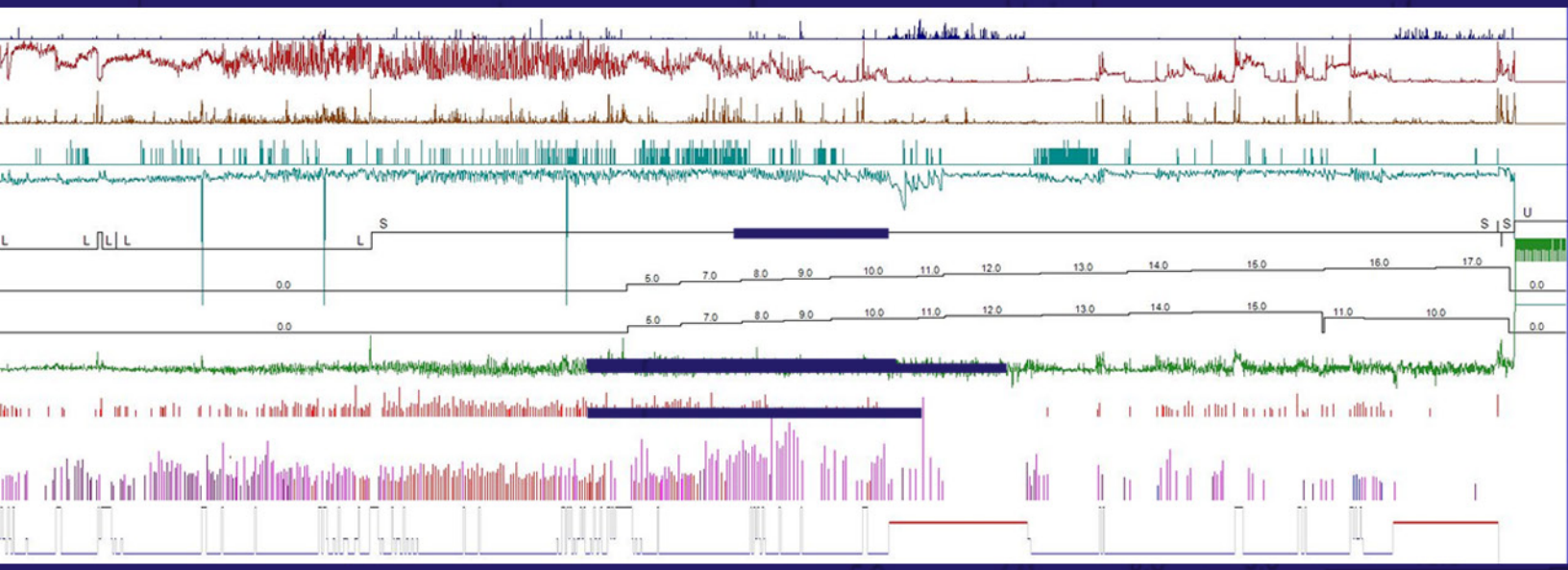
DS3X
THE DS3 EXPERIENCE

DEMYSTIFYING

THE SLEEP TEST REPORT



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REVIEW OF SLEEP

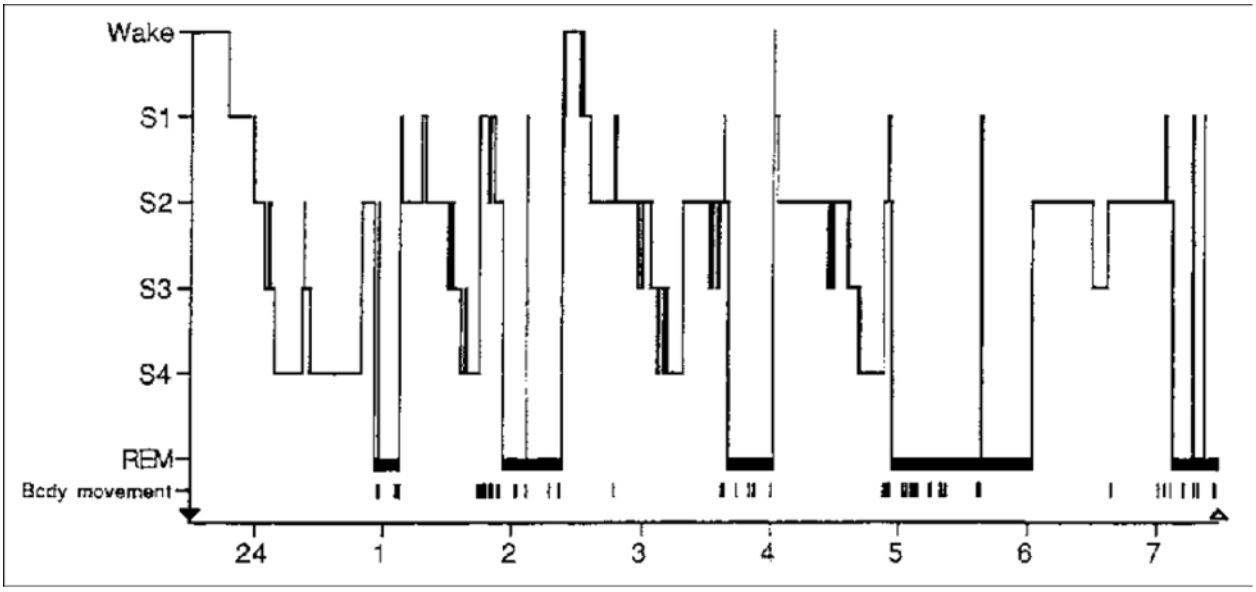
> “Blessings on him who first invented sleep. – It covers a man all over, thoughts and all, like a cloak. – It is meat for the hungry, drinks for the thirsty, heat for the cold, and cold for the hot. – It makes the shepherd equal to the monarch, and the fool to the wise. – There is but one evil in it, and that is that it resembles death, since between a dead man and a sleeping man there is but little difference.”

From Don Quixote by S. M. de Cervantes

Before we can adequately interpret sleep tests, we must first understand a few things about sleep. Such as, why do we sleep? What purpose does it serve? Though many theories have been postulated, the bottom line is we really don't know. Rather than knowing why we must do it (and we all agree that we must, because the alternative is death), it's easier to ask: What happens when we don't get enough sleep? That's a simple enough question that we all know the answer to. We feel tired; we don't think as clearly; we have trouble remembering things; we can get irritable and downright mean; we lose the ability to concentrate and focus.

SLEEP:

- The cyclic, temporary and physiologic loss of consciousness that is readily, promptly and completely reversed with appropriate stimuli.
- The purpose of sleep has simply been defined as the provision of a feeling of restoration and wakefulness.

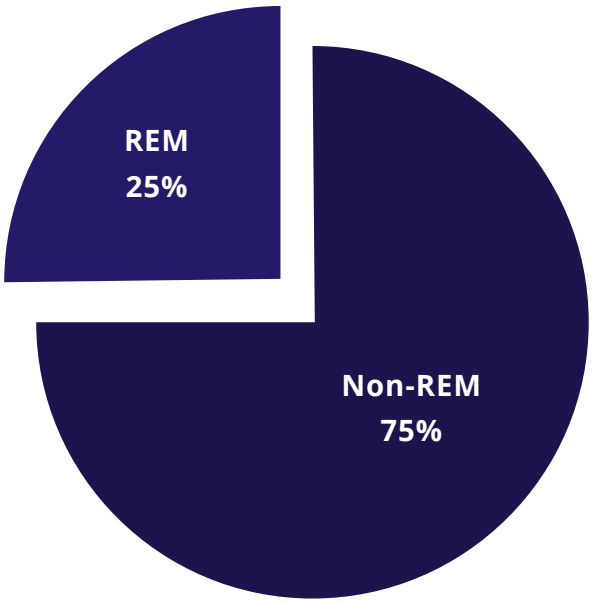


Histogram of normal sleep showing 4 to 5 cycles between REM and non-REM

Like many things in life that ebb and flow, sleep is no different. No doubt you have read about circadian rhythms, our biological time clock. Research is beginning to elucidate many of the physiologic factors that determine our drives to sleep and drives toward wakefulness. As a result, we now have medications that aid to increase our drive to sleep (Lunesta, Ambien) as well as our drives to stay awake (Modafinil).

Sleep is characterized by two distinct and separate states, Rapid Eye Movement (REM) and non-REM (NREM), that alternate back and forth about every 90-110 minutes in a healthy, normal person. NREM sleep is also called quiet or slow-wave and can be broken down into stages I through IV, with stage I being light and stage IV being deep. Over the past decade, Stage III and Stage IV sleep have been combined to be labeled N3 Sleep. NREM sleep accounts for approximately 75% of total sleep time. REM, or active sleep, accounts for the other 25% of sleep. It is characterized by a very distinct EEG pattern that is very similar to wakefulness. REM sleep is where we do almost all of our dreaming. There exists a gating mechanism in the brain stem that is activated during REM sleep, resulting in muscle hypotonicity such that the only muscles moving during REM sleep are the diaphragm and the eyes.

