Original Article

Diagnostic Modalities Of Obstructive Sleep Apnea

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DOI: 10.47750/pnr.2023.14.S02.150

Abstract

Background: OSA is a sleep related breathing disorder that characterized by a decrease or complete absent in airflow despite an ongoing effort to breathe. It occurs through relaxation and collapse of the muscles of upper air way during sleep, this leads to partial reductions (hypopneas) and complete absent (apneas) in breathing that last at least 10 seconds during sleep. Most pauses last between 10 and 30 seconds, but some may persist for one minute or longer. This leads to critical reductions in blood oxygen saturation, with oxygen levels falling as much as 40 percent or more in severe cases. OSA is caused by repetitive bouts of upper airway obstruction during sleep as a result of the narrowing of respiratory passages. The most common site of obstruction is the nasopharynx. The diagnosis of obstructive sleep apnea syndrome (OSAS) requires both assessment of clinical features and objective demonstration of sleep disordered breathing. Patients usually present with loud habitual snoring, witnessed apnea, and excessive daytime sleepiness. Inspite of the high prevalence of OSAS in the general population (at least 4% of males and 2% of females), the condition is usually unrecognized as patients often regard their symptoms as normal variants or a manifestation of poor lifestyle

Keywords: Obstructive Sleep Apnea

INTRODUCTION

OSA is a sleep related breathing disorder that characterized by a decrease or complete absent in airflow despite an ongoing effort to breathe. It occurs through relaxation and collapse of the muscles of upper air way during sleep, this leads to partial reductions (hypopneas) and complete absent (apneas) in breathing that last at least 10 seconds during sleep. Most pauses last between 10 and 30 seconds, but some may persist for one minute or longer. This leads to critical reductions in blood oxygen saturation, with oxygen levels falling as much as 40 percent or more in severe cases **(1).**

Diagnosis of OSA

The diagnosis of obstructive sleep apnea syndrome (OSAS) requires both assessment of clinical features and objective demonstration of sleep disordered breathing.

Patients usually present with loud habitual snoring, witnessed apnea, and excessive daytime sleepiness. Inspite of the high prevalence of OSAS in the general population (at least 4% of males and 2% of females), the condition is usually unrecognized as patients often regard their symptoms as normal variants or a manifestation of poor lifestyle **(2).**

The disease is associated with significant morbidity and mortality due to excessive daytime sleepiness that leads to significant impairments in quality of life, cognitive performance and increase the rate of road traffic accidents **(2).**A detailed clinical assessment is an important part of the evaluation of OSAS, however most reports indicate limited value of clinical features alone in the prediction of the disorder **(3).**

A. Nocturnal Symptoms

- **Snoring**

Snoring is the major symptom of sleep apnea as it reflects the basic pathophysiology underlying the disorder, namely a critical narrowing of the upper airway **(4)**

Snoring is the most frequent symptom of OSAS, occurring in up to 95% of patients, but has poor predictive value because of the high prevalence in the general population. However, the absence of snoring makes OSAS unlikely and only 6% of patients with OSAS did not report snoring in one report **(4)**

 Witnessed apneas

These events are a good diagnostic indicator of OSAS but do not predict severity of the disorder **(3).** Concern by the bed partner about witnessed breathing pauses during sleep is a common reason for referral to a sleep clinic. Witnessed apnea is less common among female patients with OSAS **(5).**

 Nocturnal choking or gasping

Many patients with OSAS report awaking at night with a choking sensation, which can be quite frightening. This choking almost invariably passes within a few seconds of awakening **(2).**

 Insomnia

Sleep maintenance insomnia is often mentioned as a symptom of obstructive apnea and likely reflects the disturbing effect on sleep of recurring arousal. However, most patients with OSAS have little difficulty in initiating sleep **(2).**

 Other nocturnal symptoms

Several other nocturnal symptoms may be reported by patients or their bed partner such as nocturia, enuresis, frequent arousals, diaphoresis, and impotence and a cause–effect relationship with OSAS is supported by reports that these symptoms improve with continuous positive air pressure (CPAP) therapy. **(6).**

B. Daytime Symptoms

 Excessive daytime sleepiness (EDS)

Hyper-somnolence and fatigue due to sleep fragmentation and multiple nocturnal arousals. The EDS leads to significant impairments in quality of life, cognitive performance, and social functioning.

We must differentiate EDS from other symptoms such as fatigue and patients frequently underestimate the severity of sleepiness. The severity of EDS can be assessed subjectively by various questionnaires, the most widely used being the Epworth Sleepiness Scale (ESS) **(7)** which is a simple, self-administered questionnaire shown to provide a measurement of the subject's general level of daytime sleepiness and the input of the partner can be useful in this assessment. Patients are asked to grade from 0 to 3 their likelihood of falling asleep in contrast to just feeling tired in certain situations **(The total score will be between 0 and 24).**

Indicating results of ESS in OSA (7)

10 or less you are most likely getting enough sleep.
10–16 you may be suffering from excessive daytime sleepiness.
16 and more you are dangerously sleepy.

