EFFICACY OF COBLATION ASSISTED SURGERY IN OBSTRUCTIVE SLEEP APNEA WITH OBSTRUCTION AT THE RETROPALATAL LEVEL

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M.S. OTORHINOLARYNGOLOGY

DEPARTMENT OF OTORHINOLARYNGOLOGY

KILPAUK MEDICAL COLLEGE

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BONAFIDE CERTIFICATE

This is to certify that, **Dr. Pradeep Ram S.S**, postgraduate student (2015 - 2018) in the Department of Otorhinolaryngology, Government Kilpauk Medical College and Hospital, Chennai has done this dissertation titled "**EFFICACY OF COBLATION ASSISTED SURGERY IN OBSTRUCTIVE SLEEP APNEA WITH OBSTRUCTION AT THE RETROPALATAL LEVEL"** under direct guidance and supervision in partial fulfilment of the regulations laid down by the Tamil Nadu Dr. MGR Medical University, Chennai for M.S. Branch – IV Otorhinolaryngology Degree Examination.

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DECLARATION

I, Dr. Pradeep Ram S.S, solemnly declare that the dissertation titled **EFFICACY OF COBLATION ASSISTED SURGERY IN OBSTRUCTIVE SLEEP APNEA WITH OBSTRUCTION AT THE RETROPALATAL LEVEL** is a bonafide work done by me at Government Kilpauk Medical College under the guidance and supervision of **Prof. Dr. T. Indra MS,** Professor and Head of Department of Otorhinolaryngology.

This dissertation is submitted to the Tamil Nadu Dr. MGR Medical University towards the partial fulfilment of the requirements for the M.S. Branch – IV, Otorhinolaryngology degree examination.

Place: Chennai

Date:

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CERTIFICATE – II

This is to certify that this dissertation work titled "EFFICACY OF COBLATION ASSISTED SURGERY IN OBSTRUCTIVE SLEEP APNEA WITH OBSTRUCTION AT THE RETROPALATAL LEVEL**"** of the candidate Dr. Pradeep Ram S.S with registration number 221514152 for the award of M.S. Degree in the branch of Otorhinolaryngology. I personally verified the urkund.com website for the purpose of plagiarism check. I found that the uploaded thesis file contains from the introduction to conclusion pages and result shows 3% percentage of plagiarism in the dissertation.

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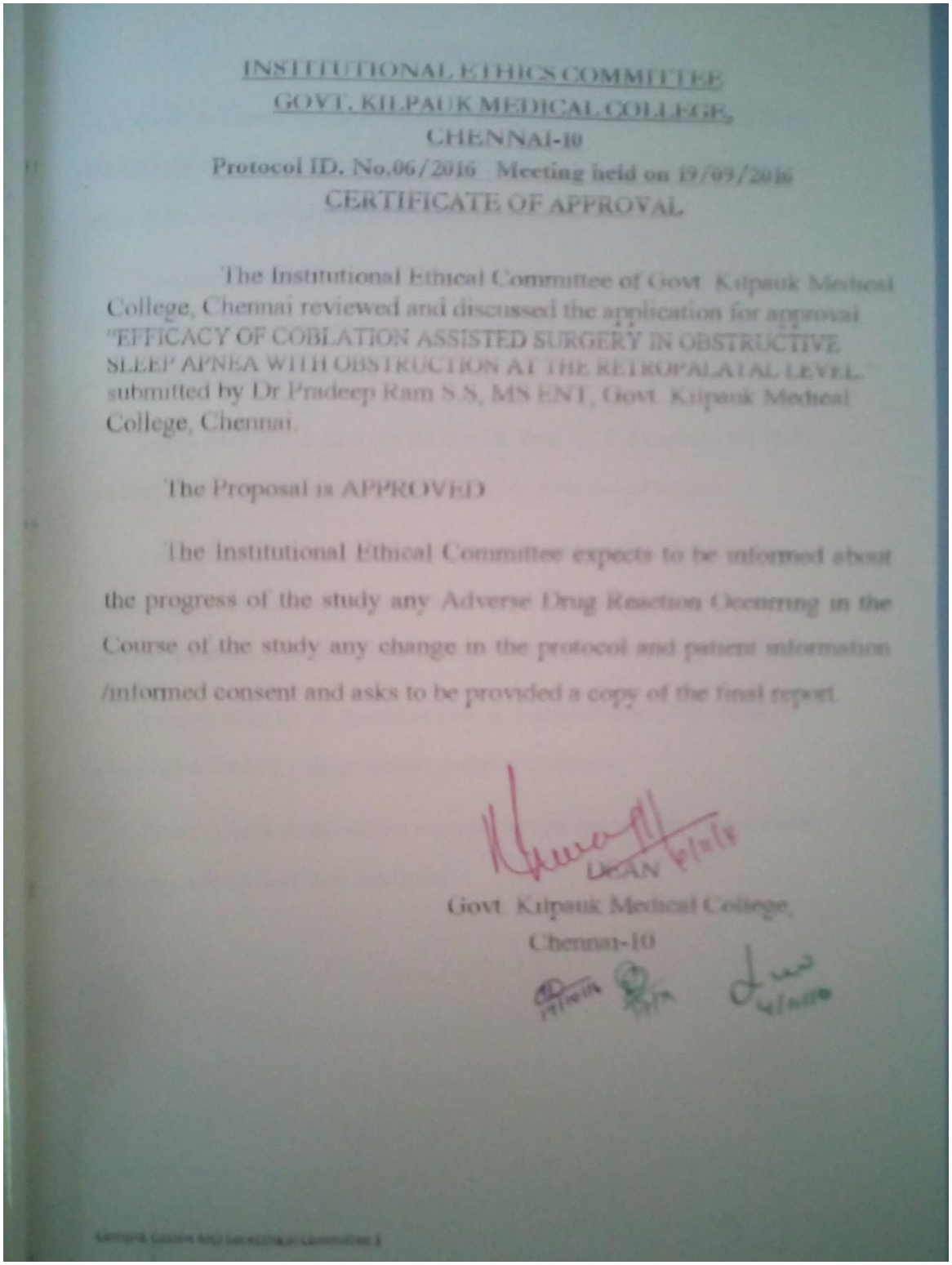

INSTITUTIONAL ETHICS COMMITTEE

GOVT. KILPAUK MEDICAL COLLEGE,

CHENNAI-10

Protocol ID. No.06/2016 Meeting held on 19/09/2016

CERTIFICATE OF APPROVAL

The Institutional Ethical Committee of Govt. Kilpauk Medical College, Chennai reviewed and discussed the application for approval "EFFICACY OF COBLATION ASSISTED SURGERY IN OBSTRUCTIVE SLEEP APNEA WITH OBSTRUCTION AT THE RETROPALATAL LEVEL" submitted by Dr Pradeep Ram S.S, MS ENT, Govt. Kilpauk Medical College, Chennai.

The Proposal is APPROVED

The Institutional Ethical Committee expects to be informed about the progress of the study any Adverse Drug Reaction Occurring in the Course of the study any change in the protocol and patient information /informed consent and asks to be provided a copy of the final report.

DEAN

Govt. Kilpauk Medical College,

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LIST OF ABBREVIATIONS

OSAS	Obstructive Sleep Apnea Syndrome
PSG	Polysomnography
UPPP	Uvulopalatopharyngoplasty
CPAP	Continuous Positive Airway Pressure
DISE	Drug Induced Sleep Endoscopy
MRI	Magnetic Resonance Imaging
EEG	Electroencephalography
EOG	Electroculography
EMG	Electromyography
ECG	Electrocardiography
SpO_2	Oxygen saturation
R & K system	Rechtschaffen and Kales system
AASM	American Academy of Sleep Medicine
REM	Rapid eye movement
NREM	Non-Rapid Eye Movement sleep
AHI	Apnea Hypopnea Index
ODI	Oxygen Desaturation Index
SEM	Slow eye movements
RERA	Respiratory event related arousal
RDI	Respiratory Disturbance Index
SNE	Sleep Nasoendoscopy

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ABSTRACT

EFFICACY OF COBLATION ASSISTED SURGERY IN OBSTRUCTIVE SLEEP APNEA WITH OBSTRUCTION AT THE RETROPALATAL LEVEL

Background and Objective: Obstructive sleep apnea syndrome is an emerging disorder in India which has contributed to the increased prevalence of various non-communicable diseases. There are many surgical procedures described in the management of OSAS of which Uvulopalatopharyngoplasty is the most commonly performed. The primary objective was to study the efficacy of coblation assisted UPPP in patients with isolated retropalatal obstruction. The effects on Polysomnography indices were also studied.

Study Design: Prospective study - Before – After analysis.

Methods: Patients diagnosed with moderate and severe obstructive sleep apnea by Polysomnography underwent Drug induced sleep endoscopy and sleep MRI to locate the level of obstruction. Only those with isolated retropalatal obstruction were selected. 25 patients underwent Uvulopalatopharyngoplasty and Polysomnography was repeated after 1 month. The parameters analysed were the Apnea Hypopnea Index, Arousal Index, Oxygen desaturation index and awakenings index. Results were also analyse using Friedman's staging system.

Results: Considering a 50 % reduction in AHI as surgical success, the efficacy of UPPP was 68% in this study. Statistically significant differences in AHI, arousal index, oxygen desaturation index and Awakenings Index were obtained in both successful and unsuccessful groups of patients.

Conclusions: Uvulopalatopharyngoplasty remains a valuable treatment option in OSA. The use of DISE and sleep MRI allows the selection of patients with isolated retropalatal obstruction who are most likely to benefit from UPPP.

Key words: Uvulopalatopharyngoplasty, Drug Induced Sleep Endoscopy, Sleep MRI, Obstructive sleep apnea, Coblation.

INTRODUCTION

Obstructive Sleep Apnea Syndrome (OSAS) is a common disorder with an estimated prevalence of 7 to 14 % among Adult men and 2 to 7 % among Adult women(1). It is a sleep disorder characterised by recurrent episodes of upper airway collapse during sleep resulting in significant decrease in airflow in the presence of respiratory effort.

This high prevalence of OSAS is associated with several risk factors including obesity, male sex, age and heritable factors. Obesity is one of the strongest risk factors among these(2). Peppard et al estimated that a 10% change in body weight was associated with a parallel change of around 30% in the apnea–hypopnea index(3).

Male sex is a strong risk factor with males having a two to threefold increased risk of sleep apnea. This may be related to the differences in the distribution of adipose tissue with males showing a central fat deposition pattern(2). There is also an increased prevalence among middle aged and older men and post-menopausal women which may be related to increased visceral fat. Hormonal and heritable factors are also associated.

The principal clinical features of OSA include loud snoring and excessive daytime sleepiness. Other symptoms reported include nocturnal gasping, choking, resuscitative snorting and apnea witnessed by the bed-partner. Patient may complain of unrefreshing sleep, morning headaches, depression, cognitive impairment, reflux symptoms and nocturia(4).

Obstructive sleep apnea is associated with the cardiovascular risk factors comprising the metabolic syndrome such as hypertension, insulin resistance and dyslipidemia independent of its relationship with obesity(5). Patients have an increased risk for hypertension, dysrhythmias, pulmonary hypertension, stroke and cardiovascular events. This risk of cardiovascular disease has been theorized to be due to complex interactions between the mechanical and chemical effects of upper airway closure and the autonomic nervous system(4). OSA patients are at greater risk for vehicular accidents with an estimated 7 times greater risk.

Historical Perspective:

The first description of the Obesity – Hypoventilation syndrome was given by Burwell et al in 1956 as the "Pickwickian Syndrome"(6) after a character from the Charles Dickens' novel "The Posthumous Papers of the Pickwick Club". This was a case report of a patient who had rapidly gained weight over the previous year whose physiologic changes were documented by Pulmonary function tests. These changes were reversible on weight loss.

Christian Guilleminault coined the term "Obstructive Sleep Apnea Syndrome"(7) in 1976. While working on patients with snoring, he observed that the apneic spells during sleep were associated with an elevation in blood pressure and cardiac arrhythmias. He postulated that upper airway obstruction was being produced during sleep and was able to produce dramatic improvements in some of these patients with Tracheostomy(8). On plugging the tracheostomy tube, the arrhythmias returned.

Uvulopalatopharyngoplasty was introduced in the 1980s and was the first surgical procedure meant specifically for the treatment of OSA(9). The aim of surgical treatment in OSA is the control of the associated neurocognitive and pathophysiologic derangements by relieving the upper airway obstruction during sleep. Though UPPP had great success in relieving snoring, its results in treating the apnea associated was unpredictable in the early years. This lead to the focus on selecting the patients who could benefit most from this procedure. Initial evaluation techniques included lateral cephalometry and awake endoscopy with Muller's manoeuvre.

UPPP remained one of the few treatment options till the introduction of Continuous Positive Airway Pressure (CPAP) in the late 1980s. CPAP provides a pneumatic splint for the upper airways preventing collapse(10). Though CPAP had great success in a laboratory setting, in real use, its compliance remains poor.

Investigation of the factors which lead to failure of UPPP and CPAP non-compliance lead to the recognition of multilevel obstruction. This lead to the development of different surgical techniques based on the level of obstruction. Various procedures targeting the tongue base, epiglottis and hyoid advancement have been developed, but UPPP remains the most commonly performed procedure in OSA. Recently introduced techniques of Drug induced sleep endoscopy and Sleep MRI have refined the ability to locate obstruction. Thus, the ability to select patients for CPAP and for specific procedures have been improved vastly.