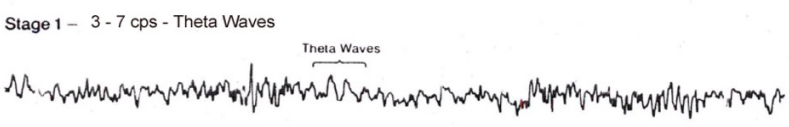
Let's take a moment to discuss sleep stages and understand how this would be displayed on a healthy adult's sleep test.



Non-REM sleep

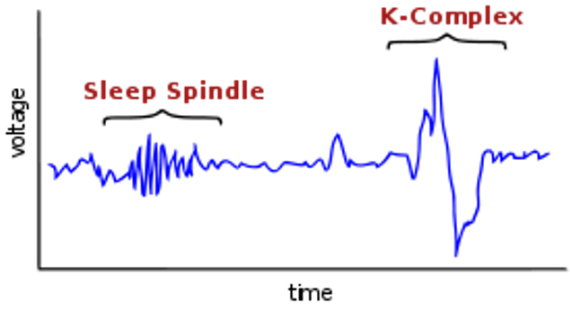
Stage I

- Thoughts begin to drift
- Thinking is no longer reality-oriented
- Short dreams often develop
- Patients subjectively feel they are awake
- Comprises approximately 2% to 5% of Non-REM sleep



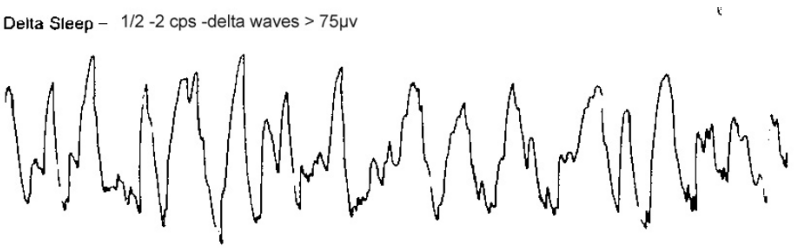
Stage II

- First bona fide sleep stage
- Majority of sleep is spent here
- Mentation consists of short mundane and fragmented thoughts
- Comprises approximately 45% to 55% of Non-REM sleep
- Appearance of sleep spindles and K complexes



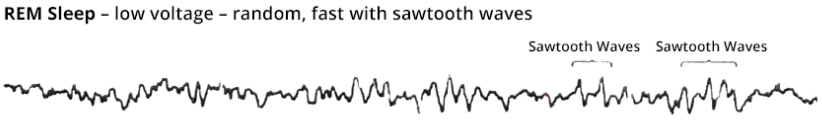
N3 Sleep (Formerly Stage III and IV)

- Also called slow wave, deep sleep or delta sleep
- Comprises about 10-20% of sleep
- Decreases with advancing age
- Important for "feeling rested", removal of neurotoxins, and production of many essential hormones such as growth hormone

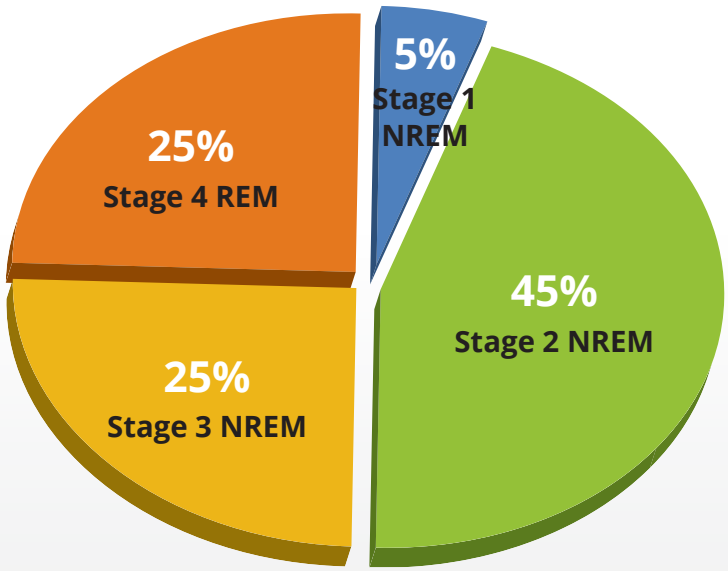


REM Sleep

- Comprises approximately 25% of sleep
- Alternates with Non-REM every 90-110 minutes
- Reduced temperature regulation: body moves toward ambient temperature
- Muscle hypotonicity or atonia
- Rapid, erratic breathing
- Increased heart rate
- Increased cerebral blood flow
- Dreaming
- Male erection
- Reduced diameter of upper airway
- Essential for memory consolidation



Duration of Sleep Stages



Sleep Stages

2-5%

Stage N1 - This first cycle of sleep is escribed as drowsiness. Eyes are closed during Stage 1 sleep. A person can be awakened without much difficulty but may feel as if they haven't slept at all.

45% - 55%

Stage N2 – This is a light stage of sleep. Spontaneous periods of muscle tightening mixed with periods of muscle relaxation are reported. The heart rate will slow and body temperature decreases, helping the body to prepare for deep sleep

10% - 20%

Stage N3 (Delta) – These are the deep sleep stages. These stages are known as slow-wave, or delta sleep.
Benefits = Feeling refreshed, hormonal & neurotoxin removal

20% - 25%

REM cycle - Intense dreaming occurs during the REM cycle. This results from heightened cerebral activity, but paralysis occurs simultaneously in the major voluntary muscle groups, such as the sub-mental muscles. The first period of REM sleep typically lasts about 10 minutes, with each recurring REM stage lengthening, eventually with the final stage lasting an hour.
Benefits = Memory consolidation

Generalizations about Sleep in a Normal Young Adult

1. **Sleep is entered through NREM sleep**.
2. **NREM sleep and REM sleep alternate with a period near 90 minutes**.
3. **N3 Sleep** predominates in the first third of the night and is linked to the initiation of sleep.
4. **REM sleep** predominates in the last third of the night and is linked to the circadian rhythm of body temperature.
5. Wakefulness in sleep usually **accounts for less than 5% of the night**.
6. **Stage 1** sleep generally constitutes approximately 2% to 5% of sleep.
7. **Stage 2** sleep generally constitutes approximately 45% to 55% of sleep.
8. **Stage 3** sleep generally constitutes approximately 3% to 8% of sleep.
9. **Stage 4** sleep generally constitutes approximately 10% to 15% of sleep.
10. **NREM sleep**, therefore, is usually 75% to 80% of sleep and REM sleep comprises the remainder, occurring in four to six discrete episodes. (Kryger R. D., 2005)

Why We Dream

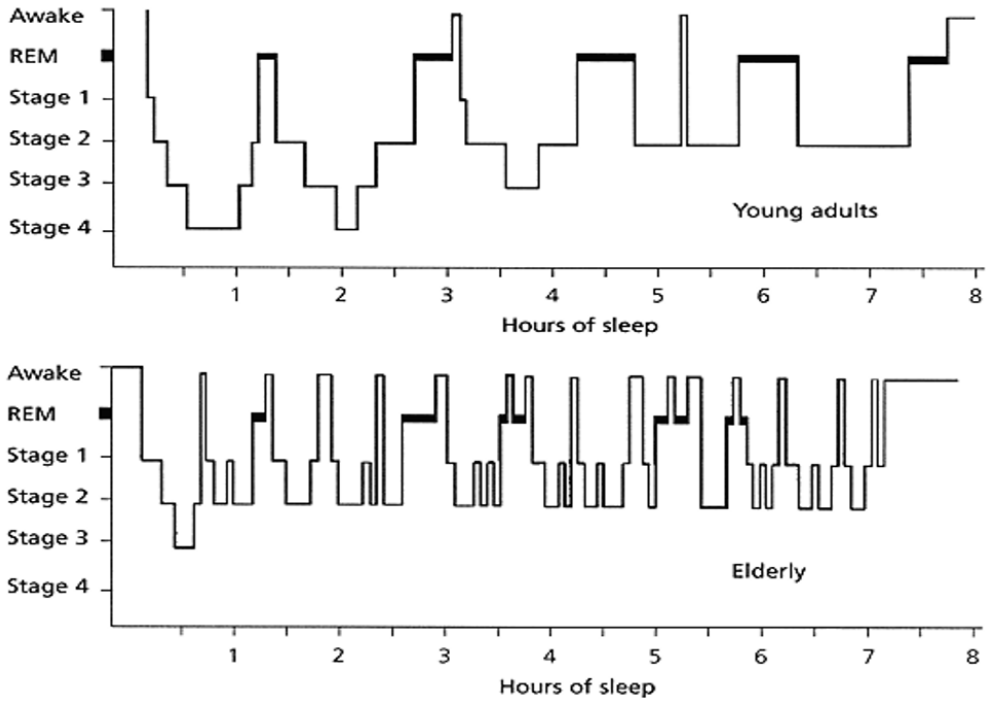
This may be a little off topic but anyone who delves into the world of sleep medicine can count on a patient asking, "Hey, Doc, why do we dream, anyway?" The search for an answer has been ongoing for thousands of years. Three publications have formed the core of scientific discussions:

