormalities of sleep and/or wakefulness and other physiologic disorders that have an impact on or are related to sleep and/or wakefulness.

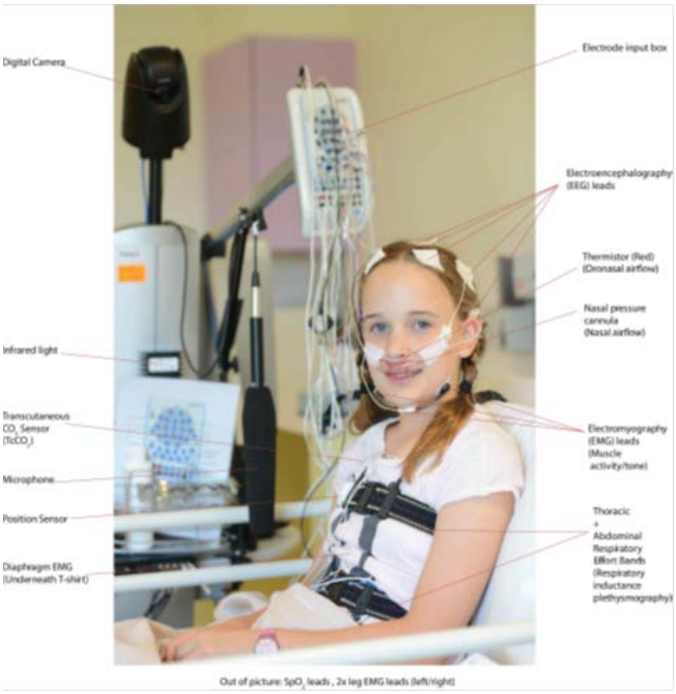

Figure 2 : Overnight polysomnography setup in children with obsdtructive sleep apnea.

Parameters Monitored IN

Assessment of sleep stages requires 3 studies[7] :

- Electroencephalography **(EEG)**
- Electrooculography **(EOG)**
- Surface electromyography **(EMG)**

Electroencephalography (EEG),

One EEG channel (central channel with an ear reference provides the best amplitude) **is** used to monitor sleep stage. However, most laboratories use 2 central channels and 2 occipital channels, with ear references as an adjunct to help identify sleep latency and arousals. A 10- to 20-electrode placement system is used to determine the location of these channels. Additional EEG channels can be used, particularly in patients with epilepsy (ie, a full 10-20 montage).

Electrooculography (EOG)

Two EOG channels are used to monitor both horizontal and vertical eye movements. Electrodes are placed at the right and left outer canthi, one above and one below the horizontal eye axis. The electrodes pick up the inherent voltage within the eye; the cornea has a positive charge and the retina has a negative charge. Evaluation of the eye movements is necessary for 2 reasons. First is for documentation of the onset of rapid eye movement (REM) sleep, and second is to note the presence of slow-rolling eye movements that usually accompany the onset of sleep.

Surface electromyography (EMG)

One EMG channel (usually chin or mentalis and/or submentalis) is used to record atonia during REM sleep or lack of atonia in patients with REM-related parasomnias. To assess bruxism, the EMG electrodes can be placed over the masseter. The EMG recording from other muscle groups is assessed for other sleep disorders. For example, the anterior tibialis EMG is helpful for assessing periodic limb movements during sleep and the intercostal EMG is used as adjunctive help for determining effort during respiratory events

Two channels are used for monitoring airflow. One thermistor channel (oral and/or nasal) is used to evaluate the presence or absence of airflow. Any change in temperature as a patient inhales and exhales leads to a normal signal, so this channel is insensitive for partial flow obstruction. Thermistor is the recommended channel for evaluation of apneas. Nasal pressure transducer channel is a more sensitive measure of airflow restriction. Normal breathing has a rounded pattern, while resistance to airflow leads to a squaring off of the flow signal. Pressure transducer is the recommended channel for evaluating hypopneas. It is also used for airflow resistance in upper airway resistance syndrome.