This study aims to analyse the efficacy of UPPP in treating OSAS associated with isolated retropalatal obstruction and also study its effects on objective data obtained by polysomnography.

POLYSOMNOGRAPHY

Polysomnography (PSG) is a multiparametric test used in the diagnosis of sleep disorders. It is considered to be the "Gold Standard" in the diagnosis of Obstructive Sleep Apnea(11). This all-night diagnostic test for sleep disorders was named Polysomnography in 1974 by Jerome Holland of the Stanford Group(12). The name is derived from Greek and Latin roots: the Greek 'poly' for many indicating the many channels, the Latin 'somnus' referring to sleep, and the Greek 'graphein' meaning to write(13).

The German psychiatrist Johannes Berger was the first to record cortical electrical activity through the scalp in 1924(13). He identified the alpha rhythm and also noted that that it disappeared when the subject fell asleep and was replaced by low – amplitude waves. Loomis et al in a series of papers published in the 1930s described the characteristics of non-REM sleep and also described the K complex(14). In 1939, Kleitman came up with techniques to record movements during sleep(15). Along with Aserinsky, He devised the Electrooculogram (EOG) to measure eye movements and described REM sleep in 1953 and hypothesized its correlation to dreaming(16). At this point, the sleep recordings were made for short sampling episodes randomly during the night, William Dement was the first to make all night continuous recordings of EEG, EOG and movement channels(13). Michel Jouvet identified the absence of muscle potentials during REM sleep in 1959 and emphasized the importance of recording EMG activity. He identified REM sleep as an independent state of alertness, which he termed paradoxical sleep(17). The basics of what came to be known as Polysomnography i.e. EEG + EOG + EMG were now

defined. Thus, the overall patterns of sleep were described and quantified and the Kleitman group proposed a classification of sleep stages into non-REM (Stages 1,2,3 and 4) and REM(13).

Categories of sleep studies:

Traditionally, sleep studies have been categorized as levels from I to IV(11). Levels II to IV come under portable monitoring during Home Sleep Apnea Testing (HSAT)

Level I – Complete, attended, in laboratory sleep study. It represents the Gold Standard against which the other types are compared. It involves recording of Electroencephalography (EEG), electromyography (EMG) of the chin and leg muscles, electrooculography (EOG), Electrocardiography (ECG), Oxygen saturation (SpO_2), respiratory effort, airflow, snoring sensor and body position sensor.

Level II – A minimum of seven channels are recorded including EEG, EOG, ECG, chin EMG, SpO_2, respiratory effort, airflow.

Level III – A minimum of four channels are recorded consisting of respiratory effort, airflow, ECG, Oxygen saturation.

Level IV – measures a single parameter or 2 parameters.

Sleep Scoring Systems:

There are 2 major systems for scoring of sleep

1. Rechtschaffen and Kales system.
2. AASM system.

Rechtschaffen and Kales system:

Allan Rechtschaffen and Anthony Kales led a committee of investigators who introduced a manual on terminology, techniques and scoring systems for sleep stages(18) in 1968, commonly called the R & K system. These were the first consensus based guidelines for scoring sleep in normal human subjects and from 1968 to 2007, served as the standard. The committee recommended:

1. A minimum of one channel of Central EEG (C3 or C4 to the opposite Mastoid)
2. Chin EMG
3. Two channels of EOG – One electrode to be placed below & lateral to one eye and the other electrode to be placed above & lateral to the other eye. Both are referenced to the same Mastoid.
4. Epoch approach to staging with a time period of 20 or 30 sec.
5. Sleep was scored in five different stages – Stages 1 to 4 and REM.

Stage	Scoring Criteria
Waking	> 50% of the epoch consists of alpha (8-13 Hz) activity or low voltage, mixed (2-7 Hz) frequency activity
Stage 1	50% of the epoch consists of relatively low voltage mixed activity, and < 50% contains alpha activity. Slow rolling eye movements +
Stage 2	Appearance of sleep spindles and K complexes lasting > 0.5 sec and < 20% of the epoch contains high voltage (>75mcV, <2 Hz) activity
Stage 3	20 – 50% of the epoch consists of high voltage, low frequency activity

Stage 4	> 50% of the epoch consists of high voltage delta (>75mcV, <2 Hz) activity
Stage REM	Relatively low voltage mixed (2-7 Hz) frequency EEG with episodic rapid eye movements and absent / reduced chin EMG activity

With improving technology and knowledge gained over several years, the R & K system was found to have certain technical limitations(19). It was designed for normal sleep and not for abnormal electrophysiologic patterns. The system included guidelines for paper recordings which became obsolete. The stages of NREM sleep 2,3 and 4 were divided on the basis of percentage of time occupied by Delta waves, which had no scientific basis.

AASM Scoring Manual:

The American Academy of Sleep Medicine (AASM) first published their "Manual for the Scoring of Sleep and Associated Events" in 2007(20). It was aimed to revise the R & K system by addressing digital methodology and included scoring of arousals, respiratory events, sleep related movement disorders and cardiac events and also took into consideration the pediatric and geriatric age groups. The AASM manual is updated annually and is currently on version 2.4(21).

Sleep Stage Nomenclature:

The sleep staging under the AASM system was changed(20). Stages 3 and 4 of NREM sleep was combined into a single stage N3. Stage R is used for REM sleep.

Stage	R & K	AASM
Wake	Stage W	Stage W
NREM	Stage 1	Stage N1
	Stage 2	Stage N2
	Stage 3	Stage N3
	Stage 4	
REM	Stage REM	Stage R

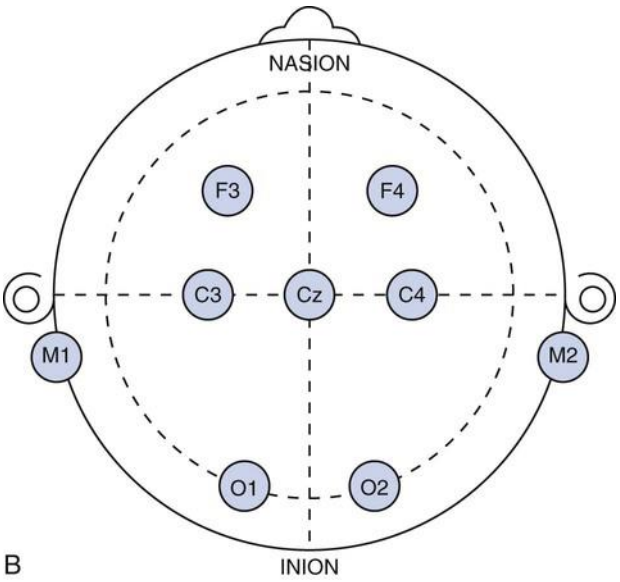
Time window for sleep staging:

A 30 second window known as an "epoch" is used to stage sleep. This convention dates from the use of paper recording with ink pens during the early sleep recordings(22). The page speed used was 10 mm / sec, thus a standard 30 cm recording page represented 30 seconds with each page representing 1 epoch. In clinical Electroencephalography, a 10 second window is used as a more detailed visualisation of waveforms is required. Modern digital equipment allows the use of different time periods for scoring different events.

Use	Optimal Time window
Sleep Staging	30 sec (epoch)
Respiratory events	60 – 120 sec
Clinical EEG	15 sec
ECG rhythm, identifying wave form frequency	10 sec

EEG Electrodes:

For the detection of sleep stages, fewer electrodes are needed than for clinical EEG monitoring. In the International 10-20 system(23), Electrodes are positioned at either 10% or 20% of the distance between landmarks namely the nasion (bridge of the nose), inion (tip of the external occipital protuberance) and preauricular points. Electrodes are named for the part over which they are placed, namely F for frontal, C for central, O for occipital, Fpz for the Frontopolar midline and Cz for the Central midline (vertex). The Fpz position is commonly used for the ground electrode and the Cz position for the reference electrode. Even numbered subscripts are used for the right side and odd numbers for the left side.



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EEG Derivations:

The EEG uses differential alternating current (AC) amplifiers which amplify the difference in voltage between electrodes. Thus, lower voltage EEG activity can be recorded against a background of higher voltage electrical noise.

An EEG derivation refers to a pair of electrodes and their voltage difference(24). The term channel is used to describe each horizontal display of a given signal versus time.

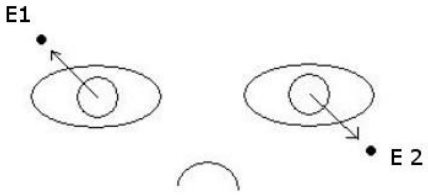
Recommended	Backup
F4 – M1	F3 – M2
C4 – M1	C3 – M2
O2 – M1	O1 – M2

Each of the recommended derivations uses a scalp electrode and the opposite mastoid electrode. In the R & K system, only central derivations were used. Using modern digital techniques, all the electrodes are recorded and all or only a subset of the possible derivations can be displayed according to need. The group of electrodes chosen is called as the Montage(22).

Electrooculography in sleep monitoring:

A potential difference exists across the eye with the cornea being positive and the retina being negative. Eye movements are recorded as voltage changes with a positive voltage recorded when the eye moves towards an electrode. Because eye movements are conjugate, they both move towards one electrode and away from the other.

The AASM recommended electrodes are E1 (left eye) and E2 (right eye). E1 is placed below the left outer canthus and E2 is placed above the right outer canthus(20).



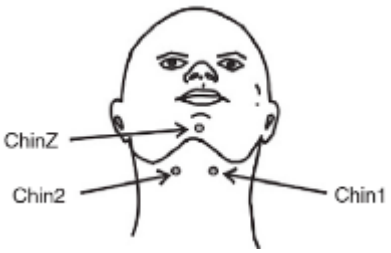
EOG derivations recommended are E1 – M2 and E2 – M2. Thus, eye movements will produce out of phase deflections in each derivation.

Chin Electromyography monitoring:

The monitoring of chin EMG is needed for identifying the stage R (REM sleep). During stage R, there is a relative reduction in chin EMG activity due to generalized skeletal muscle hypotonia during this stage. The amplitude of the chin EMG is less than the lowest chin EMG amplitude recorded during NREM sleep.

AASM recommended positions for the chin electrodes(21) include:

Chin Z – in the midline and 1 cm above the inferior edge of the mandible



Chin 1 – 2 cm to the left of midline and 2 cm below the inferior edge of the mandible.

Chin 2 – 2 cm to the right of midline and 2 cm below the inferior edge.

Derivations which are recommended are either Chin 1 – Chin Z or Chin 2 – Chin Z with the other derivation being backup. If Chin Z is faulty then Chin 1 – Chin 2 can be used.

A reduction in the EMG amplitude may be seen on transition from wakefulness to sleep and also during transitions from Stage N1 to N2 to N3. A further reduction is seen on transition from Non – REM to REM.

EEG Patterns for staging sleep:

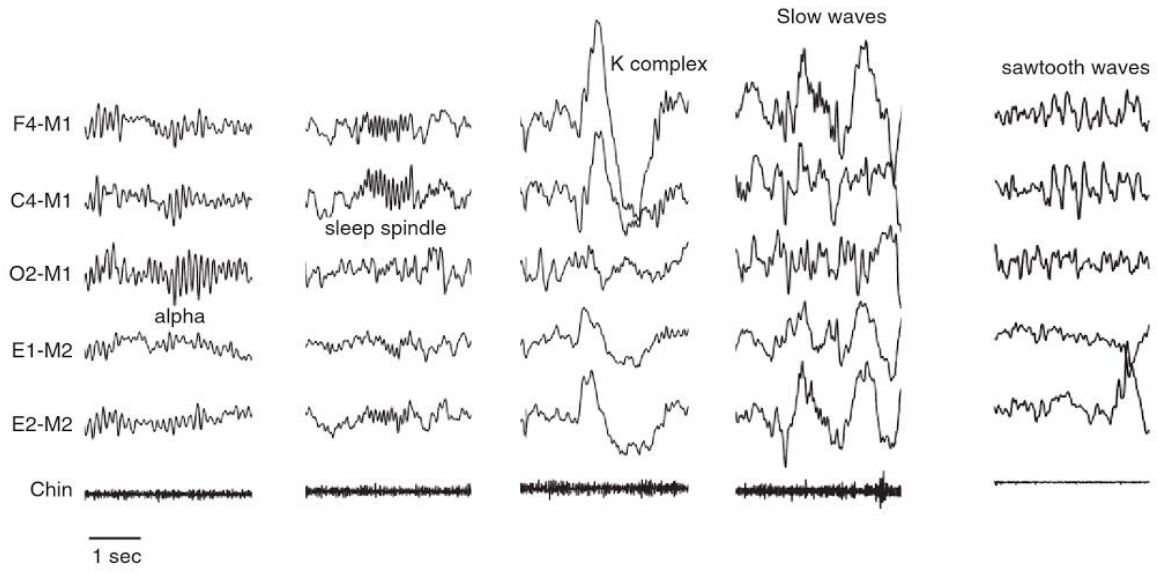
EEG activity is described in terms of

1. Frequency – in cycles per second (Hz).
2. Amplitude – in microvolts (μV)
3. Shape

Higher frequency activity produces narrow deflections while lower frequency activity produces wide deflections. The classical EEG frequency ranges include:

1. Delta (0 – 4 Hz)
2. Theta (4 – 8 Hz)
3. Alpha (8 – 13 Hz)
4. Beta (>13 Hz)

The term Sharp waves are used for narrow waves with duration of 70 – 200 msec and the term Spikes are used for waves with a shorter duration of 20 -70 msec. There are some classic EEG patterns which are used in the staging of sleep(22).