- Freud's *Interpretation of Dreams* at the end of the 19th century (Freud, 1955)
- A report in the 1950s of a correlation between dreaming and the newly discovered REM sleep (Dement WC, 1957)
- A proposal of the activation-synthesis model of dreaming in the 1970s (Hobson JA, 1977)

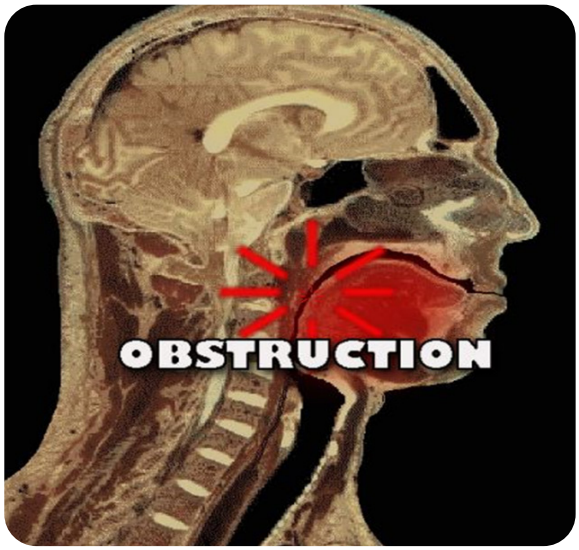
The literature is full of publications expounding upon the function of dreaming, yet there continues to be little agreement among experts. There is a growing consensus, however, that sleep serves a function of offline memory processing. Sleep has been shown to enhance prior learning of perception and motor skills (Strickgold R, 2000), improve paired word associations (Phihal W, 1999), enhance the formation of emotionally charged episodic memories (Wagner U G. S., 2001), and even to sharpen mathematical insight (Wagner U e. a., 2004).

The below (Hours of Sleep) are histograms of young and elderly sleepers. Take note of the differences: as a person ages, he gets less N3 (Stage 3 & 4) and spends more of the night awake.

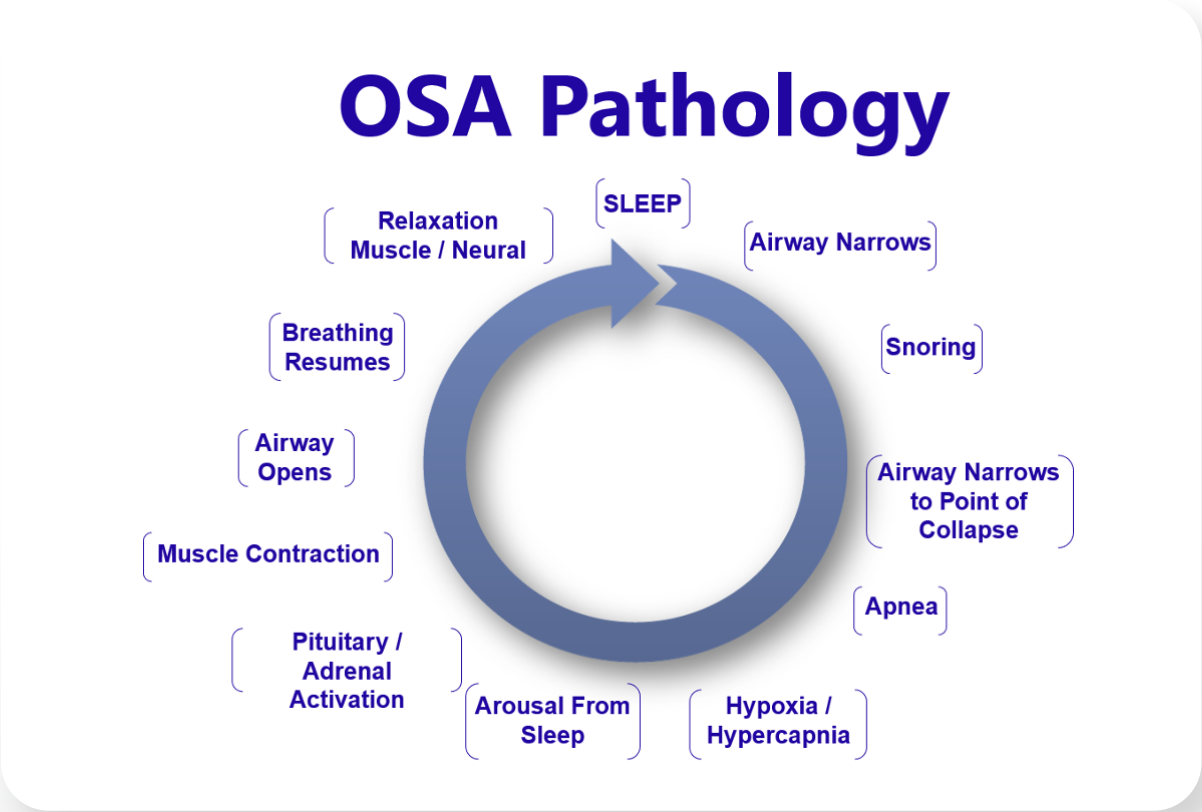
Why we sleep is unknown, but what is clear is that a lack of sleep has many negative side effects. A lack of N3 sleep will make a person feel sleepy; lack of REM sleep can result in negative cognitive consequences as well as morning headaches. Understanding the consequences of poor sleep will help you in your daily practice of dental sleep medicine.



Pathophysiology of Sleep Apnea



To a dentist, it makes perfect sense that anatomic factors contribute to the collapse of the upper airway during sleep. A very long palate, a large uvula, a large and scalloped tongue, large tonsils, a retruded mandible, etc. -- all of these contribute to a crowded airway, i.e. an airway that would be more difficult to get air through. You may ask yourself, however, why it is that people snore when they're asleep but not when they are awake. What is it about being awake that makes the airway more patent and less collapsible? The answer, though not well understood, appears to be neurologic, or more specifically relating to muscle tone. When sleep apneics fall asleep, they appear to lose some of the background muscle tone that helps maintain patency of the upper airway. It is safe to assume that both anatomical and neuromuscular factors contribute to the pathogenesis of airway collapse in OSA (Gleadhill IC, 1991). Other factors, such as lung volume, lung efficiency, and ventilator control mechanisms, may also play a part.



Sleep Testing - Polysomnogram (PSG) & HSAT

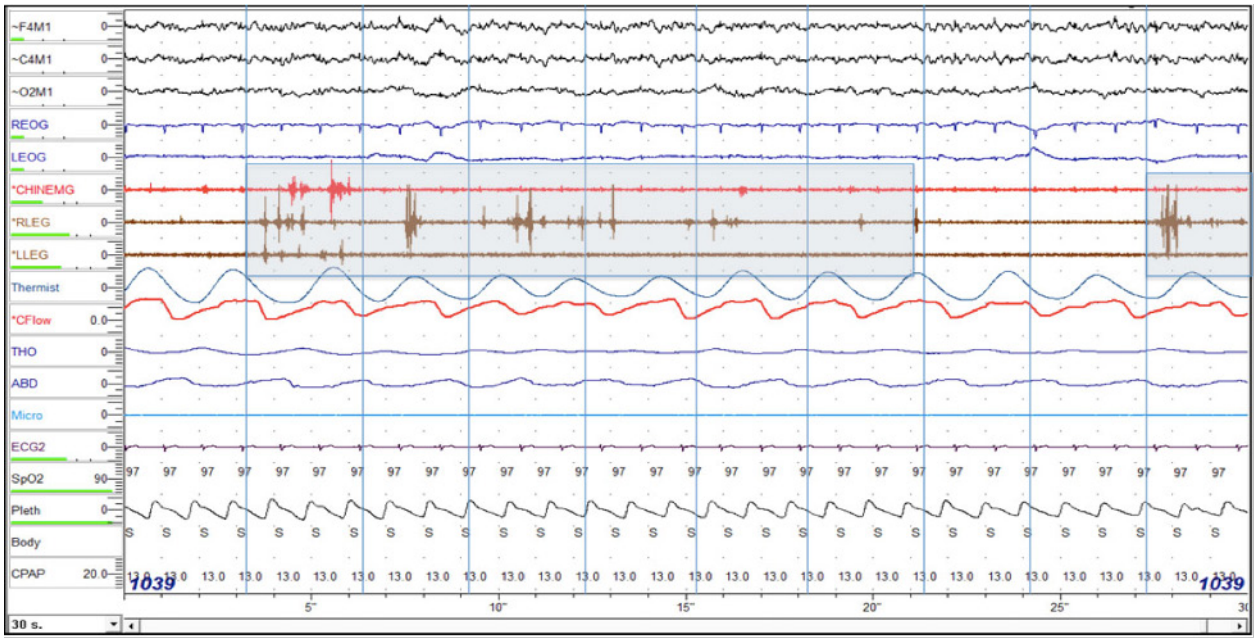
Sleep, by its very nature, is difficult to accurately monitor or test. We need sensors, which must be placed on fingers, heads, toes, etc., and the multitude of sensors, in turn, disrupt the very thing it is trying to monitor, your sleep! Nevertheless, we must monitor certain parameters, especially when one considers the significance of sleep disordered breathing and its impact on health and longevity.