Situation	**Chance to dozing**			
Sitting and reading	0	1	2	3
Watching TV	0	1	2	3
Sitting inactive in a public place e,g movie theatre or a meeting	0	1	2	3
As a passenger in a car for an hour without a break	0	1	2	3
Lying down to rest in the afternoon when circumstances permit	0	1	2	3
Sitting and talking to someone	0	1	2	3
Sitting quietly after lunch	0	1	2	3

Figure (1): Epworth Sleepiness Scale **(7)**

Choose the most appropriate number for each situation:

0 = would never doze
1 = slight chance of dozing
2 = moderate chance of dozing
3 = high chance of dozing

Other daytime symptoms:

Many other symptoms than EDS is reported to be associated with sleep apnea like fatigue, memory impairment, personality changes, morning nausea, morning headaches, automatic behavior, and depression. Although these features may be important in assessing the impact of sleep apnea on a patient and the effectiveness of therapy, there has been no systematic study of the capacity of these features to predict the presence or absence of OSA. **(3).**

Signs of OSA

A-Physical examination:

Obesity and neck circumference

Obesity is common in OSAS, particularly upper body obesity, and there is evidence that patients with OSAS are particularly prone to having fat necks. Neck circumference is a strong predictor of OSAS and values less than 37 cm and greater than 48 cm are associated with a low and high risk, respectively **(3).** BMI widely used for estimating body fat for adults. An adult who has a BMI of 25-29.9 is considered overweight and over 30 obese. BMI of 35-40 is classified as severe obesity, 40–44.9 morbid obesity, and greater than 45 is described as super obesity **(8).**

Craniofacial anatomy

These include retrognathia, micrognathia, tonsillar hypertrophy, macroglossia, and inferior displacement of the hyoid. However, the most common physical finding in patients with OSAS is a nonspecific narrowing of the oropharyngeal airway, with or without an increase in soft tissue deposition. **(4)**

Hypertension

Hypertension in a patient with symptoms suggestive of OSAS increases the possibility of the disorder. The possibility of OSA seems to be particularly high in patients with drug-resistant hypertension **(9).**

B-pharyngeal examination:

The grading of palatine tonsillar hypertrophy was according to Friedman scoring system **(10)** as follows: Tonsil's size 0, small /previous tonsillectomy. Tonsils, size 1, within the pillars. Tonsils, size 2, extend to the pillars. Tonsils, size 3, extend past the pillars. Tonsils, size 4, extend to the midline.

The grading of tongue volume was according to Friedman tongue position (FTP) scoring system **(10)** as follows:
FTP I allows visualization of the entire uvula and tonsils/pillars.
FTP IIa allows visualization of most of the uvula, but the tonsils/pillars are absent. **FTP IIb** allows visualization of the entire soft plate to the base of the uvula.
FTP III some of the soft palate is visualized but the distal structures are absent.
FTP IV allows visualization of the hard palate only

Mallampati classification relates tongue size to pharyngeal size and is an important factor in determining the degree of difficulty of direct larynogoscopy. This classification allows one to assess upper airway access based on visibility of the oropharynx **(11)**
Class I: Visualization of the soft palate, fauces, uvula and pillars. No anticipated difficulty.
Class II: Visualization of the soft palate, fauces, uvula. No anticipated difficulty. **Class III:** Visualization of the soft palate and base of the uvula. Anticipate moderate difficulty.
Class IV: Soft palate is not visible. Anticipate severe difficulty.