Alpha Rhythm:

The Alpha Rhythm also called the Posterior Dominant Rhythm (PDR) is characteristic of awake stage W with eyes closed when the patient is drowsy. The term Alpha activity is used to describe any EEG activity within the Alpha range frequency of 8 – 13 Hz. The term Alpha rhythm is used to describe Alpha activity which is most prominent in the occipital derivations and is increased by eye closure and attenuated by eye opening. Up to 10 % of people may not produce the Alpha rhythm on eye closure. Bursts of Alpha activity may also be seen during stage R with frequency being 1 -2 Hz less than stage W. Alpha activity is also frequently associated with brief awakenings or arousals.

Sleep spindles:

Sleep spindles are generated from the reticular nucleus of the Thalamus and arise due to Thalamocortical oscillations(25). Sleep spindles are defined as bursts of activity lasting for 0.5 sec or greater (usually 0.5 -1.5 sec) within a frequency range of

11 – 16 Hz (mostly 12 – 14 Hz). These bursts of activity resemble the shape of a spindle of yarn, hence the name. They are one of the defining factors for stage N2.

K complex:

This is high – amplitude, biphasic wave. It is composed of an initial well delineated negative sharp wave (deflection upwards), and then a positive (deflection downwards) slow wave. The total duration is greater than 0.5 seconds. The K complex stands out from the low voltage background activity. A burst of spindle activity is very often superimposed on it. It is maximal over the Frontal areas with Frontal > Central > Occipital. K complex is said to be associated with an arousal if the arousal starts within 1 second of its termination. The K complex is also seen in the EOG derivations as an in-phase deflection. The K complex is characteristic of stage N2.

Slow wave activity:

Slow wave activity in sleep staging specifically refers to waves with a frequency range of 0.5 to 2 Hz and a peak to peak amplitude greater than 75 μV. Slow waves have the greatest amplitude in the frontal derivations. Slow wave activity is used to define stage N3.

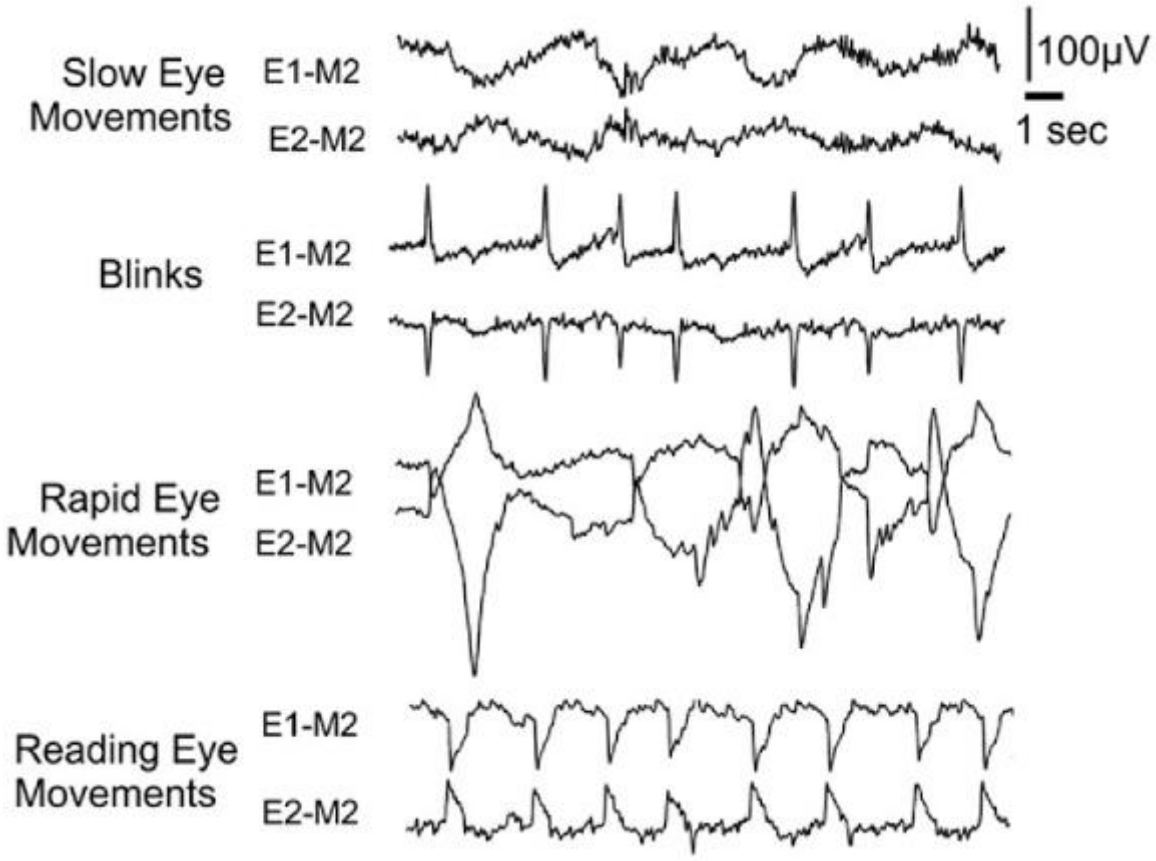
Vertex sharp waves:

They are sharply contoured waves with duration < 500 msec prominent in the central derivations and can be distinguished from the background higher amplitude activity. It occurs in stage N1 and N2.

Sawtooth waves:

They often occur prior to a burst of Rapid eye movement sleep. They are trains of triangular waves of 2 – 6 Hz with the highest amplitude in the central derivations. They are not required to score stage R since they are not always present in this stage.

Eye Movement Patterns(22):



Blinks:

These are conjugate vertical eye movements that usually occur when awake (Stage W), but may also occur during sleep. They are of short duration usually < 0.5 sec. These movements are associated with Bell's phenomenon which is a reflex upward movement occurring on eye closure. When the eye opens again, the globe returns to neutral. Thus, a blink consists of eye movement upward with a return to

neutral. Since, the upward movement causes the eyes to be closer to E2, greater deflection is seen in the E2-M2 derivation.

Reading Eye Movements:

These consist of trains of conjugate eye movements consisting of a slow phase followed by a rapid phase in the opposite direction. This is produced by the subject reading text in one direction, followed by a movement back to begin reading the next line.

Slow eye movements:

These are conjugate, regular and sinusoidal eye movements with the initial deflection lasting more than 500 msec.

Rapid eye movements:

These are conjugate, irregular and sharply peaked eye movements with an initial deflection lasting less than 500 msec. These are characteristic of stage R sleep, but may also occur in stage W when the patient looks around.

Sleep Staging:

Using the AASM rules, each epoch (30 sec time window) is assigned a sleep stage. If there is more than one stage in an epoch, the epoch is assigned the stage which occupies more time.

Stage W:

An epoch is scored as stage W when more than 50% contains either or both:

1. Alpha rhythm over the occipital region.
2. Other findings consistent with stage W
    a. Eye blinks (0.5 – 2 Hz)
    b. Rapid eye movements with high chin tone
    c. Reading eye movements.

The EEG in Eyes open stage W consists of a low amplitude mixture of alpha and higher frequencies. Eyes closed wakefulness consists of alpha rhythm in the occipital derivations.

Stage N1:

Stage N1 is usually the first stage of sleep in adults. An epoch is scored as stage N1 when:

1. In individuals who generate the alpha rhythm: N1 is scored when the alpha rhythm is attenuated and replaced by low-amplitude, mixed-frequency (LAMF 4 – 7 Hz) activity for more than 50 % of this epoch.
2. In individuals who do not generate the alpha rhythm: N1 is scored commencing with the earliest of any of the following:
    a. EEG activity in the range of 4 to 7 Hz with slowing of background frequency by more than 1 Hz from those of stage W.
    b. Vertex sharp waves
    c. Slow eye movements.

Chin EMG is variable but lower than during stage W. The final epoch of stage N1 at the transition to N2 may contain K complexes or sleep spindles with Vertex sharp waves continuing to N2. There are no specific rules for the end of stage N1.

Stage N2:

Rules for start of N2 stage –

1. EEG: When either or both of the following occur during the first half of current epoch or last half of previous epoch-
    a. One or more K complexes not associated with arousals
    b. One or more trains of sleep spindles.
2. EOG: Usually no eye movements, slow eye movements have ended.
3. Chin EMG: Variable usually less than wakefulness

Rules for continuation of N2 stage –

Epochs with LAMF (low amplitude mixed frequency) EEG activity are scored as N2 if they are preceded by an epoch containing either of the following

1. K complexes not associated with arousals.
2. Sleep spindles.

Rules defining the end of stage N2:

Stage N2 ends when one of the following occur-

1. Transition to stage W, N3 or R
2. An arousal – change to stage N1.

3. Major body movement (MBM) followed by slow eye movements and LAMF EEG.

A major body movement is defined as movement producing a muscle artifact which obscures the EEG for more than half an epoch to the extent that its sleep stage cannot be defined. If the MBM epoch has alpha activity, it is scored as stage W and N2 ends. If the MBM epoch is followed by SEM, stage N2 continues.

Stage N3:

Stage N3 is scored if more than 20 % of an epoch consists of slow wave activity over the Frontal region. Since the R & K system used only central derivations, Stage N3 scored by AASM criteria exceeds the amount of Stage 3 & 4 scored by R & K criteria. Sleep spindles may be present. Eye movements are not typically seen in this stage. Chin EMG may be of variable amplitude, lower than in stage N2 and maybe as low as stage R.

Stage R:

1. Definite Stage R – Stage R is scored in epochs with all of the following:
    a. LAMF (Low amplitude mixed frequency) EEG activity without K complexes or sleep spindles.
    b. Low chin EMG tone for the majority of the epoch concurrent with Rapid Eye Movements (REMs)
    c. REMs at any position within the epoch.

2. In the absence of rapid eye movements, segments of sleep preceding and contiguous with an epoch of definite stage R are scored as R if EEG all of the following are present:
    a. LAMF EEG activity without K-complexes or sleep spindles.
    b. Chin EMG tone is at the stage R level.
    c. No intervening arousal is present.
    d. Slow eye movements following an arousal or stage W are absent.
3. Segments of sleep that follow one or more epochs of definite Stage R are continued to be scored as R if all of the following are present:
    a. LAMF EEG activity without K-complexes or sleep spindles.
    b. Chin EMG activity is at the stage R level.
    c. No intervening arousal is present.
4. Stage R sleep ends when one or more of the following occur:
    a. Transition to stage N3 or W.
    b. An increase in chin EMG tone is seen for the majority of the epoch and criteria for stage N1 are met.
    c. An arousal occurs and is followed by LAMF EEG pattern and the chin EMG tone remains low – score N1 if Slow eye movements follow the arousal. If no SEMs are present, continue to score stage R
    d. Major body movement followed by SEMs and LAMF EEG without K-complexes or sleep spindles, stage R ends and N1 is scored.
    e. One or more K complexes or sleep spindles are present in the first half of the epoch in the absence of rapid eye movements.

5. Segments of the record with low chin EMG and a mixture of REMs and sleep spindles and/or K complexes as:
    a. Stage N2 – Segments between 2 K complexes or 2 sleep spindles or a K complex and a sleep spindle without intervening REMs.
    b. Stage R – Segments containing REMs without K complexes or sleep spindles and chin EMG at the stage R level.
    c. If the majority of an epoch contains segments considered stage N2 or Stage R, it is scored as the same stage.

Respiratory events:

Sensors for Respiratory monitoring:

Thermal sensors:

Thermal sensors or thermistors measure the temperature change produced by airflow. The difference between exhaled and ambient air is measured. They were the first sensors used in the monitoring of airflow(26). They are very accurate at measuring the presence or cessation of airflow but do not provide quantitative data.

Nasal Pressure(NP) transducers:

The drawbacks of thermistors led to the study of other devices which could produce accurate assessment of airflow limitation. Nasal pressure transducers are used to create a pressure signal contour(26) and to identify changes in size of each breath (flow amplitude). Changes in the pressure signal contour provide information on airflow limitation.

Respiratory inductance plethysmography (RIP):

It is a method of breath amplitude evaluation which uses an oscillator circuit within polyvinylidene difluoride (PVDF) belts placed around the rib-cage and abdomen. Both quantitative and qualitative data is obtained from this(26).

Oximetry:

During standard polysomnography, desaturation is measured with the finger pulse oximeter. However, accuracy of the oximetry data may be affected by motion artifacts, probe placement, haemoglobin level, ambient light and nail polish. The validity of the signal is enhanced by the use of shorter averaging times and motion artifact detection(26).

Apnea:

Apnea is defined as a temporary cessation of breathing during sleep. A respiratory event is scored as an apnea when the following criteria are met:

1. A drop in the peak signal excursion by ≥ 90% of the baseline.
2. Event duration is at least 10 seconds.

The recommended sensor for detection of apnea is the oro-nasal thermistor. Alternative sensors include Nasal pressure transducer and respiratory inductance plethysmography. Apneas may be classified as:

1. Obstructive apnea – Apnea associated with continued or increasing inspiratory effort throughout the event duration.
2. Central apnea – Apnea associated with absent inspiratory effort.

3. Mixed apnea – Absent inspiratory effort in the initial part of the event. The inspiratory effort is present in the subsequent parts.