The polysomnogram, or PSG as it is often called, has been the single tool used for the last forty years to diagnose sleep-disordered breathing (SDB); or, more specifically, Snoring, Upper Airway Resistance Syndrome (UARS), Obstructive Sleep Apnea (OSA) in mild, moderate, and severe forms, and Central Sleep Apnea (CSA). The PSG is also used to diagnose many other sleep disorders. Changes in Home Sleep Apnea Testing (HAST or HST) technologies and insurance policies have made it feasible to diagnose SDB utilizing HSAT devices since 2007 as well.

PSG

Polysomnograph

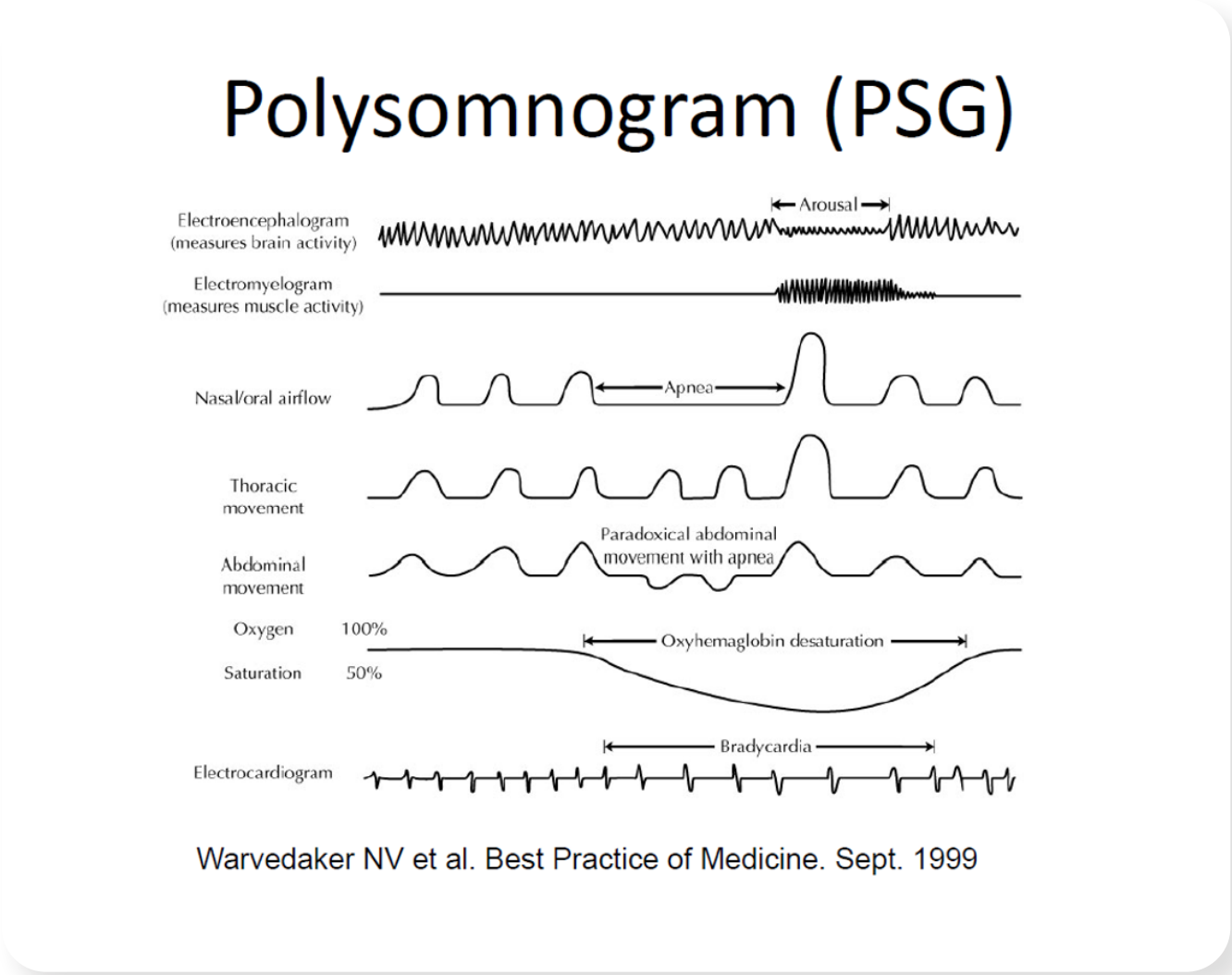
- Audio
- Video
- EEG – Brain
- EOG – Eye Movement
- EMG – Muscle
- ECG – Heart
- Esophageal Pressure (Pes)
- Oxyhemoglobin saturation ($S_p0_{2)}$)
- Pulse
- Thoracic effort
- Abdominal effort
- Nasal / Oral airflow
- Body Position



Home Sleep test

The diagnosis of OSA cannot be made accurately by clinical history or physical examination alone. The “gold standard” for diagnosis of OSA is polysomnography, a recording of at least seven parameters — electroencephalography (EEG, brain waves), electro-oculography (EOG, eye movements), chin electromyography (muscle activity), electrocardiography (ECG), respiratory effort, airflow, and blood oxygen saturation.

These data are gathered by a trained technologist using dedicated equipment as the patient sleeps overnight in a sleep laboratory. Full PSG allows calculation of the Respiratory Disturbance Index (RDI), which is the number of sleep-disordered events per hour of sleep (apneas and hypopneas) AND Respiratory Effort Related Arousals (RERAs). Other PSG reports will use the Apnea-Hypopnea Index (AHI) instead of the RDI.



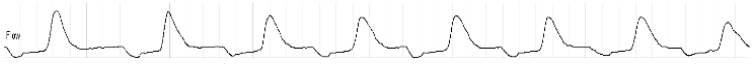
Furthermore, Peripheral Arterial Tone (PAT) is another type of HSAT (Level IV) which measures the arterial pulsatile volume changes at the fingertip combined with Artificial Intelligence (AI) to diagnose OSA and other forms of SDB.

The airway can be viewed statically or dynamically, and though this information is helpful, it is always superseded by the results of a sleep study. X-rays, cone-beam imaging, pharyngometry and even a quick peek through the mouth at the airway itself are all helpful, but how do we know what happens to the airway when a patient falls asleep? The only way to know for certain is through a sleep study. Though the PSG has been the gold standard used for diagnosis, HSAT has currently become the most utilized method for diagnosing SDB and OSA.

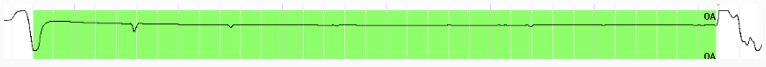
Before we dive into understanding a sleep test, let's review some important definitions.

- **Apnea** – Cessation of breath for 10 seconds or more.

Normal airflow on a sleep test

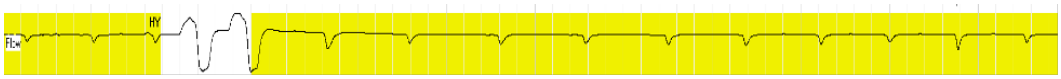


Apnea on a sleep test



- **OSA** – Obstructive Sleep Apnea. The more common form of apnea that occurs when throat muscles relax and close off the airway.
- **CSA** – Central Sleep Apnea. Occurs when your brain doesn't send proper signals to the muscles that control breathing
- **Complex sleep apnea syndrome -** Also known as treatment-emergent central sleep apnea, which occurs when someone has both obstructive sleep apnea and central sleep apnea.
- **Hypopnea** – A decrease in airflow lasting 10 seconds or greater with oxygen desaturations (4% desaturation is Medicare standard).

Hypopnea on a sleep test



- **RERA** – Respiratory Effort Related Arousal – This happens when a person struggles to breath enough to cause an arousal in sleep but does not have oxygen desaturations (i.e. not usually associated with oxygen desaturations).
- **AI** – Apnea Index. Total # of apneas/TST
- **AHI** – Apnea Hypopnea Index. Total # of apneas + Total # of Hypopneas divided by total hours of sleep. (A + H/TST).
- **RDI** – Respiratory Disturbance Index. Total # of apneas + Total # of Hypopneas + Total # of RERAs divided by the Total hours of sleep (A + H + R/TST)
- **Snoring** – Is a partial airway obstruction that reduces airflow but does not cause arousal from sleep.
- **SPO2% <90%** - Percentage (or minutes) of night that "O2" is below 90%
- **ODI** – Oxygen Desaturation Index. Total # of desaturations/TST
- **Lowest Oxyhemoglobin Saturation (LSAT or O2 Nadir)** – A measure of the lowest level of arterial oxygen in the blood during sleep. Normal oxyhemoglobin saturation is 95-98%.
- **Sleep Onset/Latency** – Period time from lights out/bedtime until sleep onset.
- **TST** – Total Sleep Time
- **Sleep Efficiency** – The ratio of time in bed versus time asleep *(TST/total recording time)*
- **WASO** – Wake after sleep onset. In other words, the first time they wake up after falling asleep.
- **REM Latency** – Time until first REM cycle
- **Arousal Index** - #/Hr. arousal/disruptions in sleep stages *(Shift in EEG for at least 3 seconds. In REM also requires increase in EMG or movement)*
- **PLMI –** Periodic Limb Movement Index. Total # of PLM/TST.