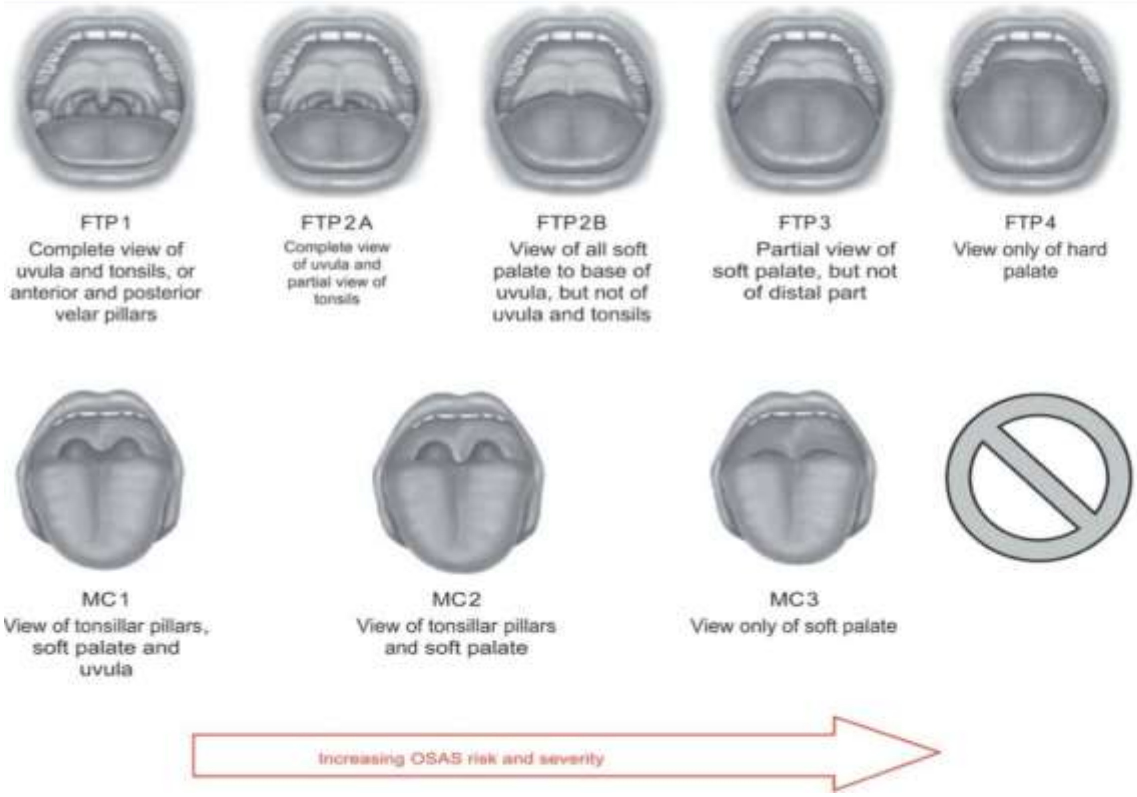

Figure (2) comparison of tongue position at rest according to Friedman (Friedman Tongue Position, above) and tongue position in protrusion according to Mallam Pati (Mallam Pati Classification, below) in OSAS

Diagnostic criteria for OSAS

Given both subjective and objective criteria in the diagnosis of OSAS, the report of a task force of the American Academy of Sleep Medicine, has provided a useful set of requirements for the diagnosis **(10).**

The patient suspected of OSAS must fulfill criterion A or B, plus criterion C. These are as follows

A- Excessive daytime sleepiness that is not better explained by other factors

B- Two or more of the following that are not better explained by other factors:

- Choking or gasping during sleep
- Recurrent awakenings from sleep
- Unrefreshing sleep
- Daytime fatigue
- Impaired concentration

C. Overnight monitoring demonstrates five or more obstructed breathing events per hour during sleep

These events may include any combination of obstructive apneas/hypopneas or respiratory effort–related arousals, as defined below. This report also proposed a grading of severity of OSAS based on the frequency of abnormal respiratory events during sleep:

Mild: 5–15 events/hour of sleep

Moderate: 15–30 events/hour of sleep

Severe: More than 30 events/hour of sleep

Investigation of OSA

Investigation of OSA could be done to achieve two objectives:

1) To differentiate between simple snoring and OSAS (Polysomnography) and to assess the type and severity of OSA.

2) To assess the site of obstruction.

1-Polysomnography

The gold standard ‘‘for the diagnosis of OSAS is full polysomnography, which provides detailed information on state of sleep and respiratory and gas exchange abnormalities, in addition to many other variables such as body position, heart rate and rhythm, and muscle tone and contraction **(12).**

Polysomnographic (PSG) studies generally involve a minimum of 12 channels of recordings that include EEG, electrooculogram (EOG), electromyogram (EMG), oronasal airflow, chest wall effort, body position, snore microphone, ECG, and oxyhemoglobin saturation **(12).** The duration of the diagnostic study should be at least 6 hours; however, this practice is broken in split-night studies, in
which the initial part is assigned to diagnosis, but the latter part involves the initiation of CPAP therapy, when an obvious case of OSAS is evident. The 6-hour duration of a diagnostic PSG allows the assessment of variability related to sleep stage and position with respect to the frequency of abnormal respiratory events and other types of nocturnal events such as periodic limb movements. The obvious advantages of PSG studies include sleep staging and the recording of arousals, but there can be considerable interobserver variability in the scoring of arousals **(13).**

2-To assess the site of obstruction

 Muller maneuver (MM)

Muller maneuver is the endoscopic examination used in the diagnosis of OSA, also is important in the identification of static pathologies and the detection of areas with more dynamic collapse. This maneuver was first described by **Borowiecki and Sassin (14)** for locating the obstructive point in the upper airway of OSAS patients. The endoscope was introduced through the nose and advanced to the level of the velopharyngeal sphincter. The appearance of the pharyngeal airway was then observed during several standardized respiratory maneuvers. These included several respirations through the nose and the mouth followed by forced inspiratory efforts with a partially obstructed nasal airway. The MM is a noninvasive, low cost, and easily reproducible method that is performed while awake. The consensus between the MM findings and the apnea-hypopnea index (AHI) has provided support to use MM in the detection and treatment of OSAS patients. However, there are disadvantages of the MM procedure, such as the inability to simultaneously show different levels of the obstruction, failure to reflect the sleeping breathing pattern because the maneuver is performed while the patient is awake and in the sitting position, inability to prevent voluntary motor activities while assessing dynamic pathologies, and incapability of every patient to create a sufficient negative pressure **(15).**