Hypopnea:

Hypopnea is a decrease in airflow manifested by shallow breathing. The scoring criteria for hypopnea has remained controversial based on whether hypopnea should be scored based on airflow and arousals when desaturation is not significant. The recommended sensor for hyponea detection is the Nasal pressure transducer. Alternative sensors include the oronasal thermistor and Respiratory inductance plethysmography.

AASM recommended criteria:

A respiratory event is scored as hypopnea if all the following are met:

1. The peak signal excursions drop by ≥ 30 % of the pre-event baseline.
2. The duration of the event is ≥ 10 seconds.
3. There is a ≥ 3 % desaturation from the pre-event baseline or there is an associated arousal.

AASM acceptable criteria:

A respiratory event is scored as hypopnea if the following are met:

1. The peak signal excursion drops by ≥ 30 % of the pre-event baseline.
2. The duration of the event is ≥ 10 seconds.
3. There is a ≥ 4 % oxygen desaturation from the baseline.

Respiratory Event Related Arousal (RERA):

A RERA or “Respirator event related arousal” are respiratory events which do not meet the criteria for apnea or hypopnea(22). They are characterised by increasing respiratory effort leading to an arousal. They are also called upper airway resistance events. The preferred sensor for RERA detection is Esophageal manometry(24). Nasal pressure transducers and RIP can also be used. The scoring of RERAs when using a hypopnea definition that requires an oxygen desaturation is clinically relevant, as sleep fragmentation may be associated with respiratory arousals in the absence of desaturation. Thus, considering only apneas and hypopneas may underestimate the severity of the problem. RERAs are scored in the presence of a sequence of breaths lasting more than 10 secs with increasing respiratory effort or by flattening of the inspiratory part of the nasal pressure curve leading to an arousal.

Other respiratory events scored – Hypoventilation and Cheyne-stokes breathing.

Apnea-Hypopnea Index:

The Apnea-Hypopnea Index (AHI) is the number of apneas and hypopneas per hour of sleep. This concept was introduced by Christian Guilleminault and William Dement(7).

AHI = No of Apneas + No of Hypopneas / Total Sleep Time

In a meta-analysis conducted by Wang et al, it was shown that a dose-response relationship exists between AHI and Cardiovascular disease with a 10-unit average increase in AHI associated with a 17% greater risk of cardiovascular disease(27). A dose-response relationship was also discovered between AHI and blood pressure(28). This was noted in patients with AHI > 15.

Based on these studies, AHI was used in the classification of Obstructive sleep apnea according to severity(29):

OBSTRUCTIVE SLEEP APNEA	**AHI**
MILD	5 – 15
MODERATE	15 – 30
SEVERE	> 30

RERA Index:

It is defined as the number of RERAs per hour of sleep. It is calculated as:

RERA Index = No of RERAs / Total sleep time

Respiratory disturbance Index (RDI):

It is the number of respiratory events per hour of sleep. It is calculated as:

RDI = AHI + RERA Index.

Arousals:

Arousals are transient phenomena that lead to wakefulness or interrupt sleep. OSA patients have associated daytime sleepiness despite a normal total sleep duration because of arousals during their sleep. An arousal is said to have occurred when a person abruptly goes from a higher sleep stage to lower sleep stage. Thus, an arousal is scored on PSG when there is an abrupt shift in EEG frequency including alpha, theta or other frequencies > 16 Hz. This should last ≥ 3 seconds, with at least 10

seconds of stable prior to the shift. During REM sleep, scoring of an arousal requires a concurrent increase in submental EMG lasting at least 1 second.

Arousal Index:

It is defined as the number of arousals per hour of total sleep time. It may be considered as one of the measures of daytime sleepiness. The arousal index has been found to increase with age(30). Normal adults have an arousal index of 5 or less. In OSA patients, an arousal index of more than 10 per hour is correlated with daytime sleepiness.

Awakenings:

An awakening in contrast with an arousal, occurs when a person completely wakes up from sleep. In the context of polysomnography, it refers to a stage W occurrence during the recording.

Awakenings Index:

It is defined as the number of awakenings per hour of total sleep time(31). Since awakening leads to sleep fragmentation, the awakenings index is also associated with daytime sleepiness.

Oxygen Desaturation Index(ODI):

It is defined as the number of desaturation events per hour of total sleep time. In most cases, the most severe desaturations occur during REM sleep. A higher BMI, supine position and smoking is also associated with more severe desaturations. This puts the patient at risk for cardiovascular events. The use of home oximetry is useful

in the home based titration of CPAP therapy. A high ODI predicts good adherence to CPAP(24).

DRUG INDUCED SLEEP ENDOSCOPY

Drug induced sleep endoscopy (DISE) involves assessment of the upper airways while the patient is sedated to mimic sleep. It is the most widespread diagnostic tool for localizing the level of obstruction in OSA(32). Fibreoptic study of the upper airways in OSA was first done by Borowiecki et al in 1978 using a flexible bronchoscope over a period of 2-3 hours during natural sleep(33). Since this procedure was not routinely feasible, the technique of fibreoptic visualisation of the airways under sedation was introduced by Croft and Pringle in 1991(34) and termed by them as Sleep Nasoendoscopy (SNE). The terminology of Drug induced sleep endoscopy (DISE) has been used in recent years to describe this procedure(32, 35).

Key Aspects:

The 3 key aspects of this investigation were described by Kezirian et al (35):

1. Pharmacologic agents are used to achieve sedation
2. Upper airway behaviour like that of natural sleep is achieved.
3. Upper airways are evaluated by flexible endoscopy.

Cardiorespiratory monitoring is essential during the procedure. It is preferably done in the operating room with the help of Anaesthesiologists to control the sedation level and to assist in airway management if required.

Contraindications:

Since sedation is being given, the anaesthetic risk profile should be acceptable. Morbid obesity is a relative contraindication. Absolute contraindications(32) include:

1. ASA class 4.
2. Pregnancy.
3. Patient allergic to Propofol or other sedatives which are being used.

Premedication:

The use of premedication has been recommended by Kezirian et al.

1. Anticholinergics like Glycopyrrolate or Atropine(35) are administered 30 mins prior to reduce secretions and thus provide better visualisation.
2. Topical anaesthetic with decongestant(35) is administered by packing the nose to reduce irritation & provide easier access.

The use of Anticholinergics has been claimed to alter the sleep physiology while Topical Anaesthetics have been claimed to influence the tone of the pharyngeal musculature(32). We perform both steps in order to get a better study.

Sedation:

Pharmacologically induced sleep has been achieved with Propofol and Midazolam. More recently, Dexmedetomidine has been claimed to provide better cardiovascular stability during DISE(36). In our institute, Propofol is used because of availability and greater experience among our Anaesthesiologists. Pre – procedure, standard nil per oral time of 8 hours is advised in all our patients.

Propofol is given by continuous infusion or by bolus technique with a loading dose of 1 mg/Kg with increasing rate of 20 mg every 2 minutes(32). Target controlled

infusion has been claimed to improve accuracy, safety and stability(37), but availability and cost factor precludes its wider use.

Midazolam is given with a bolus technique with a loading dose of 0.03 mg/Kg, then the patient is observed for 2 – 5 min, another dose of 0.03 mg/Kg is given if patient is awake. After further observation of 5 min, if still awake another dose of 0.015 mg/Kg is given(32). Combined Midazolam + Propofol techniques have also been described.

DRUG	DOSE
Propofol	Bolus Technique: Loading dose of 30 – 50 mg or 1 mg / Kg. If required increase by 10 – 20 mg / 2 minutes.
Midazolam	Bolus Technique: Starting dose of 0.03 mg / Kg, increase with rate of 0.015 – 0.03 mg / Kg.
Combined Technique	Midazolam single starting dose: 1.5 mg or 0.05 mg / Kg. Propofol Target controlled infusion: Starting dose of 1.5 – 3 µg / mL increase with 0.2 – 0.5 µg/mL

Technique:

The patient lies in the supine position. The Surgeon stands to the right of the patient and waits for the snoring to start. The Flexible Fiberoptic Nasopharyngoscope is introduced through the nasal cavity which is wider. Anecdotally, some surgeons have recommended the use of the Paediatric bronchoscope to us as it has a suction port and better visualisation is hence claimed. The scope is held in place for a few

cycles of snoring at each level to better gauge the extent of obstruction and the direction.

Insert nasopharyngoscope photo

Scoring the level of obstruction:

No consensus has been reached on an internationally accepted scoring and classification system(32). The European working group on DISE in 2014 could reach a consensus on the features that such a system(32) should include:

1. Level or Structure involved.
2. Degree of obstruction present.
3. Configuration of obstruction – pattern and direction.

In our institute, the VOTE and Fujita classifications are used.

Scoring Systems Published:

Pringle and Croft in 1993(38) –

This system is based on the level of obstruction they noted during their technique of Sleep Nasoendoscopy

Grade 1	Simple Palatal level snoring
Grade 2	Single Palatal level obstruction
Grade 3	Palatal level obstruction with intermittent oropharyngeal involvement.
Grade 4	Sustained Multi segment involvement
Grade 5	Tongue base level obstruction

Camilleri et al in 1995(39) –

They suggested a simplified grading system to aid in treatment planning with patients being divided into 3 categories based on the level of obstruction.

Category 1 – Palatal snorers.

Category 2 – Mixed snorers.

Category 3 – Non-palatal (tongue base) snorers.

NOHL classification, 2012 -

In this system described by Vicini et al(40), scoring is done first during awake upper airway endoscopy with the Muller manoeuvre and then during DISE. This is similar to the VOTE classification with the addition of Nasal and Laryngeal levels.

SITE	NOSE Static obstruction	OROPHARYNX	HYPOPHARYNX	LARYNX: Supraglottic Glottic
% grade value (1-4)	0-25 %: 1 25-50%:2 50-75%:3 75-100%:4	0-25 %: 1 25-50%:2 50-75%:3 75-100%:4	0-25 %: 1 25-50%:2 50-75%:3 75-100%:4	Positive or Negative collapse / obstruction

Bachar et al in 2012 -

Bachar et al used a DISE classification which showed the level of obstruction and the degree of obstruction(41). The configuration of obstruction was not taken into

account. Five anatomical sites were documented – N (Nose/Nasopharynx), P (Uvulopalatine plane), T (Tongue Base), L (Larynx), H (Hypopharynx). A severity grade of 0 or 1 or 2 was assigned for each site and was then tallied to yield a Severity Index (SI)

LEVEL	No collapse	Partial collapse	Complete collapse
N -Nose / Nasopharynx	0	1	2
P -Uvulopalatine plane Tonsils	0	1	2
T - Tongue Base	0	1	2
L – Larynx	0	1	2
H – Hypopharynx	0	1	2

Gillespie et al in 2013 –

They introduced the DISE index based on the extent of obstruction in various levels.(42)

DISE INDEX	0	1	2	3	4
Palate	No collapse	Partial Collapse	Complete Collapse	-	-
Hypopharynx	No collapse	Partial Collapse	Complete Collapse	-	-

Tonsils	No collapse	Partial Collapse	Complete Collapse	-	-
Tongue Base	No collapse	Partial Collapse with Lingual Tonsil	Partial Collapse without Lingual Tonsil	Complete Collapse with Lingual Tonsils	Complete Collapse without Lingual Tonsils
Epiglottis	No collapse	Partial Collapse	Complete Collapse	-	-

Koo et al in 2013:

Koo et al published a DISE classification with Retropalatal and Retrolingual levels.(43) The degree of obstruction and configuration of obstruction was also included.

Level of Obstruction	Degree of Obstruction	Configuration		
		Antero Posterior	Lateral	Structure involved
Retropalatal	0 /1 /2	Palate +/-	Lateral Pharyngeal wall +/-	Tonsils +/-
Retrolingual	0 /1 /2	Tongue Base +/-	Lateral Pharyngeal wall +/-	Epiglottis

VOTE classification:

The VOTE classification was introduced by Kezirian et al in 2011(35). It is currently the most widely used scoring system(44) for DISE.

LEVEL	DIRECTION		
	ANTEROPOSTERIOR	LATERAL	CONCENTRIC
V – VELUM			
O-OROPHARYNX			
T – TONGUE BASE			
E- EPIGLOTTIS			

Shaded boxes indicate the directions in which collapse does not occur at each level with degree of obstruction (x, 0, 1, 2) being filled into non-shaded boxes.

This classification focuses primarily on the most common and well-known structures that contribute to upper airway obstruction.