The standard PSG which is performed in a sleep laboratory is categorized as a (Tab.1)

Type I : Monitoring devices perform in-lab; technician is present; overnight[8]
Type II : Monitoring devices can perform full PSG outside of the laboratory; technician is not present; comprehensive portable devices
Type III : Monitoring devices do not record the signals needed to determine sleep stages or sleep disruptions; typically only respiratory movement and airflow, heart rate and arterial oxygen saturation is measured; some devices may record snoring, detect light or monitor the body position
Type IV : Monitoring devices record one or two variables (eg. arterial oxygen saturation and airflow); can be used without a technician; continuous single or dual bio-parameter devices

Table 1: Categories of sleep monitoring devices [LBL09]

Staging of Sleep in Polysomnography test[9]

EEG background

Alpha EEG

- Frequency of 8-13 Hz
- Produced in occipital region
- Crescendo-decrescendo appearance

Theta EEG

- Frequency of 3-7 Hz
- Produced in the central vertex region
- No amplitude criteria
- Most common sleep frequency

Delta EEG

- EEG frequency of 0.5-2 Hz
- Seen predominantly in frontal region
- Amplitude of greater than 75 microvolts

Sleep spindle

- Frequency of 12-14 Hz
- Produced in central-vertex region
- Greater than 0.5-3 seconds in duration
- 0.5-second spindles with 6-7 cycles
- Indicative of stage 2 sleep

K complexes

- Sharp, slow waves with a negative, then positive, deflection
- No amplitude criteria
- Duration must be at least 0.5 seconds
- Predominantly produced in central-vertex region
- Indicative of stage 2 sleepMay occur with or without stimuli

Wake stage

- Greater than 50% of each epoch contains alpha activity
- Eye blinks at a frequency of 0.5-2 Hz
- Reading eye movements
- Irregular conjugate rapid eye movements associated with normal or high chin tone.

Stage N1 (formerly stage 1)

- Greater than 50% of the epoch contains theta activity (4-7 Hz) with slowing of the background rhythms greater than
- or equal to 1 Hz from those of stage wake
- Vertex sharp waves
- Slow-rolling eye movements in EOG channels
- Relatively high submental EMG tone

Stage N2 (formerly stage 2)

- Theta activity (4-7 Hz)
- K-complexes and sleep spindles occur episodically
- High tonic submental EMG

Stage N3

- Greater than 20% of each epoch must contain delta activity
- Amplitude of 75 microvolts or greater
- Submental muscle tone may be slightly reduced

Discontinued former stage 3

- Between 20-50% of each epoch must contain delta activity
- Amplitude of 75 microvolts or greater
- Submental muscle tone may be slightly reduced

Discontinued former stage 4

- Greater than 50% of the epoch has scorable delta activity
- Amplitude of 75 microvolts or greater
- Submental EMG activity slightly reduced from that of light sleep

REM sleep

- Rapid eye movements (fig. 3)
- Low amplitude, mixed frequency EEG (similar to awake pattern)
- Atonia or the lowest tonic submental EMGMay see saw-tooth waves

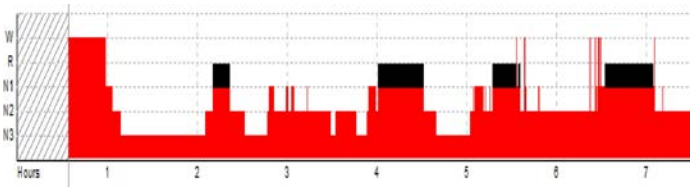

Figure 3: Hypnogram showing normal sleep architecture during a night of sleep with all of the typical sleep stages. W, wake; R, REM sleep; N1, non-REM stage 1 sleep; N2, non-REM stage 2 sleep; N3, non-REM stage 3 sleep.