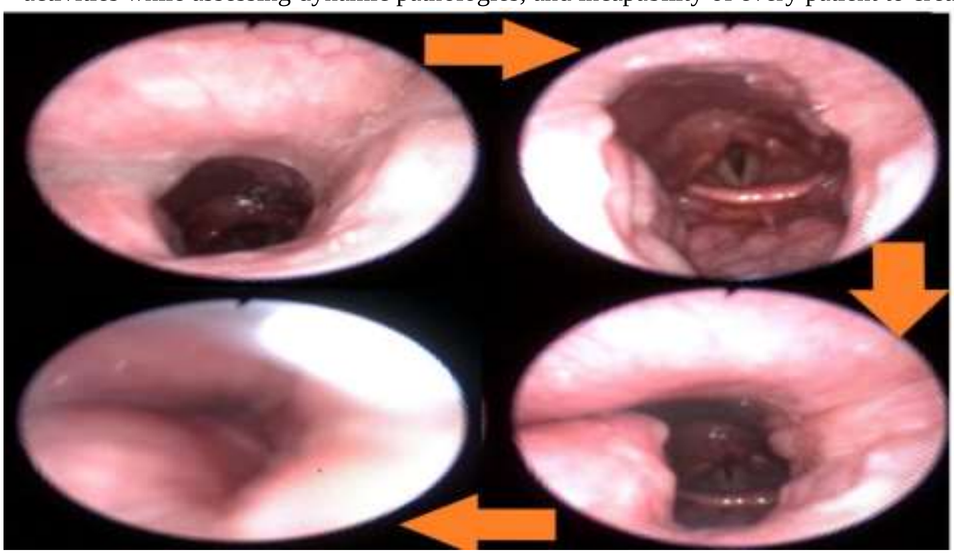

Figure (3) The Value of the Muller maneuver during endoscopic evaluation of OSAS patients
Total lateral collapse of the pharyngeal muscles

Drug- induced sleep Endoscopy

Drug-induced sleep endoscopy (DISE) tends to show the level and mechanism of obstruction and helps to specify therapy individually. Therefore, increasing success rates are expected. It is a method of three-dimensional evaluation of upper airway obstruction which is used in patients with OSA or primary snoring. During DISE, a flexible endoscope is inserted through one nostril of the sedated patient and is positioned on different levels of the upper airway (soft palate, tonsils, tongue base, epiglottis) to visualize the airway during spontaneous respiration thus detecting mechanisms and sites of snoring and apneas. This information is used to decide upon the necessary surgical treatment plan. DISE indicated in patients affected by socially disturbing snoring and OSAS, in whom non-CPAP therapy is considered or failed CPAP therapy. The contraindications are, pregnancy, and patients with an allergy to Propofol or to other DISE drugs. Relative contraindications may include morbid obesity **(16).**

Figure (4) Lateral wall collapse in the velum and lateral pharyngeal walls **(16)**

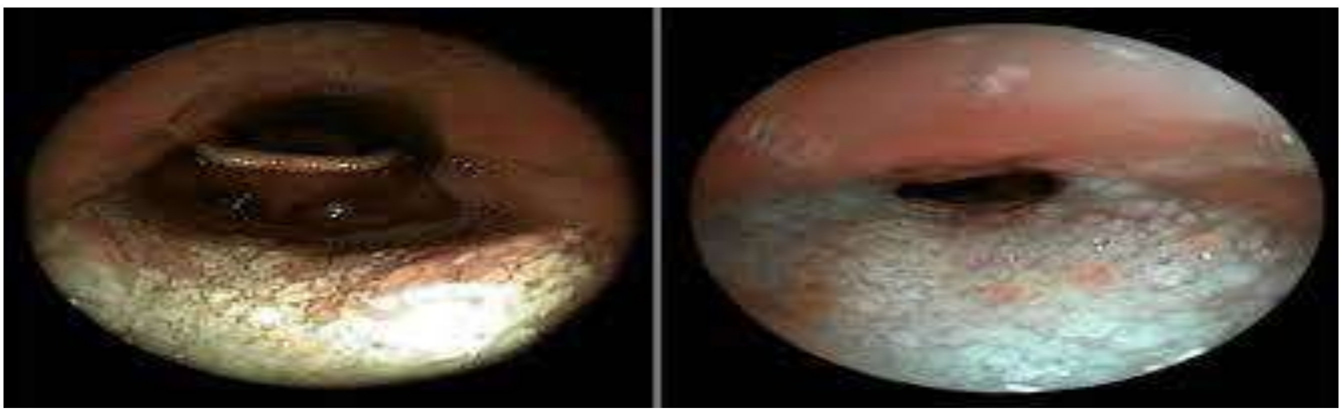

Figure (5) Tongue base collapse due to muscle relaxation **(16)**

Scoring and classification systems

A scoring and classification system should include the following features: level (and/or structure), degree (severity), and configuration (pattern, direction) of obstruction. The VOTE system has only 3 degrees of severity—none, partial, and complete obstruction. Other systems use a semiquantitative system with 0–25, 25–50, 50–75, and 75–100 % of obstruction **(16).**