OSA Classification

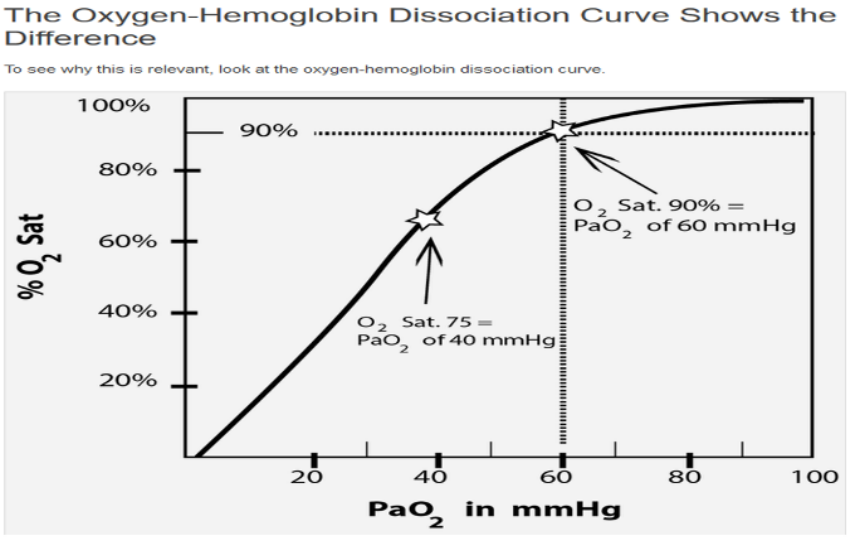
Although there are many factors affecting patients afflicted with OSA, the standard for classification for the severity of the disease is based on AHI as follows:

- AHI < 5 = Not diagnosed with OSA
- AHI 5 – 14 = Mild OSA
- AHI 15 – 30 = Moderate OSA
- AHI >30 = Severe OSA

Note that many reports will use the terms AHI, RDI, ODI, and REI interchangeably, though there are some subtle differences and this is not entirely accurate.

Among the many other factors that affect patients with OSA, we believe it is also critical to consider the pulse oximetry readings at the very least. There is very good evidence that patients who spend time with SPO2 readings below 90% are at much higher risk for a multitude of health problems.

This evidence is why we believe it is important to consider the patient's LSAT and time below 90% when evaluating patients for dental sleep therapy as well as their post-treatment calibration sleep studies.



https://airwayjedi.com/2015/12/09/difference-oxygen-saturation-pao2/

SPO2	Pa02
98-100	100
97	90
95	80
93	70
90	60

***Pa02 is** a measurement of the actual oxygen content in arterial blood

Demystifying Sleep Studies

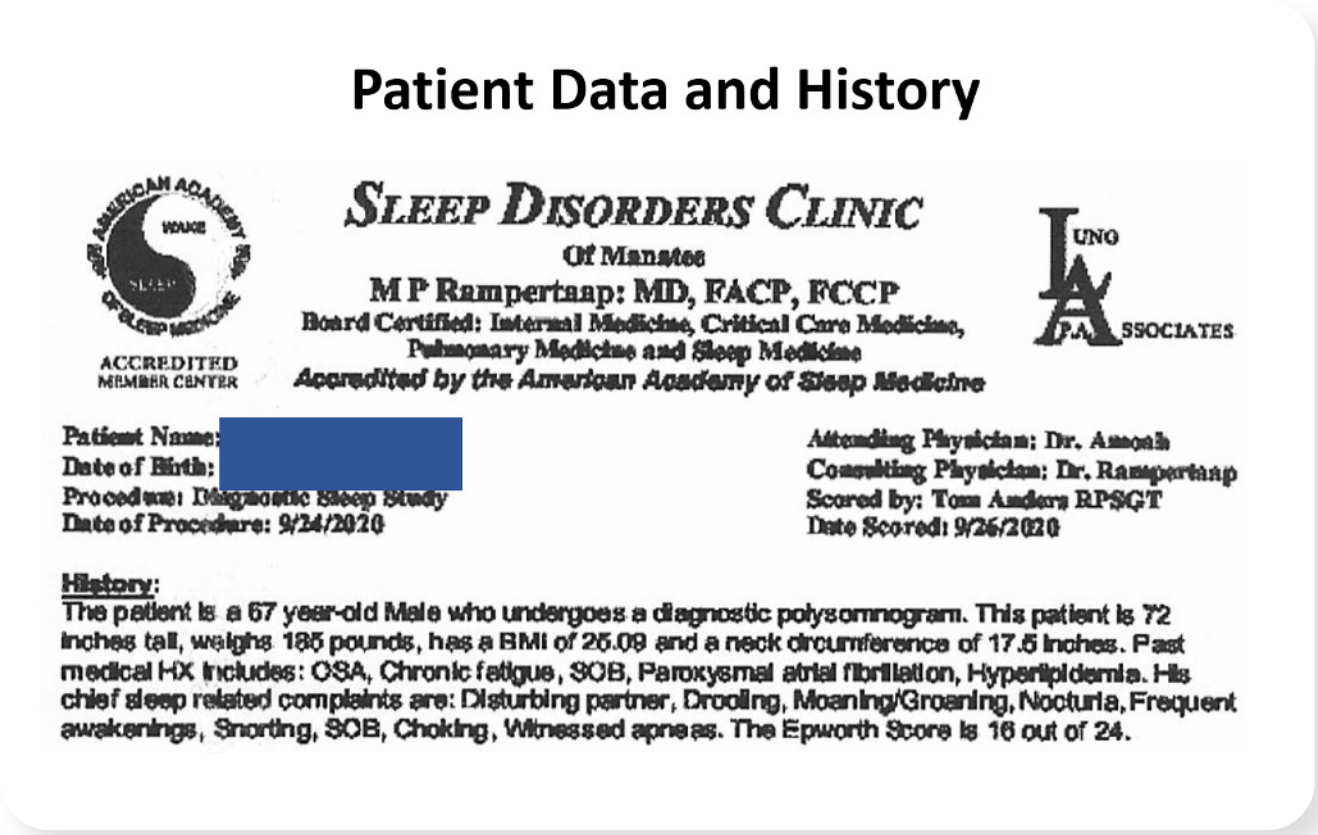
Although many of the HSAT reports are now generated automatically with a much higher degree of accuracy, most sleep physicians still prefer to have a technologist manually review and score the data. There are many industry standards in place for how a computer or technologist scores events in a sleep test. Differences arise in how the raw data is formatted into a report. Some will be in a narrative, paragraph style. Others will have bullet points outlining important parameters. Regardless, you should always look for certain information within that report. With some reports, this is accomplished easily; with others, it is difficult; and with others still, the information needed will not be there at all.

Although the appearance and layout of sleep test reports can vary as much as snowflakes, for the most part, they contain the following common sections and data:

- **Patient Data & History**
- **Description/Scoring Protocol**
- **Sleep Architecture & Arousals**
- **Respiratory Parameters**
- **Body Position/REM Data**
- **Cardiac, & Limb Movement/Non-Ventilatory**
- **CPAP Titration**
- **Impression/Diagnosis**
- **Recommendations**

Patient Data & History

This section is self-explanatory. Typically, the information at the beginning of the report will be the patient's name, demographic information, type of test (PSG, HSAT and Diagnostic or Titration) facility and date of the test. This section often includes a review of the patient's medical history as it pertains to OSA in particular.



Description/Scoring Protocol

This section describes the method and the scoring protocols that were utilized during the test. Of particular importance in this section is the percent desaturation that was utilized to define a Hypopnea. Although the Medicare standard is 4%, some sleep physicians will utilize 3% or 2% and even 1% on occasion. Lowering the % will almost always increase the AHI. As we will discuss later, it is critically important to utilize similar test parameters when doing follow up Dental Sleep Therapy (DST) titration/calibration tests. If a baseline study used a 4% setting and your follow up test used 2%, then understand that it's "unfair" to try and compare these two tests, apples to oranges. You can see in the examples below that the Medicare 4% standard was utilized. It is underlined in the first example. Can you find the information in the second example?

Testing Type & Methods

Type of Test:

PSG

Method:

Polysomnography with MAD Type III Oral Device was conducted on the night of 5/19/2017. The following parameters were monitored: frontal, central and occipital EEG, electrooculogram (EOG), submentalis EMG, nasal and oral airflow, anterior tibialis EMG, body position and electrocardiogram. Additionally, thoracic and abdominal movements were recorded by inductance plethysmography. Oxygen saturation (SpO2) was monitored using a pulse oximeter. The tracing was scored using 30 second epochs. Hypopneas were scored per AASM definition VIII-D 1B (4% desaturation).