Procedure

In 1992, the Office of Technology Assessment of the Agency of Health Care Policy and Research recommended, in an evidence-based assessment, declared two tests as having been studied sufficiently. Both tests are performed in a sleep laboratory. The first is overnight polysomnography (PSG) or sleep study, which is an overnight recording of the patient's sleep. Typically for a baseline study, the patient is observed sleeping naturally without any treatment, but if a signficant amount of sleepdisordered breathing (AHI> 20–30 events per hour) is seen in the first hours of the study, a split-night study is performed during which positive airway pressure (PAP) is started[10] . Titration studies may also be done with initiation of PAP from the start of the study to determine optimal settings (Fig 4) .The second is multiple sleep latency testing (MSLT), which records multiple naps throughout a day. Maintenance of wakefulness testing (MWT) can also be performed, which determines how long wakefulness can be maintained. Standard sleep studies usually use the overnight PSG (may be performed over several nights). If daytime sleepiness is an issue and cannot be fully explained by the overnight study results, an MSLT should be performed the next day. Limitations usually stem from the fact that recording conditions may not reflect what happens during a regular night in the patient's home. Although diagnosing a sleep problem on the basis of a recording over a single night is common practice, some authorities caution that more than one night of recording may be necessary so the patient can become comfortable with unfamiliar surroundings and sleep more naturally.

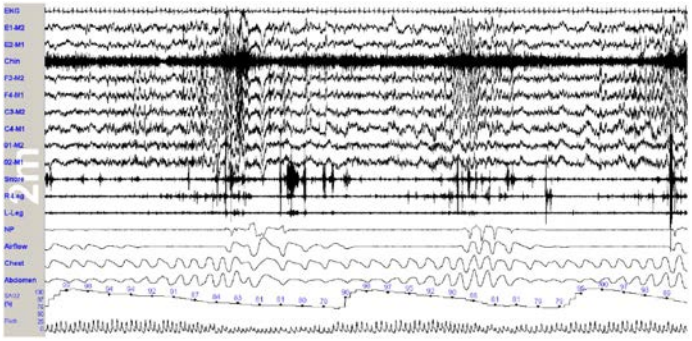

Figure 4 : Digital tracing of a 2-min epoch of stage 2 non-REM sleep showing several obstructive apneas (thin arrows) with no flow in NP or airflow leads. Effort is present in chest and abdomen leads. There are also associated oxygen desaturations (wide arrows) and EEG arousals (microarousal). E1-M2, left EOG; E2-M-1, right EOG; F3-M2, F4-M1, C3-M2, C4-M1, O1-M2, O2-M1, EEG derivations; chin, chin EMG; EKG,

electrocardiogram; snore, snore microphone; R-Leg, right tibialis anterior EMG; L-Leg, left tibialis anterior EMG; NP, nasal pressure transducer; airflow, oronasal thermistor; chest, chest inductance plethysmography; abdomen, abdomen inductance plethysmography; SAO2, oxygen saturation percentage; pleth, plethysmography

This effect is greatest on the first night in the sleep laboratory (ie, first-night effect).Sporadic events may be missed with a single-night PSG. External factors that disturb the subject's sleep may be present in the home but absent from the controlled environment of the sleep laboratory.

Patient preparation is important so that the patient sleeps naturally. Patient instructions include the following:

- Maintain regular sleep-wake rhythm.
- Alcohol and sleeping pills may alter the PSG results, but if they are part of the patient's normal routine, they should
- Alcohol and sleeping pills may alter the PSG results, but if they are part of the patient's normal routine, they should not be abruptly stopped.
- Avoid stimulants, including medications for narcolepsy.
- Avoid strenuous exercise on the day of the PSG.
- Avoid naps on the day of the sleep study.

Daytime PSG can be useful for patients who typically sleep during the day. Simplified sleep studies with limited subsets of monitored parameters, such as PAP-NAPs, can be used to help the patient with acclimatization and finding optimal settings. High costs and long waiting lists have prompted the exploration of alternative methods of evaluation and many insurance companies are requiring home-based, limited-channel sleep studies prior to in-laboratory PSG. Instead of in-laboratory titration, many patients with obstructive sleep apnea can be started on automatically adjusting continuous positive airway pressure (CPAP) and then have the settings adjusted and response monitored through data collected by the device[11]

Home Sleep Apnea Testing

Overview

Home sleep apnea testing (HSAT) is an alternative to PSG in the diagnosis of OSA. When used in accordance with the most recent clinical guidelines, HSAT can be part of the assessment and treatment of OSA[12] . The HSAT is used only for the assessment of OSA in uncomplicated patients who are at moderate to high risk of OSA and who do not have comorbid medical conditions or other suspected sleep disorders (Tab.2). HSAT is also not recommended in patients over age 65, as it has not been extensively studied in that population, and older patients may have difficulty applying the HSAT sensors properly. Additionally, patients with a body mass index of >40kg/cm2 are at increased risk