Degree of obstruction: It is qualitatively graded as

x for not visualised

0 for none (less than 50% airway narrowing compared to nonapneic state)

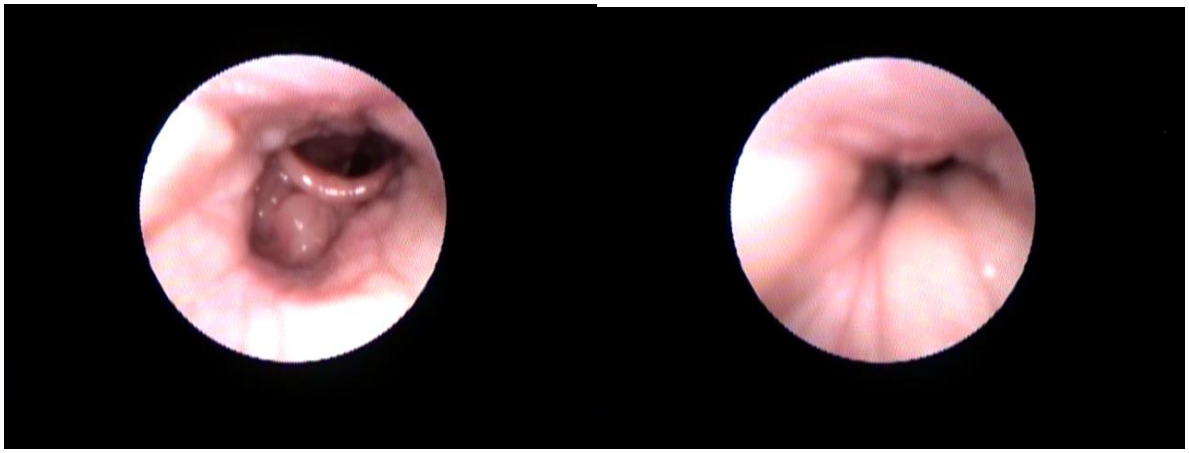
1 for partial (50 – 75 % narrowing with vibration of structures)

2 for complete (> 75% no airflow)

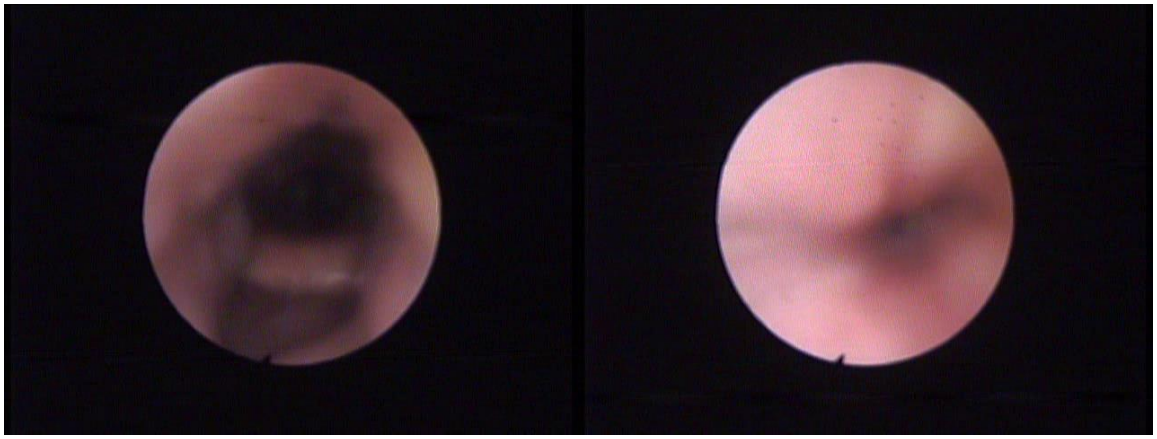
This was considered to be more realistic from a clinical perspective and has moderate reliability(45).

Velum(V): Obstruction due to the uvula, soft palate, or lateral velopharyngeal wall is grouped under the Velum (V) level. Airway closure at this level is commonly anteroposterior or concentric in direction and rarely lateral.

1 Anteroposterior collapse at the Velpharyngeal level



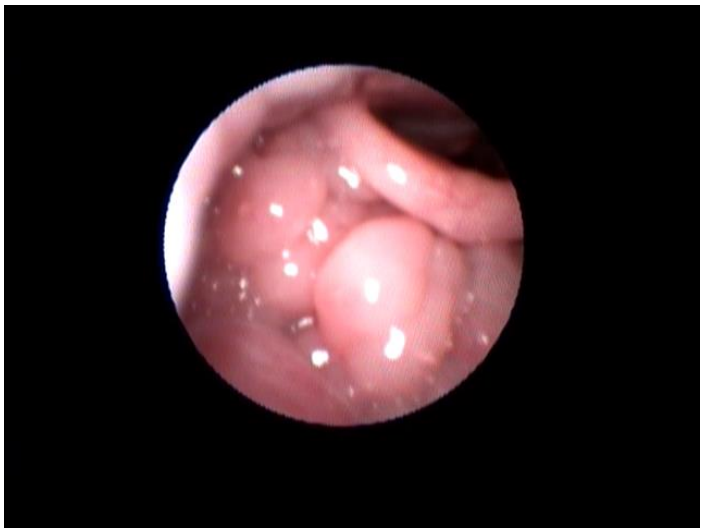
2 Circumferential collapse at the velopharyngeal level



Oropharynx(O): In this classification, this consists of 2 structures – The Tonsils and the Lateral pharyngeal tissues including the musculature and parapharyngeal fat pads. This obstruction occurs in the lateral direction but a concentric pattern can result in combination with collapse of other structures.

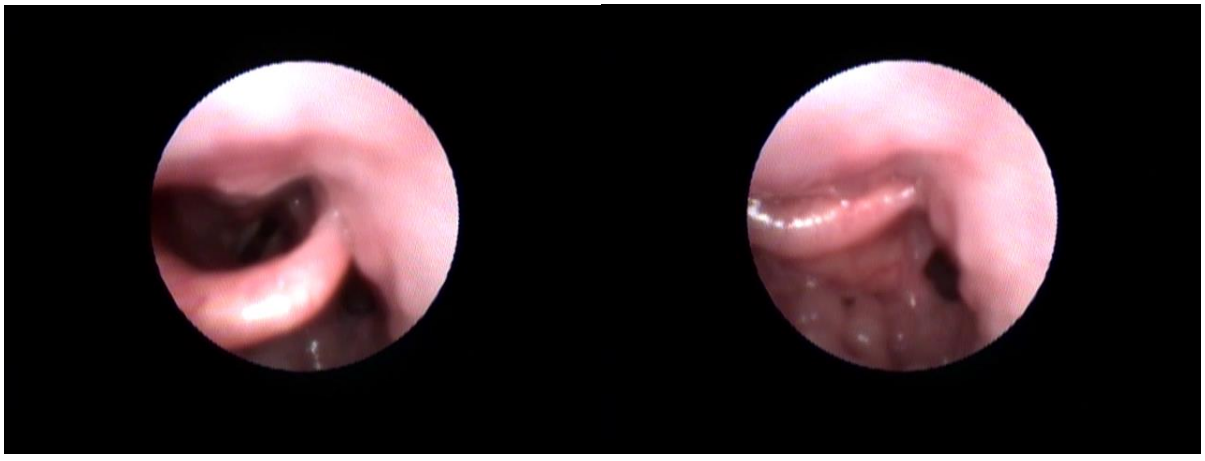
Tongue Base(T): Airway obstruction at this level occurs in an Anteroposterior direction. During sleep, there is a fall in the muscle tone of the tongue, which occurs to a greater degree in OSA patients.

3 Hypertrophied Lingual Tonsil



Epiglottis(E): The role of DISE in demonstrating epiglottic collapse is unique. Epiglottic collapse can occur in two directions – anteroposterior or lateral. Anteroposterior collapse can occur due to decreased structural integrity of the epiglottis or with a posterior displacement of the entire epiglottis against the posterior pharyngeal wall.

4 Epiglottis - Anteroposterior collapse



Lateral collapse can occur due to a central vertically oriented crease of decreased structural integrity. Epiglottic collapse can be primary or due to secondary pressure changes due to obstruction at higher levels.

Validity and Reliability of DISE:

Berry et al(46) studied the validity of DISE using Propofol infusion. A group of symptomatic patients were compared with a control group of asymptomatic individuals. They reported that all the patients in the snoring group snored at different Propofol concentrations with no statistically significant difference in the concentration required. None of the patients in the control group snored at these concentrations. This study answered the possibility of false positive results with DISE.

Rodriguez-Bruno et al studied the test-retest reliability of DISE in 2009 and reported good results especially in the evaluation of the hypopharyngeal airway(47) between examiners. Another study conducted by Kezirian et al(48) concluded that the interrater reliability of DISE was moderate to substantial. It had greater reliability for the pattern of obstruction than for the degree. Reliability for evaluation of hypopharyngeal structures was greater than for palatal strucutres.

Fujita Classification:

This system is for the pattern of obstruction in OSA and was introduced by Fujita(49).

Type I – Isolated Retropalatal collapse.

Type II – Collapse in both Retropalatal and Retrolingual regions.

Type III – Isolated Retrolingual collapse.

Sleep MRI

Sleep MRI involves the MR imaging of the upper airways during sleep to evaluate the level of obstruction. MRI allows better visualization of the soft tissues involved. A video is produced of the real-time sequences produced during sleep.

Technique:

The MRI is taken both when the patient is awake and then during sleep to observe for upper airway collapse. Sleep is either natural or pharmacologically induced(50). When natural sleep is used, noise protectors and ear plugs have been utilised to block the sound(50). Shin et al used a continuous background "white noise" to facilitate sleep and mask the scanning noise(51). They were able to perform sleep MRI with natural sleep in all their patients.

In the literature, Sleep MRI studies are mostly performed with pharmacologically induced sleep because the MRI scan room environment is not conducive to natural sleep.

Sedatives used:

In 1993, Suto et al used IV Hydroxyzine Hydrochloride to induce sleep(52). Moon et al in 2010 used IV Midazolam 2.5 mg(53). We also use IV Midazolam. Initially 1 mg is given as an anxiolytic. Then the awake scan is done. Following this 1 mg doses to a maximum of 3 mg are given at 5 min intervals during which the sedative effect is evaluated. All doses are diluted in 5 mL of Normal Saline and given slow IV over 2 min.

Following the recommendations of Shin et al, we ask our patients to avoid stimulants like caffeine and all sedatives on the day of the investigation(51).

Collection of Physiologic data:

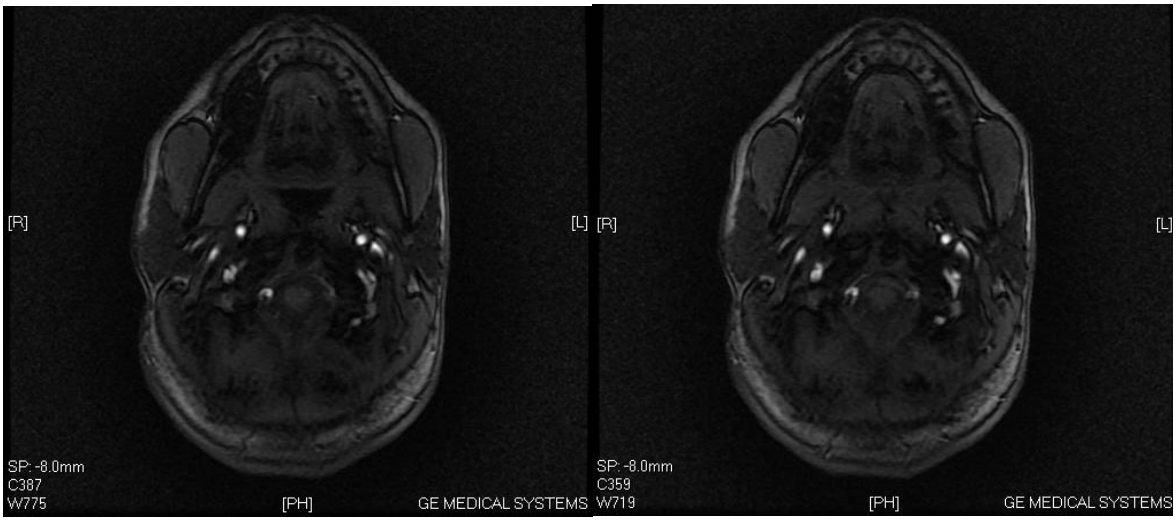
During sleep MRI, real time physiologic data has been collected to identify the timing of apneic and hypopneic episodes. These are then correlated with the real time MR images identifying the airway collapse during these episodes. This data also helps in monitoring of the patient under sedation. Mostly in the literature, portable Polysomnography devices have been used for this purpose(51, 52).

More recently, the EEG electrodes have been claimed to degrade the images obtained and actigraphy has been used for monitoring by Barrera as well as Moon et al(53, 54). This involves the Peripheral Arterial Tonometer (PAT) which does not cause image artifacts. This device can detect the respiratory events with a reasonable level of accuracy(55). Cost and availability of such MR compatible devices precluded its use in our study.

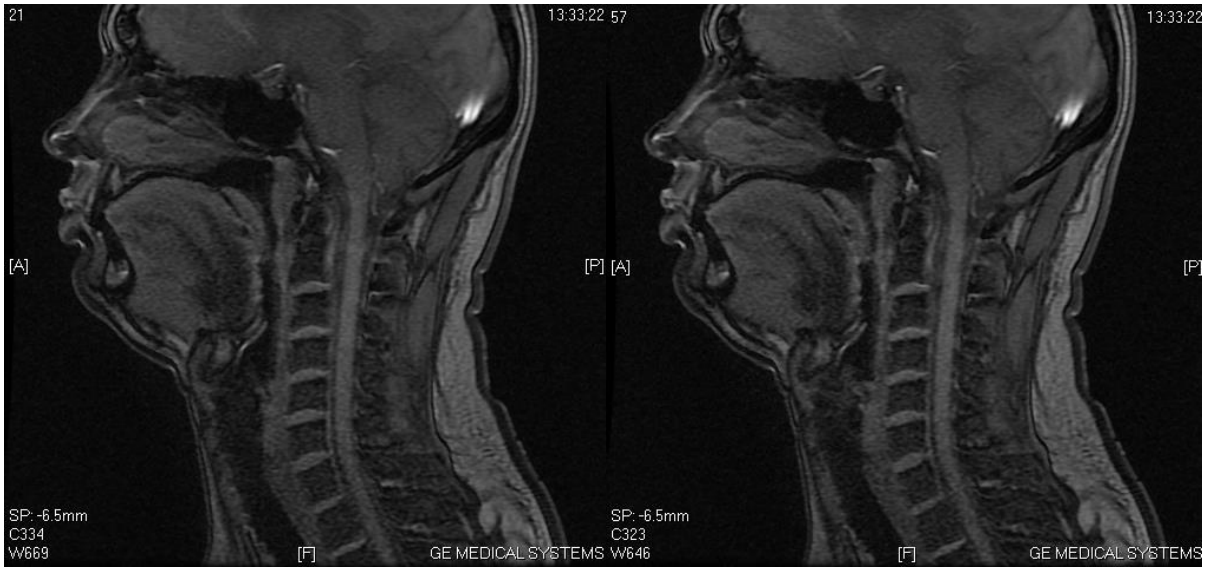
Scoring:

Like other aspects of the sleep MRI technique, no consensus has been achieved with scoring in sleep MRI. In our institution, the patients are scored as having retropalatal or retroglossal obstruction or combined.