Table 1 VOTE Classifications systems for DISE (17)

STRUCTURE	DEGREE OF OBSTRUCTION[a]	CONFIGURATION[c]		
		A-P	LATERAL	CONCENTRIC
Velum				
Oropharynx lateral walls[b]		(shaded)		(shaded)
Tongue Base			(shaded)	(shaded)
Epiglottis				(shaded)

Open boxes reflect the potential configuration that can be visualized related to a specific structure. Shaded boxes reflect the fact that a specific structure-configuration cannot be seen.

A-P Anteroposterior.

a degree of obstruction has one number for each structure: 0, No obstruction (no vibration); 1, Partial obstruction (vibration); 2, Complete obstruction (collapse); X, Not visualized, b Oropharynx obstruction can be distinguished as related solely to the tonsils or including the lateral walls, with or without a tonsillar component. c Configuration noted for structures with degree of obstruction greater than 0.

 Lateral cephalometry

Lateral cephalometry uses a standardized lateral head film of the head and neck taken under standardized conditions using a cephalostat with fixed head orientation. This provides an upright, two-dimensional image of the skeletal and soft tissue anatomy of the head and neck during wakefulness. Lateral cephalography has the advantage of being available, easy to perform, and less expensive than a polysomnographic examination. On lateral cephalometry, OSA patients have a variety of anatomical abnormalities, including an abnormally small airway below the base of the tongue, a long bulky soft palate, an inferiorly placed hyoid bone and retrognathia. Limitations of cephalometry pertain to the two-dimensional nature of the image and to the examination of soft tissue. Cephalometry provides two-dimensional static images in the sagittal plane and therefore cannot provide information about transverse dimensions, cross-sectional shape or volume, or dynamic changes of the airway during sleep. The patient is required to be awake and therefore extrapolation to the sleep state may be inaccurate **(18).**

A) Soft tissue variables measured on the lateral cephalograms (19).

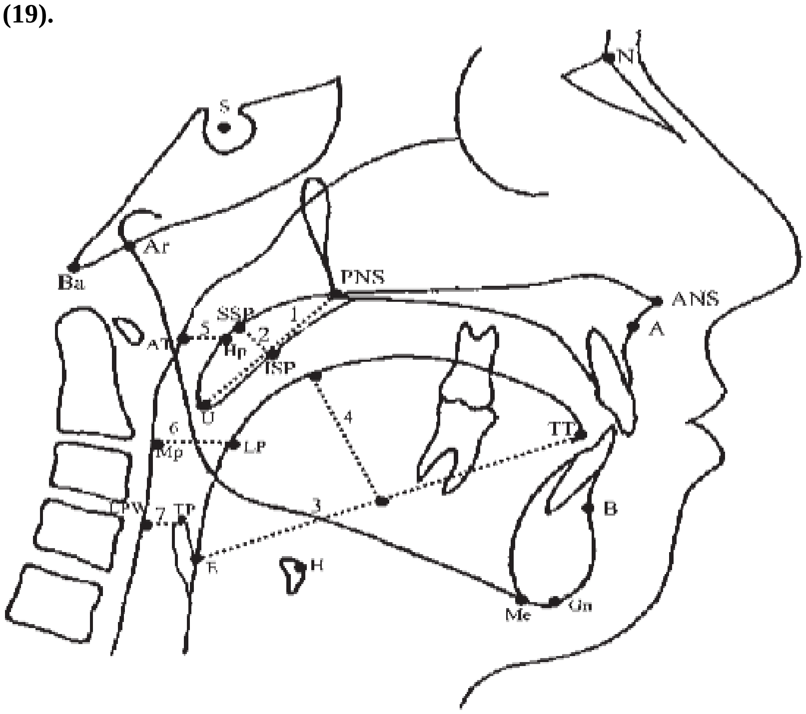

Figure (6 A) Soft tissue variables measured on the lateral cephalograms.
1-Length of the soft palate (U–PNS).
2- Thickness of the soft palate (SPP–ISP).
3- Tongue length (TGL).
4-Tongue height (TGH)
5- Upper posterior pharyngeal space (AT–Hp)
6- Middle posterior pharyngeal space (Mp–Lp)
7- Lower posterior pharyngeal space (LWP–TP

B) Skeletal variables measured on the lateral cephalogram (19).