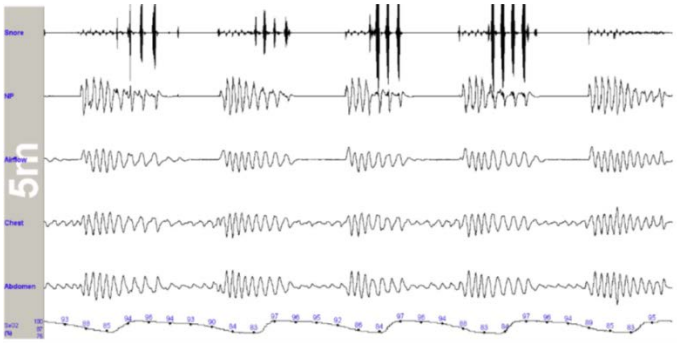

Figure 5: Digital tracing of a 5-min epoch from a home sleep apnea test (HSAT) showing several obstructive apneas (thin arrows)with no flow in NP or airflow leads. Effort is present in chest and abdomen leads. There are also associated oxygen desaturations (wide arrows). NP, nasal pressure transducer; airflow, oronasal thermistor; chest, chest inductance plethysmography; abdomen, abdomen inductance plethysmography; SAO2, oxygen saturation percentage

Exclusion criteria for HSAT

1. Significant cardiorespiratory disease (i.e., congestive heart failure or chronic obstructive pulmonary disease)
2. Potential respiratory muscle weakness due to neuromuscular disease
3. Chronic opioid use
4. Awake or high risk for sleep-related hypoventilation (i.e., obesity hypoventilation)
5. Recent stroke
6. Severe insomnia
7. Symptoms of other sleep disorders (i.e., narcolepsy, central sleep apnea, movement disorders in sleep, parasomnias)
8. Environmental or personal reasons that may lead to poor acquisition and interpretation of HSAT results

Table 2 : Exclusion criteria of Home sleep apnea testing

HSAT devices typically use the same type of sensors used in PSG; however Type III (Level III) and Type IV (Level IV) sleep studies have fewer sensors in total, and EEG is not recorded(Fig.5). The most common devices used for HSAT are Type III devices, but others have extended sensors beyond the traditional Type III classification, using an alternative SCOPER (sleep, cardiovascular, oximetry, position, effort, and respiratory) assessment system (Tab. 3). HSATs may also include sensors for body position, heart or pulse rate, movement assessment as a surrogate measure for sleep EEG for sleep, and pulse wave analysis, including peripheral arterial tonometry [13] .Type II devices are generally reserved for hospitalized patients. Type IV (Level IV) devices have one to two sensors, similar to nocturnal pulse oximetry testing. Type IV devices are not recommended by the AASM for HSAT, as these devices do not record oxygen saturation, airflow, or respiratory effort.

American Academy of Sleep Medicine guidelines

The American Academy of Sleep Medicine (AASM) evaluated the literature on unattended sleep monitoring devices to develop their clinical guidelines, published in 2007[14] .These guidelines include the following recommendations and cautions:

- Portable monitoring (PM) may be indicated for the diagnosis of obstructive sleep apnea (OSA) in patients for whom in-laboratory PSG is not possible by virtue of immobility, safety, or critical illness. PM may also be indicated to monitor the non-CPAP treatments of sleep apnea including oral appliances, weight loss, and upper airway surgery.
- PM is not appropriate for diagnostic evaluation of patients who may have comorbid sleep disorders including central sleep apnea, periodic limb movements, insomnia, parasomnias, circadian rhythm disorders, or narcolepsy.
- PM is not appropriate for the diagnosis of OSA in patients with significant comorbid medical conditions that may degrade the accuracy of PM. This includes, but is not limited to, severe pulmonary disease,[5] neuromuscular disease, or congestive heart failure.
- PM is not indicated in the absence of a comprehensive sleep evaluation.
- PM is not appropriate for general screening of asymptomatic patients.
- At minimum, PM must record airflow, respiratory effort, and blood oxygenation.
- The PM device must allow for display of raw data with the capability of manual scoring or editing of automated scoring by a qualified sleep technologist.
- A board-certified sleep specialist or an individual who fulfills eligibility criteria for the sleep medicine certification examination must review the raw data from PM using scoring criteria consistent with current published AASM standards.
- False negative rates may be as high as 17% in unattended PM studies. If the PM test is technically inadequate or does not provide the expected result, in-laboratory polysomnography should be performed.
- AASM does not support type IV devices for home sleep testing