In this series of patients, sleep MRI could localise the obstruction to the retropalatal area in 21 patients. In 2 patients the site of obstruction could not be made out. In 2 more patients, the investigation could not be completed due to extreme anxiety on the patient's part. All these patients were operated based on DISE findings.



Axial cuts on sleep MRI showing the retropalatal collapse.



Sagittal cuts on sleep MRI showing the retropalatal collapse.

Friedman Staging System

Friedman et al(56) introduced an “OSA score” or “Friedman score” in 1999 based on clinical criteria used by Anaesthesiologists to predict a difficult intubation. The Modified Mallampati score, tonsil size and the BMI of the patient were calculated and the OSA score was derived from this. This score was found to be predictive of both the presence and severity of OSA.

Mallampati Classification

A clinical sign was proposed by S. Rao Mallampati in 1983 to predict the difficulty of orotracheal intubation based on the anatomical relationship of base of tongue to the faucial pillars and uvula(57). This was later expanded into the Mallampati classification(58). This classification is also useful in the evaluation of patients with OSA. The patient is asked to open his mouth and protrude his tongue maximally while in the sitting position without vocalising.

Original Mallampati Scoring:

Class 1	Faucial pillars, soft palate and uvula could be visualised
Class 2	Faucial pillars & soft palate visualised. Uvula masked by base of tongue
Class 3	Only soft palate visualised.

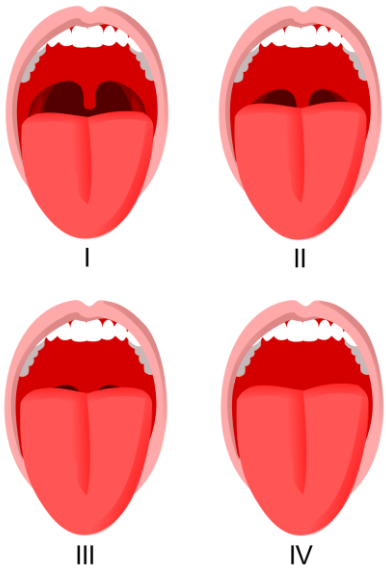
Modified Mallampati Scoring:

Class	Structure Seen
I	Soft palate, fauces, uvula, pillars

II	Soft palate, fauces, uvula.
III	Soft palate, base of uvula.
IV	Soft palate not visible.

Class 0 – Part of the Epiglottis seen.

The modified Mallampati scoring was introduced by Samsoon and Young(59). In addition to this, Class 0 has been proposed as a predictor of easy intubation(60). It may also be associated with a large, floppy airway which may produce difficulties with mask ventilation.

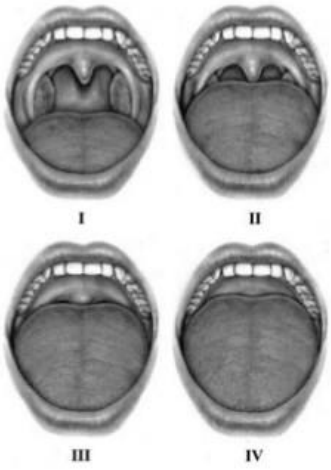


Mallampati Score in Obstructive Sleep Apnea:

The Mallampati score is associated both with the presence and severity of OSA. It is an independent predictor. Nuckton et al(61) reported that for every 1 point increase in the score, the odds of OSA increased 2 fold and the AHI increased by 5.

Friedman Palate Positioning System:

This is based on the Modified Mallampati Classification which was further modified for use in OSA. The structures are visualised with the mouth widely open without tongue protrusion(62). Thus, this system assesses the tongue in its neutral position with respect to the palate and this system is also called the Friedman tongue position (FTP).



Grade I	Entire Uvula and Tonsils seen
Grade II	Visualisation of the uvula but not the tonsils
Grade III	Visualisation of the soft palate but not the uvula
Grade IV	Visualisation of the hard palate only

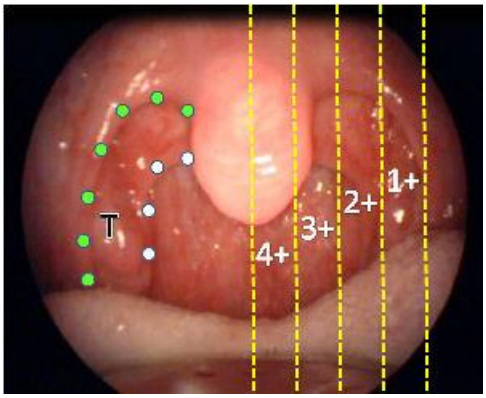
Tonsil Size Grading Scales:

The evaluation of tonsil size is essential in patients with OSAS who are planned for a surgical management. The 2 most widely used scales for tonsil size are:

1. The Brodsky grading scale
2. The Friedman grading scale

Brodsky grading scale:

This scale was introduced by Linda Brodsky(63) in 1989. The percentage of the oropharyngeal airway (the linear distance between the 2 anterior pillars) occupied by the Tonsils are observed and the Tonsils are assigned a grade.

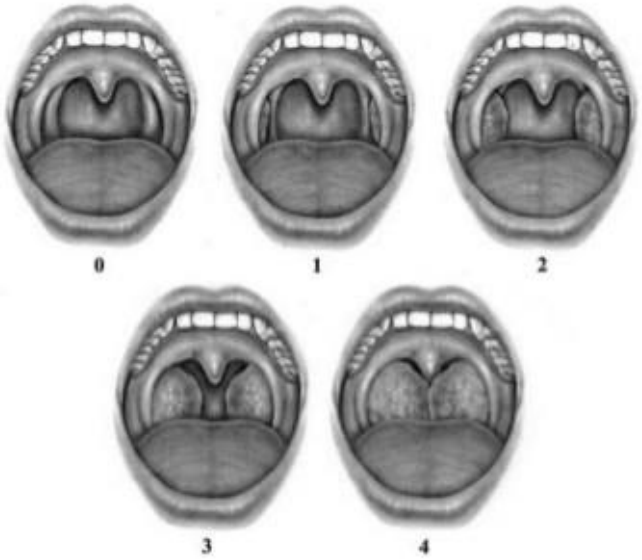


Grade	Airway Percentage
0	Tonsils within the fossa.
1	≤ 25
2	26 – 50
3	51 – 75
4	> 75

Friedman scale:

Introduced by Michael Friedman, the Tonsil size is classified using the location of the tonsils relative to the surrounding structures namely the anterior pillars and the uvula(56). The Friedman scale has a separate grade for post-tonsillectomy patients as

this can affect the surgical technique used (64) and is part of the Friedman Staging System for Obstructive sleep apnea.



Grade	Description
0	No tonsils seen (post-tonsillectomy status)
1	Within Tonsillar fossa
2	Visible beyond the Anterior pillars
3	Beyond the pillars but not to the midline
4	Kissing Tonsils – completely obstructing the airway

Comparision of the tonsil grading scales:

Ng et al studied the Brodsky scale and found that it had acceptable intra-observer and interobserver reliability compared to other scales(65). **Kumar et al** studied the Brodsky scale versus the Friedman scale and other scales(66). They reported that the Brodsky scale had the highest intra-observer and interobserver reliability. They

suggested its uniform use for future clinical and research work. These conclusions were disputed by Friedman as overstatements(64) as this study was conducted only in the pediatric age group and did not study the differing clinical applications of the scales. Friedman claimed his scale had greater use for OSA surgical planning in adults.

Friedman Staging System:

In 2002, Friedman expanded the concept of the Friedman score into a staging system(67) consisting of 3 stages. He showed that this system was a predictor of the efficacy of Uvulopalatopharyngoplasty. In 2004, he modified this system(62) to include a 4th stage to denote patients with morbid obesity or craniofacial deformities. Patients in the 4th stage are not candidates for palatal or tongue base surgery.

Stage	Friedman Palate Position	Tonsil size	BMI
I	1 2	3, 4 3, 4	<40
II	1, 2 3, 4	1, 2 3, 4	< 40
III	3 4	0, 1, 2 0, 1, 2	< 40
IV	1, 2, 3, 4	0, 1, 2, 3, 4	>40
	All patients with significant craniofacial or other anatomic deformities		

Friedman recommended that morbidly obese patients be directed to bariatric surgery and patients with skeletal deformities towards skeletal treatment. This staging system was used in this study.

Uvulopalatopharyngoplasty

Uvulopalatopharyngoplasty is the most commonly performed surgical procedure for adults with obstructive sleep apnea. This surgical procedure was introduced by Fujita et al in 1981(9).

Concept:

The principle behind this procedure is to reduce palatal and pharyngeal redundancy by excising the excess palatal and pharyngeal mucosa and submucosa after doing a Tonsillectomy.

Functions of Uvula:

The Uvula has 3 main components(68) –

1. Surface epithelium
2. Sub epithelial region
3. Glandular tissue

The uvula is almost devoid of muscle fibres(69).

The Uvula has several physiologic functions(70) –

1. It controls the resonance of the air column superior to the larynx and thus prevents excessive nasality.
2. It acts as the pilot for eating and swallowing(71). When the Uvula contacts a food bolus, the palatal and uvular muscles contract and close off the nasopharynx.

3. The Stroma of the uvular mucosa contains loose connective tissue, mixed seromucous glands, and adipose cells which help to moisten the oral cavity.

Coblation:

Coblation (from controlled ablation) was invented by Thapliyal and Eggers(72). It produces the dissolution of soft tissues at low temperatures of 40 °C – 70 °C. This is based on radio frequency energy of higher frequencies. Radio frequency energy is made to flow through a conductive medium like Normal Saline. This breaks it into its component ions. These high energy ions form a plasma field which can break through the organic molecular bonds within the soft tissues. The thickness of the plasma field is only 100 – 200 µm around the active electrode. Thus, the effect of coblation is chemical and produces volumetric dissolution of targeted tissue with minimal collateral damage(73).

<u>Components</u>:

1. RF Generator
2. Foot pedal control
3. Irrigation system
4. Wand

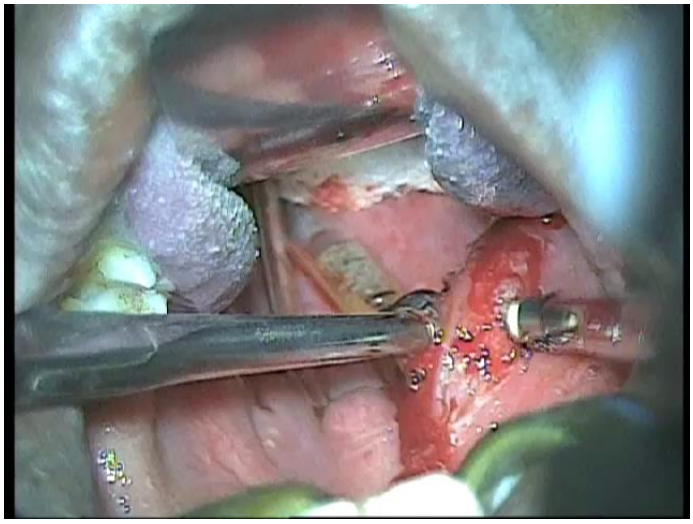
Normal saline is passed through the wand which also has suction. The RF generator has 2 settings – one for coblation and one for cauterization. For the tonsil wand used in UPPP, the settings are “7” for plasma (coblation) and “3” for non-plasma (cauterization). The efficiency of the system is improved by intermittent application while in the ablation mode and by copious irrigation with cold normal saline(73).

Patient Preparation:

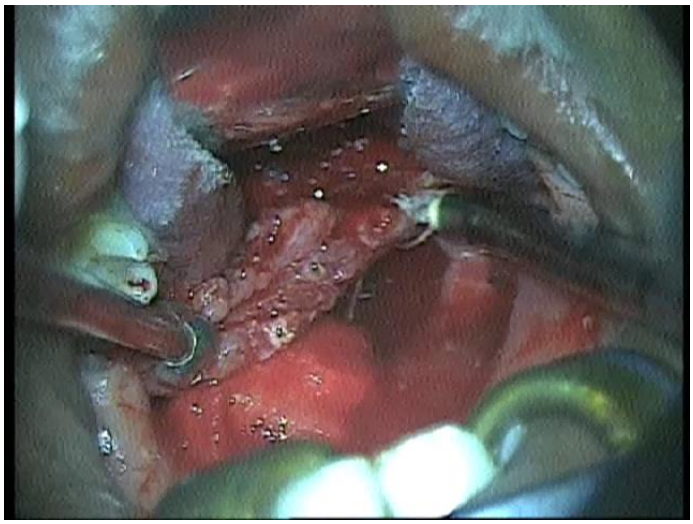
Basic investigations were performed and anaesthetic assessment was done for all patients. Prior to surgery, all patients are advised a standard nil per oral time of 10 hours. Informed consent was obtained from all patients. Peroperatively, intravenous steroid (8mg Dexamethasone) and IV antibiotics are administered.