Definition of Apneas and Hypopneas:

An **Obstructive Apnea** was defined as a cessation of airflow for at least 10 seconds (2 respiratory cycles in children) in the presence of continuous respiratory movements.
A **Central Apnea** was defined as a cessation of airflow for at least 10 seconds with absent inspiratory effort throughout the entire period of the absent airflow.
A **Mixed Apnea** was defined as a cessation of airflow for at least 10 seconds with absent inspiratory effort in the initial portion of the event, followed by resumption of inspiratory effort in the second portion of the event.
A **Hypopnea** was defined as an abnormal respiratory event lasting at least 10 seconds with at least a 30% reduction in thorocoabdominal movement or airflow as compared to baseline, and with at least a 4% oxygen desaturation.

Sleep Architecture & Arousals

This section of the sleep study contains information about how the patient slept. Here you'll find information about sleep latency, sleep efficiency and amount of time spent in each stage of sleep. Among the important things to note here are the sleep efficiency and the amount of N3 sleep & REM sleep. If the sleep efficiency is low (less than 80% or so), the patient may not have slept well which could make for an inaccurate test. If the patient doesn't get enough N3 or REM sleep, this could affect how they function daily.

Which one of these two patients had better sleep?

Sleep Data

The study began at 10:45:15 PM. The patient was monitored for a total of 401.2 minutes, out of which the patient slept for 311.5 minutes. Sleep onset occurred at 11:05:57 PM for a sleep latency of 20.7 minutes. REM latency was 91.5. Wake After Sleep Onset (WASO): 69.0 minutes. The study ended at 5:26:27 AM.

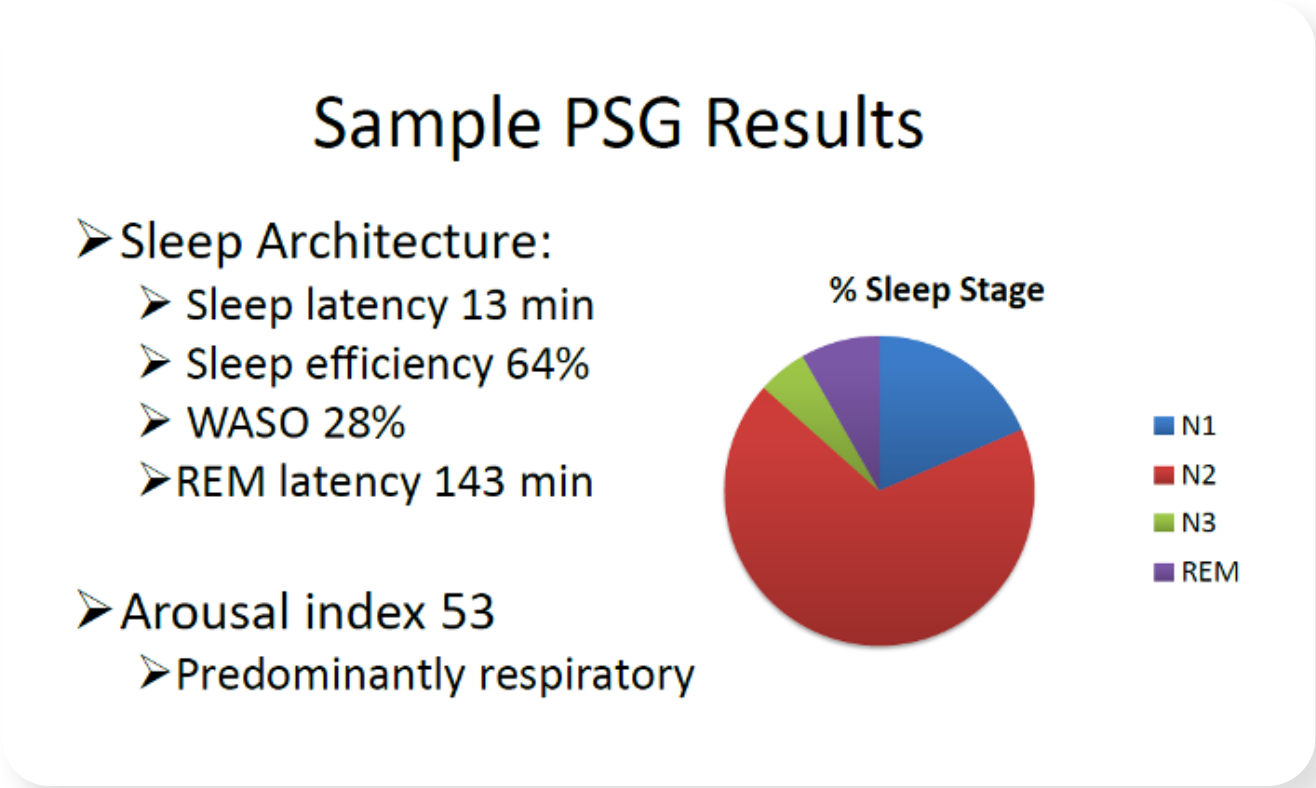
A breakdown of sleep staging reveals the following: Stage N1 36.0 minutes (11.6% of total sleep time), Stage N2 187.5 minutes (60.2% of total sleep time), Stage N3 0.0 minutes (0.0% of total sleep time) and last, REM 88.0 minutes (28.3% total sleep time).

Sleep Architecture:

The study was initiated at 22:31 and terminated at 05:16. The total recorded time was 404 minutes. EEG confirmed total sleep time was 370.5 minutes yielding a sleep efficiency of 91.7%. Sleep onset after lights out was 9.5 minutes with a REM latency of 82.5 minutes. The patient spent 3.4% of the night in stage N1 sleep, 37.9% in stage N2 sleep, 22.4% in stage N3 and 36.3% in REM. Wake after sleep onset (WASO) was 24 minutes. The Arousal Index was 7.1/hour.

If you said the second one you were correct. In the first case, the patient had no N3 sleep but did have 28% REM. In the second case, the patient had 22.4% N3 and 36.3% REM sleep. Since N3 sleep is primarily credited for giving us a feeling of restfulness, the first patient did not appear to sleep restfully.

A third example highlights what primary concern?



Although the patient did not appear to get an adequate amount of N3 nor REM sleep, the most significant finding on this report is the sleep efficiency of 64%. That finding would make me question the validity of the test. Is this a normal night for the patient? In this case, it should likely be investigated further. Note also that less sleep time almost always equates to an *underestimation* of the patient's SDB.

**Note: It is important to note that as of the writing of this eBook, most HSATs do not measure sleep, so this section may not be present.*

Respiratory Parameters

This is the section that is likely the most important to most dental sleep dentists. In this section, you will find information about respiratory disturbances. Here you will find information about apneas, hypopneas, RERRAs, AHI, RDI and pulse oximetry readings. As previously mentioned, these reports can be in a very easy-to-read bullet-point format or sometimes you have to look for the information contained in long paragraphs. You may find highlighting the crucial information to be helpful (we will discuss what is crucial later).

What do you gather from this information?

Respiratory Parameters:
There were a total of 9 respiratory disturbances recorded; 1 apnea (1 obstructive, 0 mixed, 0 central), 4 hypopneas and 4 RERAs. **The apnea/hypopnea index (AHI) was .8 events/hour and the RDI was 1.9 events/hour.** The central sleep apnea index was 0 events/hour. The REM AHI was 2.2/h and NREM AHI was 0/h. The REM RDI was 4.5/h and NREM RDI was .5/h. The supine AHI was 2.1/h, and the non supine AHI was 0/h; supine during 39.0% of sleep. The supine RDI was 5/h, and the non supine RDI was 0/h. Respiratory disturbances were associated with oxygen desaturation down to a nadir of 84% during sleep. The mean oxygen saturation during the study was 94%. The cumulative time under 88% oxygen saturation was 1.1 minutes.

Let's break down the information to the following bullet points:

- **AHI = 0.8** (1 obstructive event, 4 hypopneas and 4 RERRAs total = 9)
- **RDI = 1.9**
- **REM AHI = 2.2** This means while in REM sleep the patient would have 2.2 events per hour.
- **Supine AHI – 2.1** If the patient slept on their back for one hour, their AHI would be 2.1
- **LSAT/Nadir = 84%**. Again, this is the lowest reading of the night for their pulse oximeter readings.
- **T <88% = 1.1 minutes**. This test used 88% instead of 90%

Does this patient have OSA? Likely not would be the correct answer.

Let's look at another report. Is this one easier to read? What do you find noteworthy in the below report?

*AHI: 11.4 /h ODI: 11.8 /h Snore Percentage: 17.8 %

AHI is the number of apneas and hypopneas per hour. ODI is the number of oxygen desaturations per hour.