Table 3: Clinical guidelines given by American Academy of sleep medicine

In 2012, the AASM also published evidence-based practice parameters for the non-respiratory indications for polysomnography and multiple sleep latency testing for children[15] . PSG is indicated for children suspected of having periodic limb movement disorder (PLMD) for diagnosing PLMD. Children with frequent NREM parasomnias, epilepsy, or nocturnal enuresis should be clinically screened for the presence of comorbid sleep disorders and polysomnography should be performed if there is a suspicion for sleep-disordered breathing or PLMD. Because of the lack of EEG monitoring, Type III devices may underestimate the severity of sleep-disordered breathing. Typically, events must be associated with 3% desaturations to be scored, so patients with events primarily causing arousals may be missed. Additionally, the apnea/hypopnea index (AHI) is calculated by the number of apneas and hypopneas per hours of test rather than hours of sleep, which can also underestimate severity. For these reasons, if a homestudy is normal in a patient with suspected sleep apnea, an in-laboratory PSG is recommended.

Practical Orthodontic Applications

The diagnosis of adult OSA was an overview from the orthodontic prospective, we did not go in depth with OSA

treatment, which will need another short clinical review. However, we can still emphasize two points related to diagnosis and treatment planning of OSA patients. First, for obese orthodontic OSA patients with a convex type of facial divergence, the orthodontist may implement modified treatment goals. For instance, if the orthodontist was considering extraction-based therapy in such patients, less effect might be seen on the profile and on lip support. Second, the evidence of an association between facial morphology and OSA may point to therapeutic orthodontic modalities that enhance the shape of the anatomical traits of the face although such gain is limited by genetic determinism[16] . In summary, medical history (e.g., snoring) and clinical examination allow orthodontists to identify the risk factors of OSA or signs related to OSA (obesity, allergy, nasal dysfunction, maxillary constriction, retrognathia, long uvula, mouth breathing). PSG is an important diagnostic test. Several imaging modalities (lateral and frontal cephalogram, cone beam computed tomography, magnetic resonance imaging) can assist orthodontic professionals in assessment of this condition. Orthodontic professionals need to expand their cooperation with physicians and sleep medicine specialist and should try to look for sleep lab to refer the patients for better patients care. The orthodontist should be more alert to enquire about snoring even in Class I; class II malocclusion and straight and convex profile patients especially with vertical growth patterns. When orthodontist carries out the functional, positional, and structural assessments of the dentofacial pattern, we strongly support the suggestion of inclusion the assessment of the pharyngeal structures with the orthodontic diagnosis and treatment planning [17] . Shortly, the demand of integrating sleep into the orthodontic practice will be driven by the need of the societies as some of our patients will be coming into our offices aware of sleep apnea, and what would be a casual, patient conversation may lead to a positive discussion about how an orthodontist could help in the process of diagnosis and treatment of this disorder [18]

Conclusion

For children, OSA and habitual snoring are most commonly associated with adenotonsillar hypertrophy, obesity, micrognathia, and tongue hypertrophy. The latter chronic sleeprelated airway obstruction results in sleep disturbance and repetitive asphyxia that can cause behavioural and developmental abnormalities, growth disturbance, and cor pulmonale. Therefore, before treatment of children with habitual snoring and/or OSA, a precise evaluation utilizing morphological and functional diagnosis is recommended in order to administer the appropriate treatment. Caution should be undertaken while interpreting pediatric polysomnography. Currently, polysomnography is the optimum test for diagnosing OSA and other sleep-related breathing disorders. It includes evaluation of sleep staging, airflow and ventilatory effort, oxygen saturation, body position, and periodic limb movements. Home oximetry may be a more convenient and less expensive alternative in patients with established OSA who are being monitored to assess the response to treatment.

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