Technique:

1. Uvulopalatopharyngoplasty in our institute is done using the Microscope for better visualisation. Coblator is used to aid dissection and for achieving hemostasis.
2. Nasotracheal intubation is preferred as it affords more operating room which is advantageous.
3. The Boyle-Davis or Doughty's mouth gag is used and is suspended with Draffin's bipod stand. This provides excellent visualisation of the oropharyngeal structures.
4. The Tonsil is grasped with Dennis-Brown's forceps and retracted medially. An incision is made with the Coblator on the mucosa just medial to the anterior pillar. This incision is extended superiorly and inferiorly and continued along the posterior pillar.



5. The superior pole is released and dissection with the coblator is done along the avascular plane which is achieved between the capsule and the bed of the tonsil towards the inferior pole. The inferior pole is then cut with the coblator on coagulation mode to complete the Tonsillectomy. Bleeding points are identified and coagulated using the coblator to achieve hemostasis. The procedure is repeated on the contralateral tonsil.



6. A Horizontal incision is made on the soft palate just anterior to the uvula and connected to the superior edge of the tonsillectomy incision on either side. The oropharyngeal mucosa posterior to this incision is then excised in a skiving fashion with coblator down to the palatal muscle. The Nasopharyngeal mucosa should be preserved.

7. The tip of the uvula is also excised. We preserve part of the uvula for better cosmetic and functional outcomes.

8. Mucosa overlying the anterior and posterior pillars is also denuded. Hemostasis is achieved with coblator.

9. Sutures with absorbable material is used to bring the nasopharyngeal and oropharyngeal mucosa together in a single layer. We prefer to use 2-0 Vicryl (Polyglactin 910) on a round bodied needle for this purpose as it can maintain its tensile strength for a longer period of 2 weeks(74). The knot of the suture is placed on the oropharyngeal side.

10. The inferior part of the Tonsillar fossa is left open. Cotton balls soaked in 1% Bupivacaine are rolled over the suture lines and open part of the tonsillar fossa for analgesic purposes.

Post – Operative Care:

All patients are advised a standard postop nil per oral (NPO) time of 6 hours. Head end elevation is advised and Vital signs – Temperature, SpO_2, blood pressure, pulse rate and respiratory rate are monitored.

After 6 hours, the patient is advised a diet of cold liquids and semisolids on the day of surgery and a soft diet thereafter. The open inferior aspect of the tonsillar fossa is checked periodically for postoperative bleed. Postoperative IV antibiotics are given till II postop day.

Complications:

OSA patients are predisposed to certain complications regardless of the surgery performed(75). Perioperative airway obstruction may occur and is the most disastrous

complication. This can occur with the use of narcotic analgesics. Hypertension is a common comorbidity which predisposes to cardiopulmonary complications.

Transient velopharyngeal insufficiency may occur and is manifested as nasal regurgitation commonly and as hyper-nasal speech less commonly. This usually subsides with time. Postoperative bleeding has an incidence of 2%. Prolonged "dryness of throat" may occur.

UPPP may cause mild change in voice characteristics which may impact a professional voice user. A rise in the fundamental speech frequency of upto 10 Hz is produced. The vocal trill is a sound used in some European languages which is produced by the Uvula. Its loss is noticed by these language users.

Nasopharyngeal stenosis is one of the more severe complications. It produces a significant disability and is difficult to correct. Most often it is mild and asymptomatic due to adherence of the lateral aspect of the palate to the posterior pharyngeal wall. More severe forms occur due to excessive scarring of the velum producing a cicatricial band on the posterior pharyngeal wall resulting in nasal obstruction.

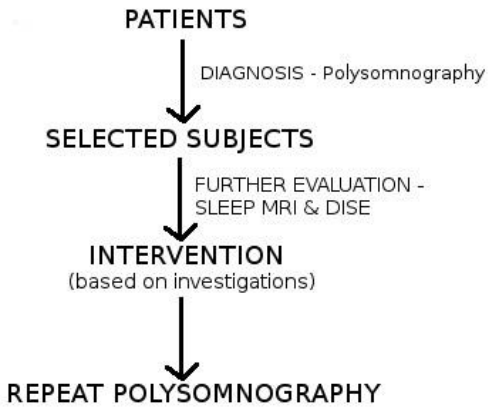
Postoperative bleed occurred in only one of our patients. This was noticed in the immediate postop period. Patient was re-intubated and bleeding point was ligated. No other major complications occurred.

MATERIALS AND METHODS

Aim of the study:

To analyze the efficacy of coblation assisted uvulopalatopharyngoplasty in Obstructive Sleep Apnea Syndrome(OSAS) with isolated obstruction at the Retropalatal level.

Methodology:



1. Design of the study: Before – After Analysis
2. Period of study – 1 year September 2016 to September 2017
3. Place of study – Government Kilpauk Medical College Hospital and Government Royapettah Hospital attached to Kilpauk Medical College.
4. Ethical clearance - Obtained
5. Financial support – nil
6. Sample size - 25 patients.
7. Patients were diagnosed on the basis of Polysomnography.

8. Patients with moderate & severe levels of OSA were further evaluated by Drug Induced Sleep Endoscopy (DISE) and Sleep MRI to find the level of obstruction.
9. A thorough examination of the patient and necessary investigations were done.
10. Written informed consent was obtained from all participating subjects. Privacy was ensured.
11. Polysomnography was repeated 1 month postoperatively.
12. Primary End point – Apnea Hypopnea Index (AHI)
13. Secondary End points – Arousal Index, Oxygen Desaturation Index and Awakenings Index.
14. Based on the post-op polysomnogram, results were classified as:
    a. Surgical Success – Reduction of AHI by more than 50% of preop value.
    b. Non – responder – Less than 50% reduction in AHI.
15. Analysis of the data obtained was done using SPSS software.

INCLUSION CRITERIA:

1. Patients with moderate and severe levels of obstructive sleep apnea i.e. Apnea Hypopnea Index greater than 5.
2. Patients with isolated obstruction at the retro-palatal level (Fujita Type-I), as shown by investigation with Drug Induced Sleep Endoscopy and with Sleep MRI.
3. Age greater than 20

EXCLUSION CRITERIA:

1. Patients with Body Mass Index (BMI) greater than or equal to 40 Kg/m^2 (i.e) Obese Class III or very severely obese.
2. Patients with high surgical risk according to the classification of the American Society of Anaesthesiologists (ASA) i.e. greater than ASA class III.
3. Patients with multilevel obstruction, obstruction at other levels.

SAMPLE SIZE CALCULATION:

The sample size was calculated by considering the statistical power of Polysomnography to be 0.8 with an expected efficacy of 70% for the surgical procedure and a variation in accuracy of 20%.

LIMITATIONS:

1. Subjective symptoms of the patient were not taken into account.
2. The sample was not randomized in this study. A future randomized controlled trial may be done to confirm the results.
3. A bigger sample size may be selected in subsequent studies to get more accuracy.
4. The follow-up period of one month is not sufficient to study the long term effects of the surgery.

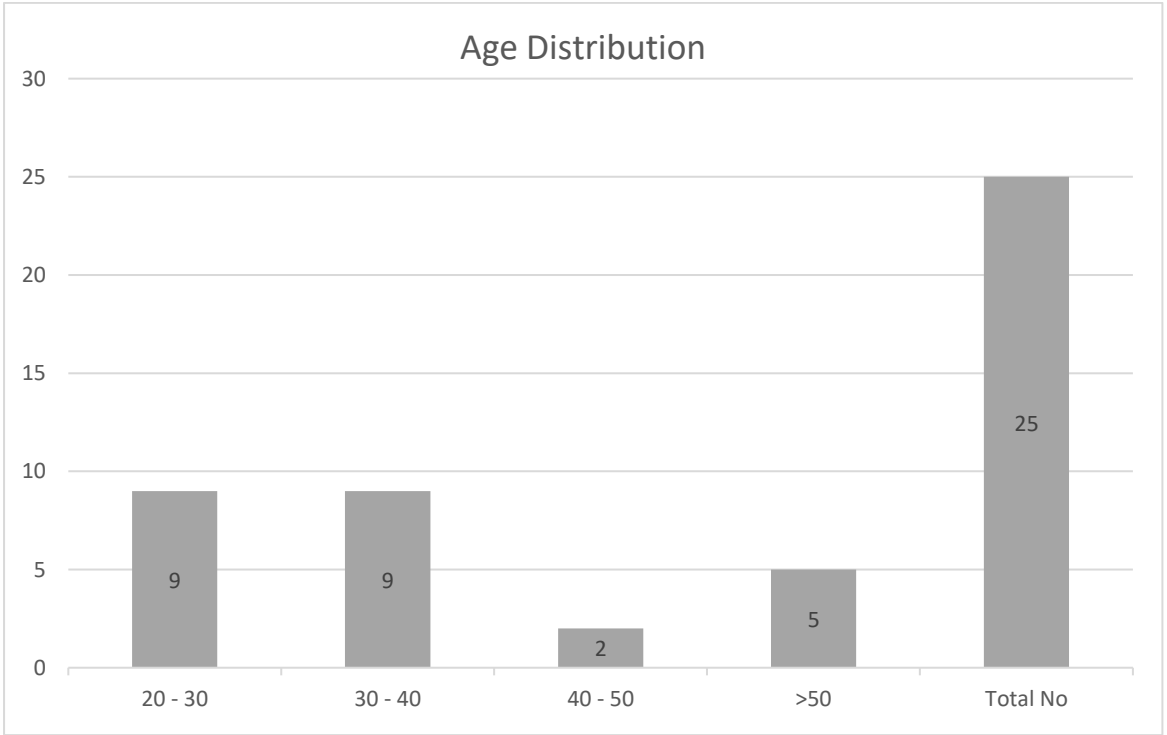
RESULTS

25 patients were selected into the study following the inclusion and exclusion criteria. Statistical analysis was carried out with SPSS software and the Student T test was used to test for significance.

Age Distribution:

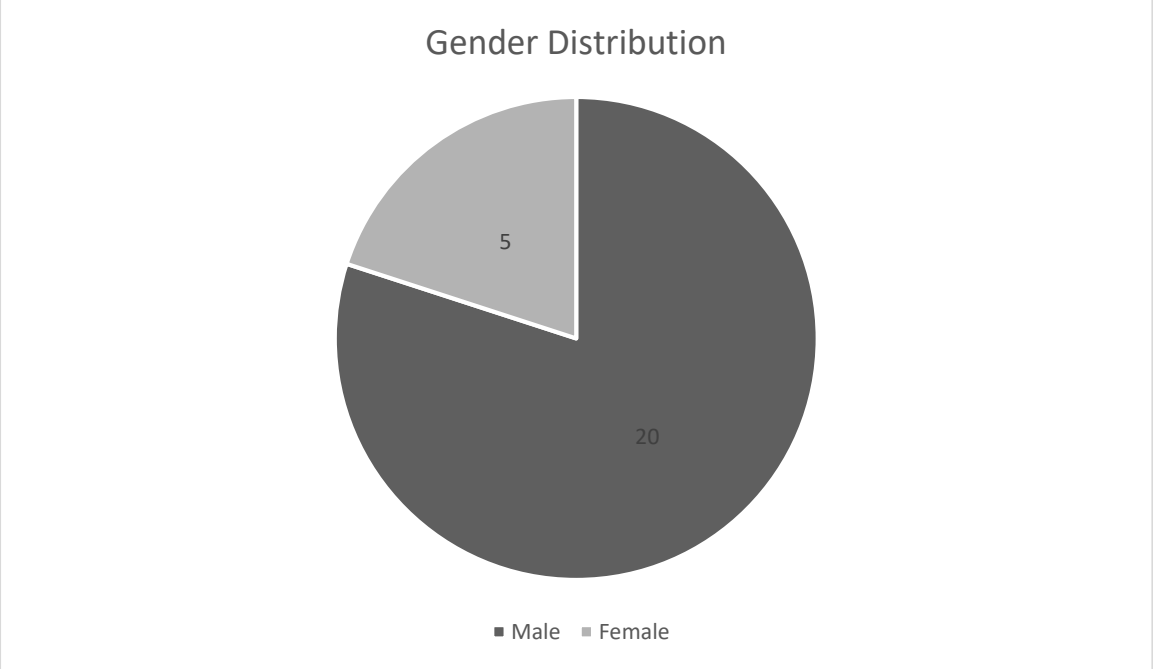
In this study, only patients with age greater than 20 were included according to the inclusion criteria. The youngest patient was a 24-year-old male and the oldest patient was a 54-year-old male. The average age of the patients was 36 years with a standard deviation of 9 years.

	N	Minimum age	Maximum age	Mean age	Std. Deviation
Age	25	24	54	36.08	9.764



Gender Distribution:

In this study, of the 25 patients, 20 patients i.e. 80 % were male and 5 patients i.e. 20 % were female.