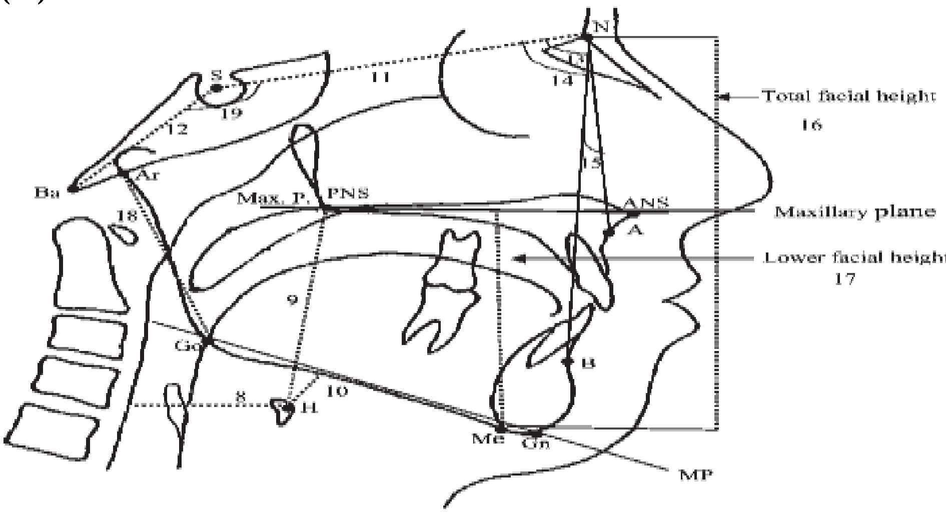

Figure (6 B) Skeletal variables measured on the lateral cephalogram.
8- The distance from hyoid bone to the posterior wall of the pharynx.
9- Distance from hyoid bone to PNS (H–PNS).
10- Distance from the hyoid at right angles to the mandibular plane.
11- Anterior cranial base (S–N).12- posterior cranial base (Ba–S)
13- Maxillary protrusion (SNA).14- mandibular prognathism (SNB)
15- Maxillomandibular discrepancy (ANB). 16- total face height (N–Me).
17- Lower anterior face height (ANS–Me). 18- posterior face height (Go–Ar).
19-Cranial base flexure angle: nasion–sella–basion (N–S–Ba).

Table 2 Cephalometric landmarks for skeletal and soft tissues (19).

Landmark	Definition
Point A	A point on the concavity between anterior nasal spine and the lowest point on the alveolar bone overlying the maxillary incisors.
Point B	A point on the anterior cavity of the mandibular symphysis.
Basion (Ba)	The median point of the anterior margin of the foramen magnum, located by following the image of the slope of the inferior border of the basilar part of the occipital bone.
Nasion (N)	The innermost point on the concavity between the frontal and nasal bones.
Posterior nasal spine (PNS)	Located at the intersection of the continuation of the pterygopalatinal fossa and the floor of the nose . It marks the posterior limit of the maxilla
Sella (S)	The center of pituitary fossa of the sphenoid bone.
Hyoid(H)	The most superior point on the anterior surface of the body outline of the hyoid bone
Gnathion (Gn)	The most antero-inferior point on the contour of the bony chin symphysis
Gonion(Go)	A constructed point of the intersection of the ramus and mandibular planes
Articulare(Ar)	The point of insertion of the images at the posterior border of the condylar process of the mandible and the inferior border of the basilar part of the occipital bone
Menton(Me)	The lowest point on the symphyseal shadow of the mandible.
Mandibular plane (MP)	Aline drawn between gonion and gnathion
Maxillary plane	Points ANS and PNS joined by a line.
Vallecula(E)	The most antero-inferior point of the epiglottic fold.
Point ISP	The most prominent point on the inferior soft palate surface
Point SSP	The most prominent point on the superior soft palate surface.
Point U	The tip of the uvula.
PointTT	The tip of the tongue.
Point AT	A point on the adenoid tissue of the posterior wall of the nasopharynx.
Point Hp	A point on the upper surface of the palatinal vellum of the anterior wall of the nasopharynx.
Point Lp	A point on the anterior wall of the oropharynx.
Point Mp	A point on the posterior wall of the oropharynx.

Point LPW	A point on the posterior wall of the hypopharynx.
Point TE	The tip of epiglottis.

- **Computed Tomography Scanning (CT):**

CT is a noninvasive technique, improves soft tissue contrast, leads surgical interventions toward the abnormal anatomic sites and allows for precise measurements of cross-sectional areas at different levels. CT scan has a limited soft-tissue contrast resolution of upper airway adipose tissue when compared to MRI scanning. Other restrictions of CT scan include expense and the radiation exposure every time a CT scan is taken **(20)**