Respiratory Indices	Index Total	Index Supine	Index Non-supine	Count
*Apneas + Hypopneas (AH):	11.4/h	26.7/h	7.3/h	75
Apneas:	1.7/h	7.2/h	0.2/h	11
Obstructive (OA):	1.7/h	7.2/h	0.2/h	11
Mixed (MA):	0/h	0/h	0/h	0
Central (CA):	0/h	0/h	0/h	0
*Hypopneas:	9.7/h	19.5/h	7.1/h	64
Obstructive (OH):	0/h	0/h	0/h	0
*Obstructive Apnea Hypopnea (OA + MA + OH):	1.7/h	7.2/h	0.2/h	11
Central Apnea Hypopnea (CA + CH):	0/h	0/h	0/h	0
	Percentage of Sleep			Duration
Snore:	17.8%	26.5%	15.4%	70.3m
Cheyne-Stokes Breathing:	0%	0%	0%	0m

Oxygen Saturation (SpO2)	Total	Supine	Non-supine
Oxygen Desaturation Index (ODI):	11.8 /h	29.5 /h	7.1 /h
Minimum SpO2:	72.0 %	72.0 %	85.0 %
SpO2 Duration ≤ 88%	10.4 m	7.4 m	3 m
Longest Duration under 88%:	m		

Position and Analysis Time	Duration	Percentage
Supine (in TST):	83.3m	21.0%
Non-Supine (in TST):	312.3m	78.0%
Upright (in TRT):	4.9m	1.2%
Invalid Data (Excluded):	0m	0%

Yes, it does appear easier to interpret. I would note on this patient that although their AHI is in the mild range (11.4), the patient did spend 10.4 minutes below 88% and had an LSAT of 72%. This patient would likely be given a diagnosis of mild OSA but some would argue that this patient's SPO2 readings are more indicative of a moderate to severe case. Treatment goals, regardless of the therapy, are to reduce apnea load as much as possible, to raise the LSAT as high as possible, and to get the SP02 readings to remain above 90% as long as possible.

It is also important to note that this patient's AHI is more than doubled while they are in the supine position. Positional therapy would be part of our initial discussion when consulting with this patient.

One last report to review in this section. What does the "P" mean in "pRDI", etc.? What criteria was used for Hypopneas?

Sleep Study Report

Sleep Summary

Start Study Time:	04:23:03 AM
End Study Time:	12:02:13 PM
Total Study Time:	7 hrs, 39 min
Sleep Time	**6 hrs, 52 min**
Inconclusive REM Detection	

Respiratory Indices

	Total Events	REM	NREM	All Night
pRDI:	175	N/A	N/A	25.6
pAHI:	173	N/A	N/A	25.3
ODI:	175	N/A	N/A	25.6

Indices are calculated using valid sleep time of 6 hrs, 50 min.

Oxygen Saturation Statistics

Mean:	92	Minimum:	65	Maximum:	98
Mean of Desaturations Nadirs (%):					87

Oxygen Desatur. %:	4-9	10-20	>20	Total
Events Number	118	53	4	175
Total	67.4	30.3	2.3	100.0

Oxygen Saturation:	<90	<=88	<85	<80	<70
Duration (minutes):	31.9	23.3	11.2	5.5	0.5
Sleep %	7.7	5.7	2.7	1.3	0.1

Pulse Rate Statistics during Sleep (BPM)

Mean:	88	Minimum:	48	Maximum:	107

If you look above, you can see for this test that 3% was used for Hypopnea desaturations instead of the Medicare standard of 4%. The "P" stands for PAT. This is a test with a WatchPat and you will see the "P" in front of AHI & RDI when it is a PAT Test.

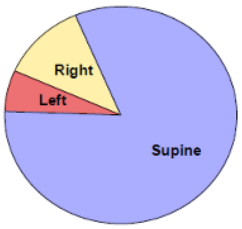
Body Position/REM Data

This section contains information about the body position during the sleep test. Since OSA is often worse in the supine position, paying special attention to that information is often important.

Is the below patient a back sleeper (82.1% of sleep was in the supine position)?

Body Position Statistics

Position	Supine	Prone	Right	Left	Non-Supine
Sleep (min)	318.4	0.0	45.7	23.9	69.6
Sleep %	82.1	0.0	11.8	6.2	17.9
pRDI	21.9	N/A	27.8	12.6	22.5
pAHI	14.4	N/A	5.3	5.0	5.2
ODI	9.3	N/A	6.6	5.0	6.1



You bet! If his AHI is much worse in the supine position, positional therapy may an option or considered as an adjunctive therapy. It is also important to note this information when comparing pre and post-treatment test results as we will discuss later.

This section may also contain information about the severity of OSA while in Rem Sleep. OSA is typically elevated during REM sleep due to the muscle atonia that is present in this stage of sleep. This may be important in considering DST for our patients.

	Total Events	REM	NREM	All Night
pRDI:	142	29.3	19.2	22.0
pAHI:	82	23.3	8.6	12.7
ODI:	56	19.9	4.3	8.7

Cardiac & Limb Movement/Non-Ventilatory

Cardiac information, snoring, arousals, and Periodic Limb Movement is contained in this section. Of importance for DST is the highest heart rate and heart rate variability (if given). This information can help explain the cardiac effects of OSA. Also, a high PLM index can influence arousals and the patient's feelings of being well-rested.

Look at the highest heart rate in this patient at 188 bpm!

Cardiac Data

The average heart rate during sleep was 57.5 bpm. The highest heart rate during sleep was 188 bpm.

Arousal Statistics

A total of 62 arousals (11.9/hour) were observed during the analysis period as follows, 9 respiratory arousals, 8 Leg Movement arousals, 45 spontaneous arousals and 0 snore arousals.

PLM Statistics

There were 160 PLMS with a PLMS Index of 30.8/hour. 9 PLMs arousals with a PLMS arousal index of 1.7/hour.

• CPAP Titration

Here is where you will find information about the CPAP titration, if applicable. Important information to note from this section are how well the CPAP reduced the AHI and what pressure was needed to reach that level.

Can you find that information below? What does this mean if we were to treat them with DST?

CPAP TITRATION: With the diagnosis of sleep apnea confirmed, the patient was started on CPAP from 0132 until 0455. The sleep efficiency improved to 92.84%. Percent sleep period times were not appreciably changed from the diagnostic portion of the night.

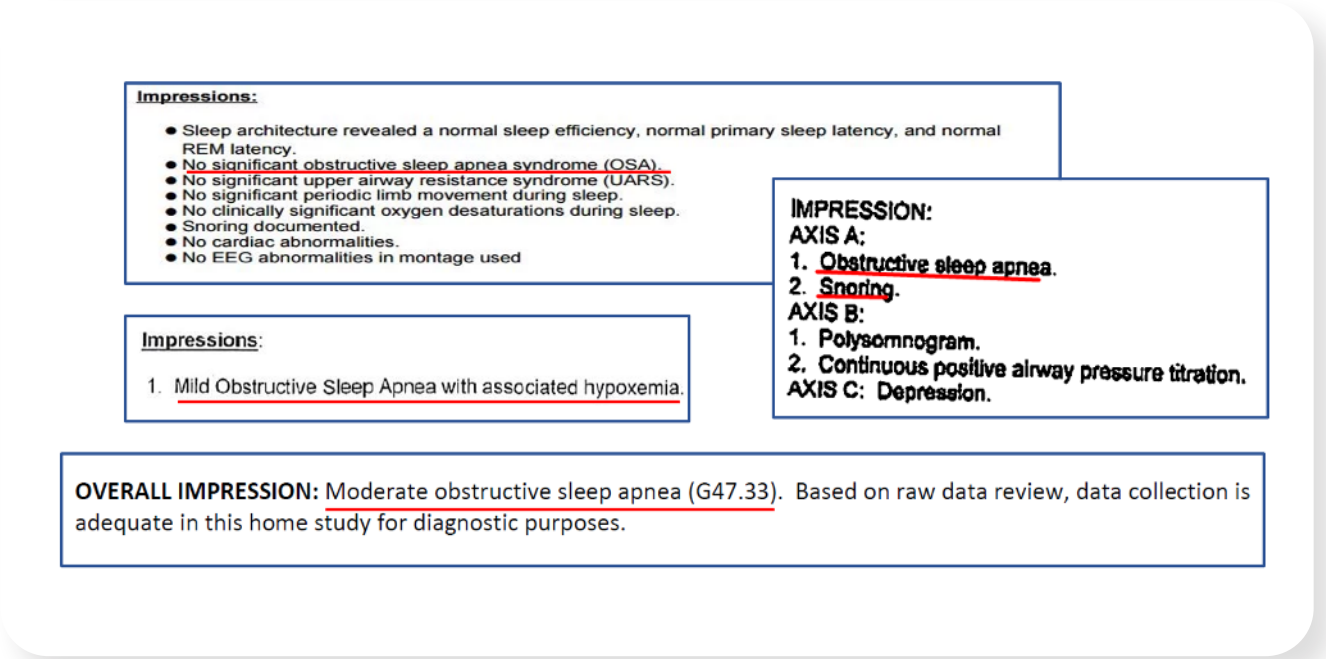
With positive pressure therapy, the patient's snoring resolved on CPAP of 7. Pressures of 4 through 7 were utilized. On 7, she had an apnea-hypopnea index of 0 after 37.5 minutes while on this setting with insignificant desaturations to 86%; + 7 included non-REM supine sleep. The patient's only REM sleep occurred on 5 of CPAP, which also occurred supine with an apnea-hypopnea index of 0 after 102.5 minutes. The patient did have some snoring during this time, however.

The above patient did quite well with their CPAP titration. They showed good sleep efficiency of 92% with a CPAP pressure of 7 bringing their AHI to 0. We would have to first consider that if this patient is compliant then their treatment is outstanding, and I would hesitate to consider DST. If the patient isn't compliant, we would consider this information to be a positive indicator for DST because the CPAP pressure needed was fairly low at 7 cm H20. *(Note: CPAP pressures typically range from 4 to 24 with under 10 being on the lower end).*

Impression/Diagnosis

All that information finally brings us to the diagnosis, which is self-explanatory. Below are some examples of diagnoses from various sleep tests.

As you review these impressions/diagnoses, there are two critical things to consider, which are the diagnosis of G47.33 and the level of apnea. If you want to get paid by insurance companies that information is crucial! It is also important to understand your patients' level of SDB and the likelihood that DST would be effective. "I like to know what it is that I'm treating" I once heard a very smart sleep dentist say (Rich Drake).



Recommendations

This section is also mostly self-explanatory. Here is where the sleep physician will make their recommendations for treatment. We would like to say that most sleep physicians follow the AASM/AADSM Practice Parameters and recommend dental devices as a treatment option for OSA, but in most cases that is not true. We recommend that you meet with any sleep physician that you are going to work with to ensure they are open to recommending DST for patients when appropriate.

Below are some examples of Recommendations:

Recommendations:

1. MAD Type III Oral Device setting requiring additional adjustment with dental sleep medicine.
2. Begin a medically supervised program to achieve and maintain ideal body weight.
3. Sleep in a non-supine position.
4. Avoid bedtime alcohol and sedatives.
5. Avoid driving while feeling drowsy.

General Recommendations:

Avoid operating motor vehicle until above disorder can be corrected if significant sleepiness is a concern.

Limit or preferably avoid evening sedatives, hypnotics, and alcoholic beverage consumption.

Consider a comprehensive weight reduction program with guidance from primary care physician and dietician as indicated, especially for a Body Mass Index greater than 27.

Consider further ENT evaluation and possible surgical intervention if significant nasopharyngeal upper airway impedance.

The patient should inform their physicians of the diagnosis of OSA. Anesthesiologists in particular should be informed and the patient should bring their own PAP device and mask when away from home or admitted to the hospital.

Specific Recommendations for Ronald W Kelly:

1. PAP therapy with autoPAP 5-15 cm H2O with interface of patient's choice and heated humidity.
2. Follow up smartcard download to ensure correction of OSA

Dissecting the Sleep Test

That was a lot of information we covered and at times it can be overwhelming. This can be even more evident when trying to compare pre and post-treatment results. We developed our DS3 system and software nearly a decade ago to help with this challenge. We are going to walk you through how we break down the information that is most crucial for DST with our DS3 system. **If you would like more information about DS3, visit DS3sleep.com**.

We recommend the dentist first becomes comfortable with this process but ultimately a team member can readily extract the most needed information from the patient's sleep test. Take the sleep test in one hand and your computer or worksheet in the other and extract the following information from the sleep test.

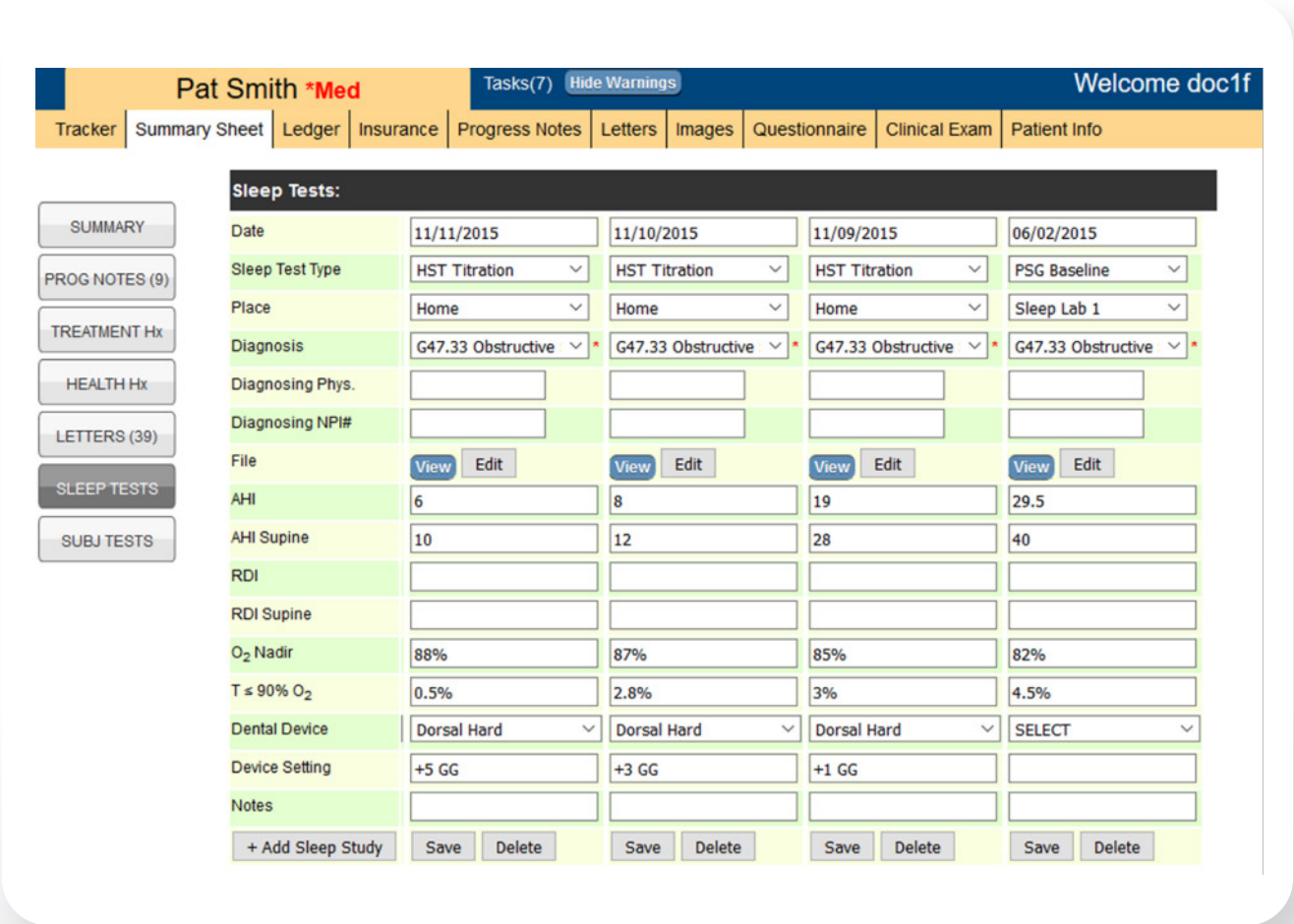
- **Date of test**
  - If over 1 year, consider having patient retested.
- **Type of test (HST/PSG, Baseline/Titration)**
  - Here you would enter the type (PSG or HST) and if the test was a Diagnostic/ Baseline test or a Titration study
- **Place/Facility**
  - The facility where the test was completed. If you are utilizing your own equipment, then we recommend you label it with your office name and the equipment type. An example would if your office were named Acme Sleep and you used a Z-Machine recorder. We would input "Acme – ZMach"
- **Diagnosis**
- **Diagnosing Physician and NPI #**
  - This is important information for filing medical insurance
- **AHI/AHI Supine**
  - Input the AHI and the Supine AHI if given
- **RDI/RDI in Supine Position**
  - Input the RDI and the Supine RDI if given
- **02 Nadir/LSAT**
  - Input the lowest oximeter reading for the night
- **% SPO2 < 90%**
  - Enter the % or time the patient spent below 90%. If the test uses 88% then just put (<88%) after you enter.
- **Dental Device**
  - It the patient was wearing a dental device during the test, place the brand name of the device here
- **Device Setting**
  - If the patient was wearing a dental device during the test, place the titration information here. If they were wearing a CPAP during the test, put the CPAP pressure.

Comparing Sleep Tests

We hope that helps with understanding sleep tests and what is most important for DST. We would like to conclude by giving you some valuable information on comparing sleep tests.

Once you deliver a device for OSA, you complete a follow-up titration test or, as some call it now, a calibration test. You need to compare the previous/diagnostic test to a test with the dental device in place. With the availability of less expensive multi-night sleep tests, this process has become very streamlined. We will be discussing the process in detail in a future eBook. **If you would like information about that webinar and eBook, then visit DS3sleep.com/webinars.**

For now, we will give you a glimpse of the process. You will need to become proficient at understanding sleep tests and you will need a system like DS3 to help compare the results of a multi-night test. Do you know where this patient's ideal position for their device is?



In our next eBook, we will discuss how we will know and simple methods to make this process streamlined and effective.

When comparing tests, it is also important to discuss other factors such as the following:

- Apples to Apples
- HSAT Vs PSG
- Equipment
- Dates of tests
- AHI
- Same Definitions
- SPO2
- Recording time
- Weight gain/loss
- Sleep position
- Other factors

If your patients' calibration tests are giving you the desired results, we will discuss how the above factors can influence positive outcomes as well.

We hope that you will join us for a future webinar and read our upcoming eBook on **Revolutionary Calibration Techniques**.

We help dentists succeed in Dental Sleep Medicine.
Please let us know how we can help you reach your goals.

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