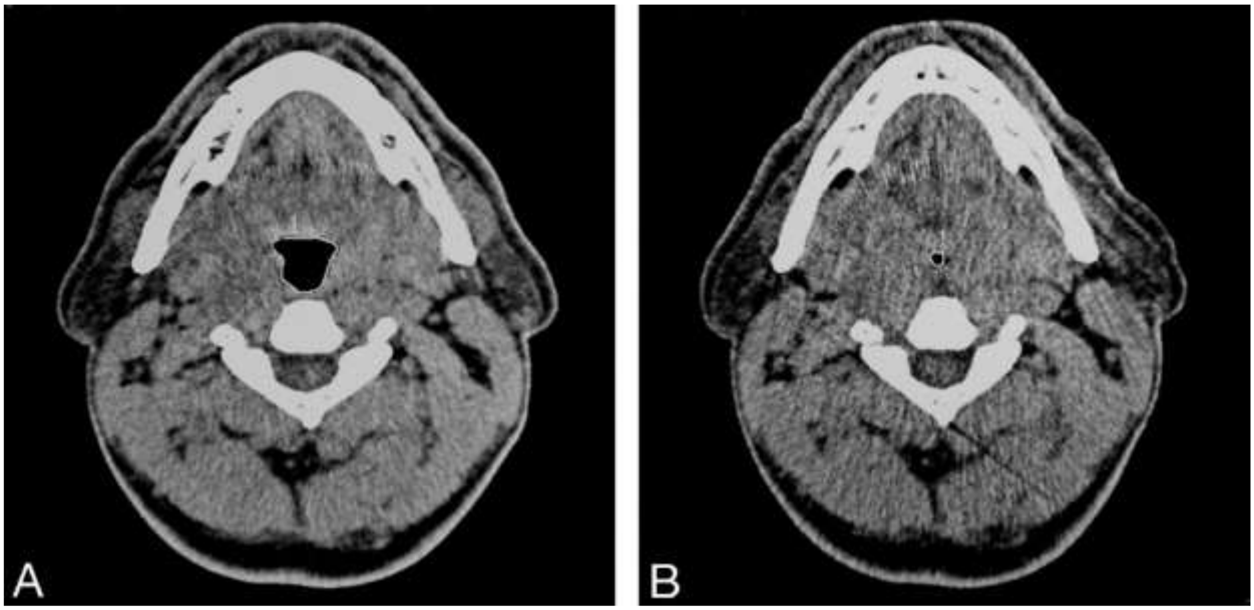

Figure (7) A, Cross-sectional image of a patient at the level of uvula in tidal breathing. **B**, the significant narrowing at the same level in forced expiration is seen. **(21)**

Nowadays, the advances in computed tomography imaging and the three-dimensional technology such as cone beam computed tomography (CBCT), allow better visualization of the airway, volumetric analysis and give the ability to understand and diagnose OSA and its relationship to the airway and craniofacial anatomy **(22).**

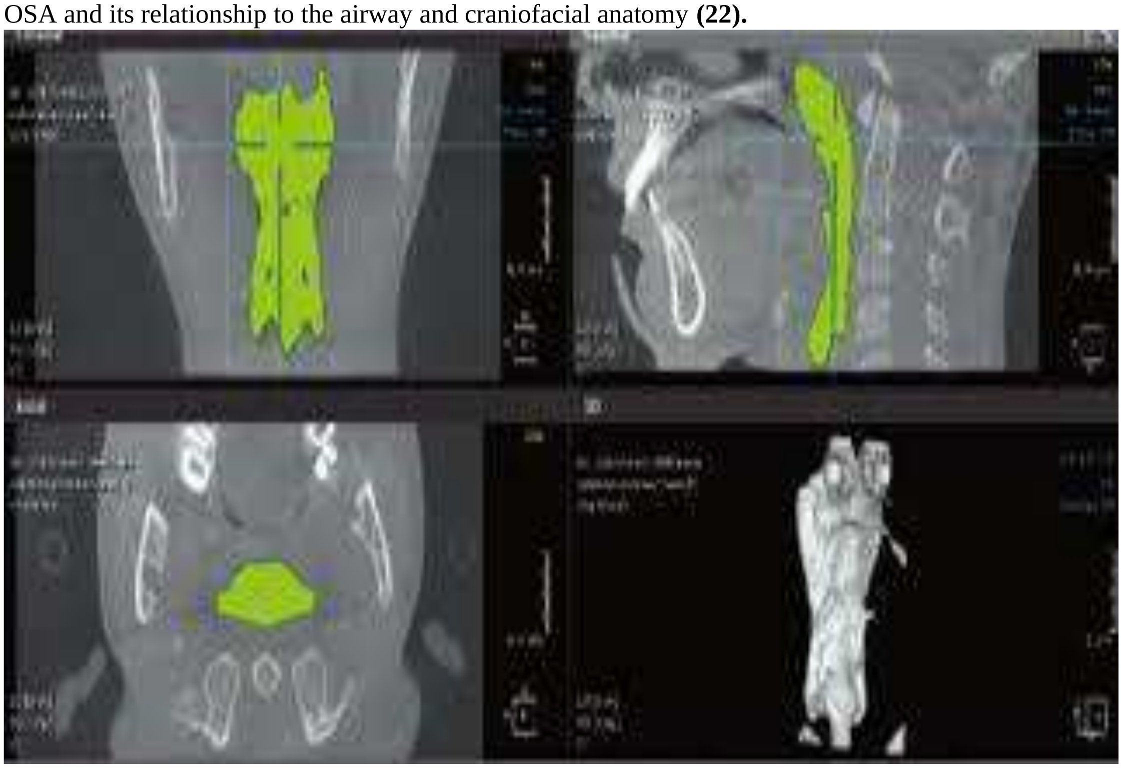

Figure (8) CBCT image revealing a defined and colored pharyngeal airway space (green clour) in the axial, coronal and sagittal planes according to the threshold level **(23)**

Magnetic resonance imaging (MRI):

MRI has excellent soft tissue resolution; provides accurate measurements of the upper airway and the surrounding tissue; obtains different images in the axial, sagittal, and coronal planes; permits volumetric data analysis including three-dimensional reconstruction images of the upper airway; and avoids ionized radiation exposure allowing for repetitive measurements .The advantages of lacking ionized radiation makes MRI the imaging technique of choice for the assessment of children with OSA. Its main disadvantages is costly, not commonly available, not in patients with metallic implants, difficult in patients with morbid obesity and difficult to performed in OSA patients during sleep due to the noise produced by scanners. Some investigators have tried to deprive their patients of sleep prior to scanning, while others have used sedatives **(24)**

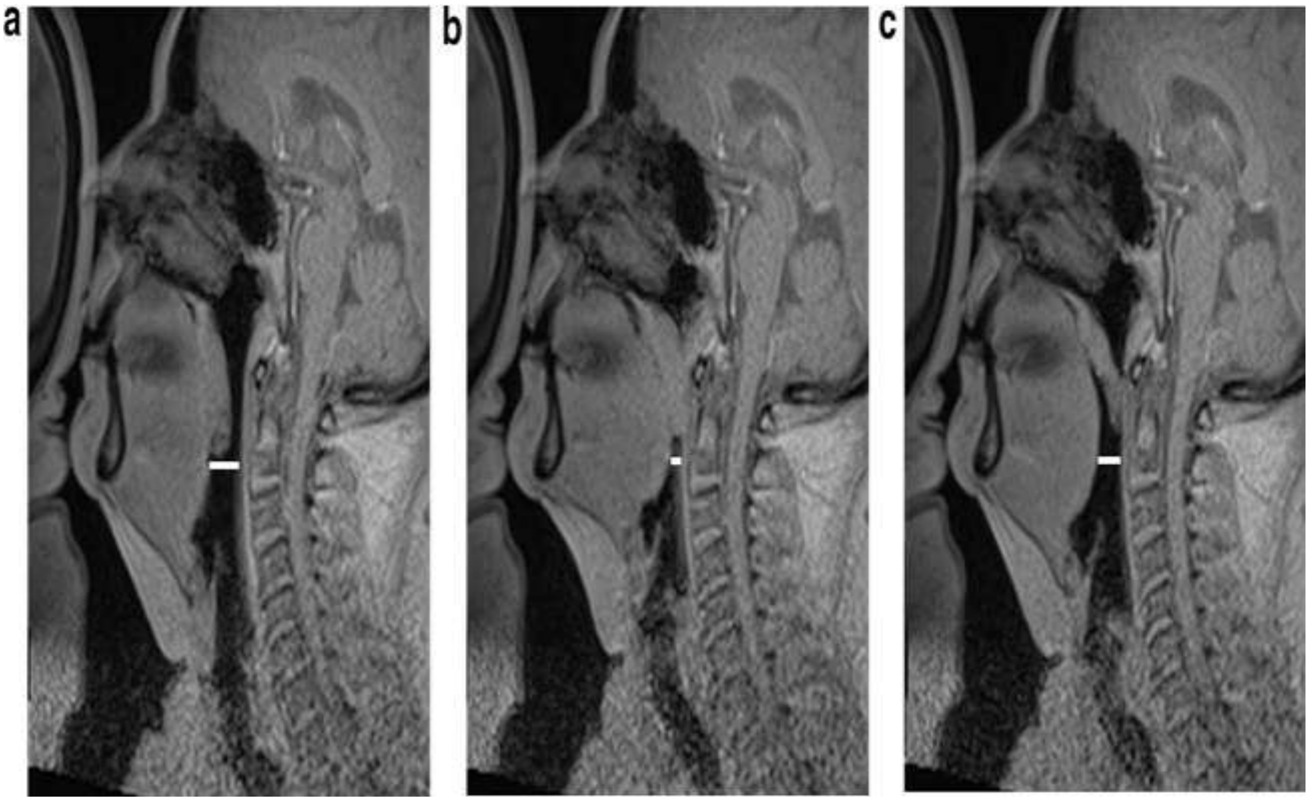

Figure (9) Midline sagittal magnetic resonance images showing two types of complete airway obstruction: open airway (A), obstruction with soft palate attached (B) or detached (C) to the tongue base. Note the significant narrowing of the retrolingual space in the first type and no narrowing in the second type of obstruction (white line). **(25)**

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