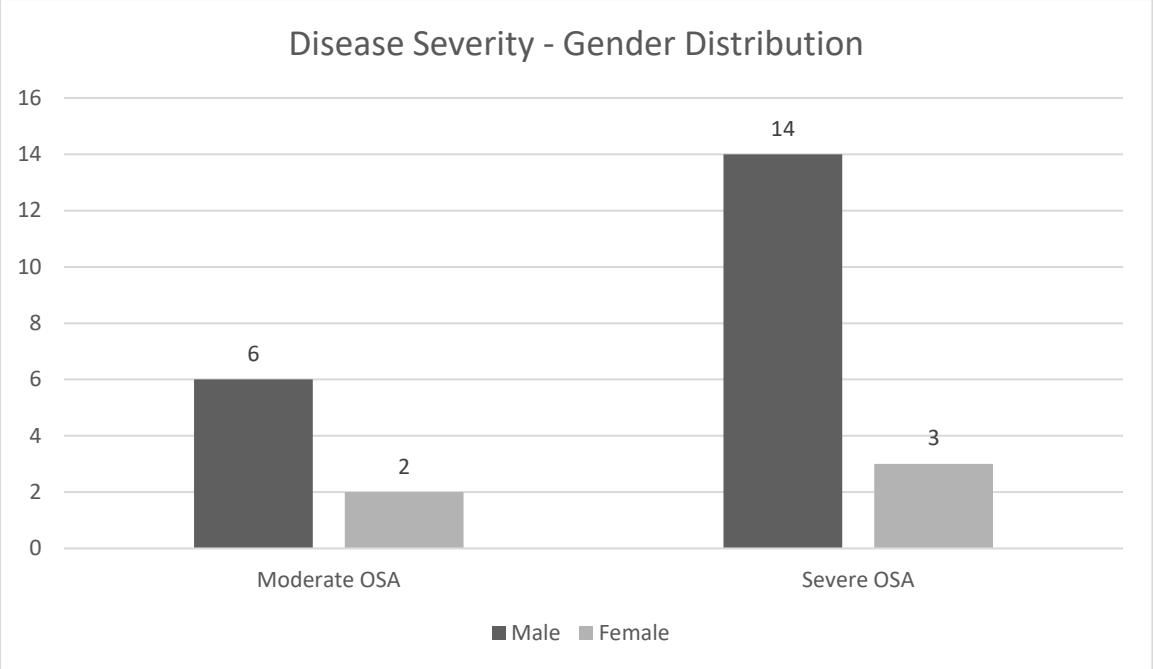


Distribution according to Disease severity:

All the cases were classified using the Apnea Hypopnea Index (AHI) with AHI > 15 classified as moderate OSA and AHI > 30 as severe OSA. Patients with mild OSA were not included.

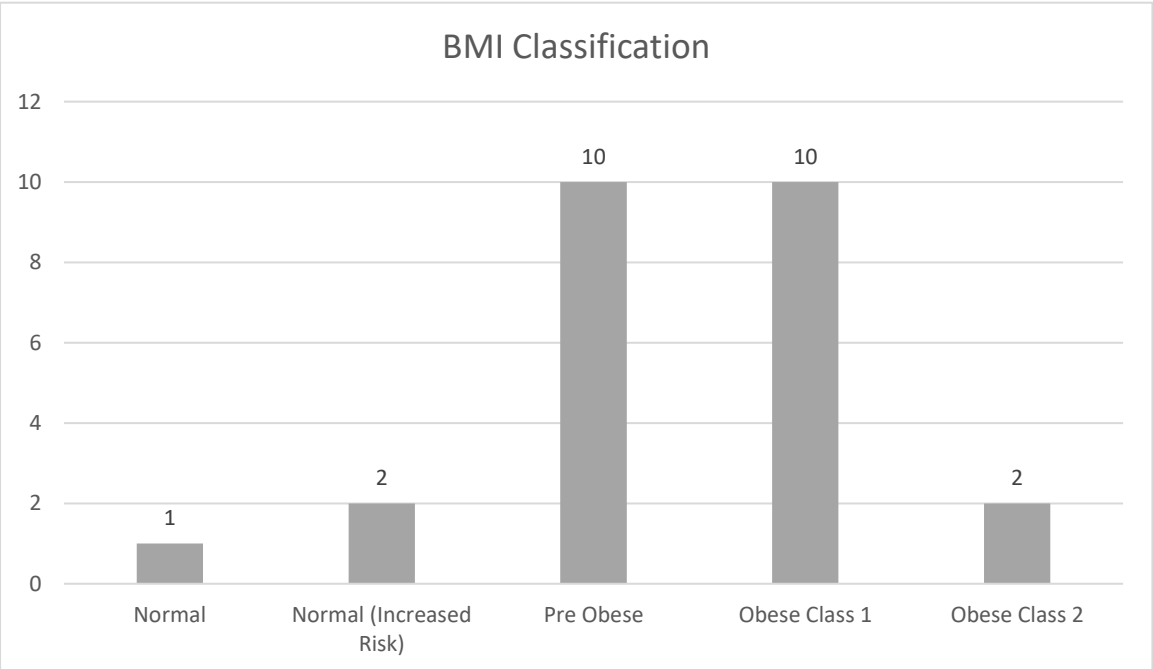
Disease Severity	Number
Moderate OSA (AHI>15)	8
Severe OSA (AHI>30)	17

Of those with Moderate OSA, 6 were males and 2 were females. Of those with Severe OSA, 14 were males and 3 were females.



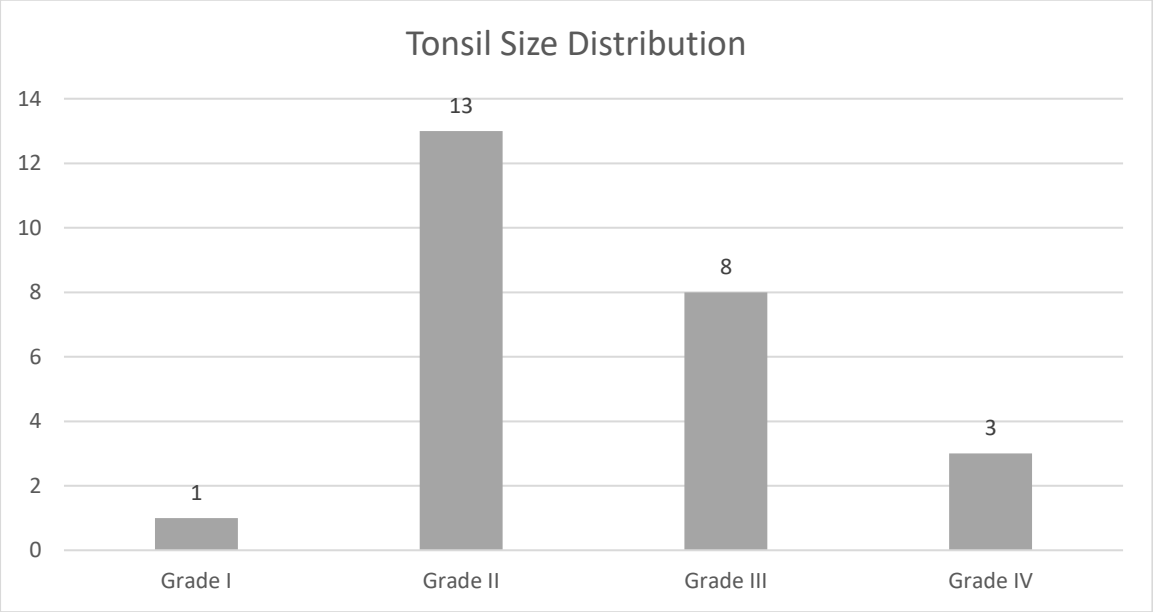
Distribution according to BMI:

The patients were classified according to the WHO criteria for Asian populations. 10 patients were Pre-Obese, 10 were Obese class 1 and 2 patients were Obese class 2. Of the 3 patients with normal BMI, 2 were classified as Normal with increased risk according to the revised criteria. Obese class 3 was excluded.



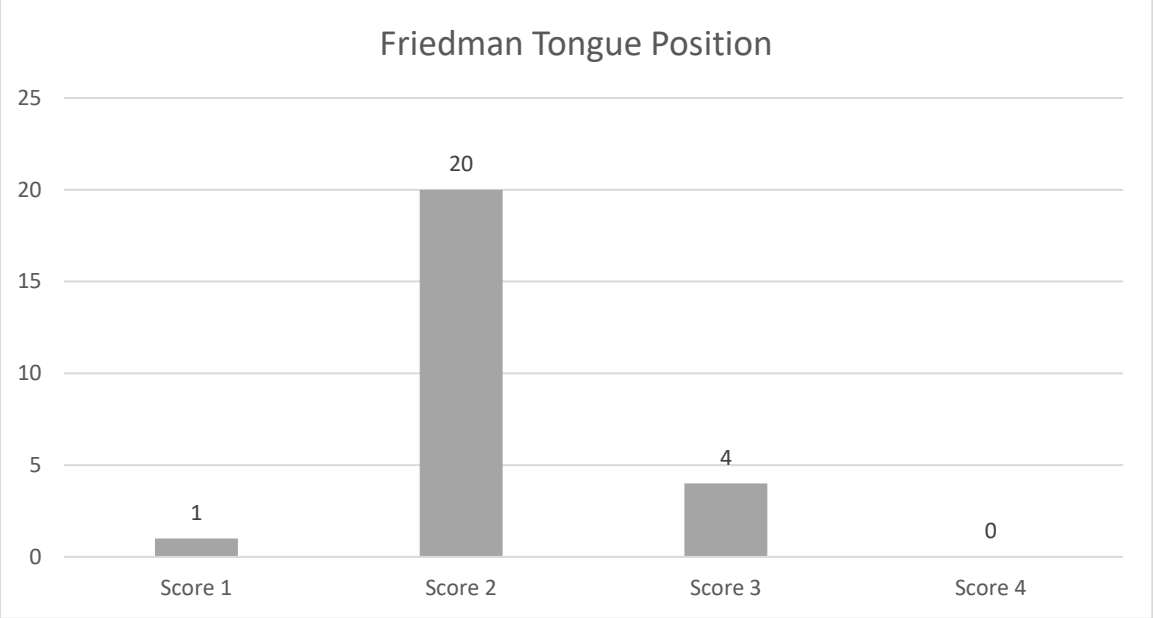
Distribution according to Tonsil size:

The Friedman grading scale was used. 13 patients had grade II tonsillar enlargement, 8 patients had grade III, 3 patients had grade IV and only 1 patient had grade I tonsillar hypertrophy.



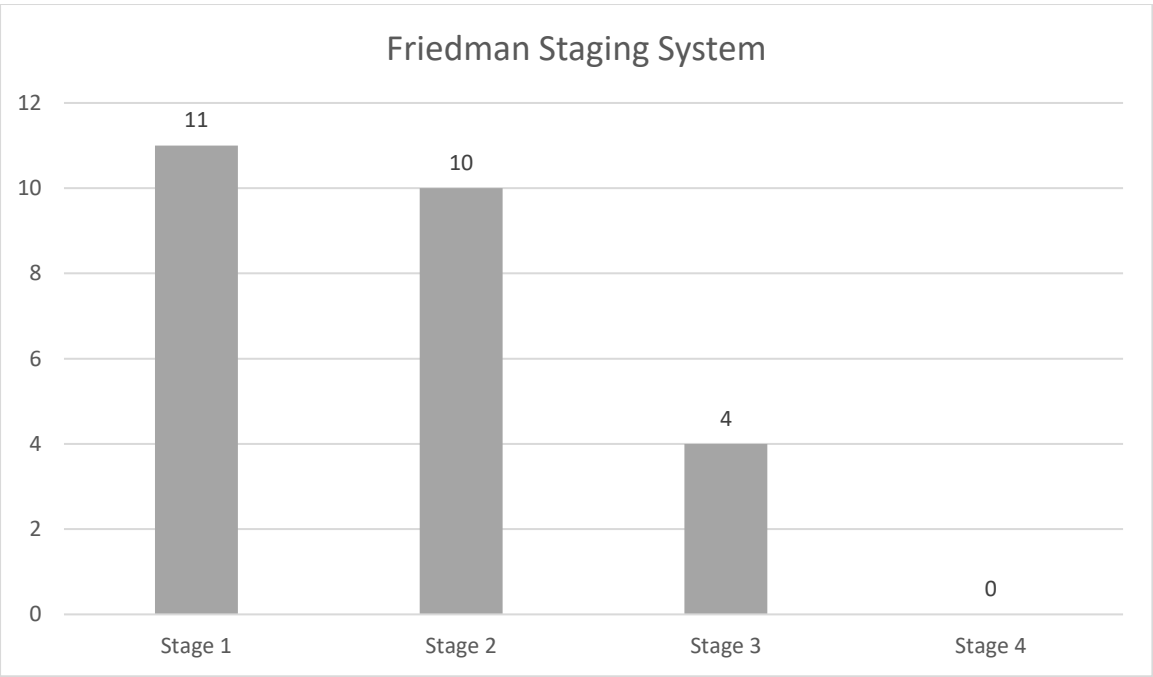
Distribution according to Palate position:

The Friedman tongue position was calculated for all the patients. 20 patients scored 2 on the scale, 4 patients scored 3 and 1 patient scored 1.



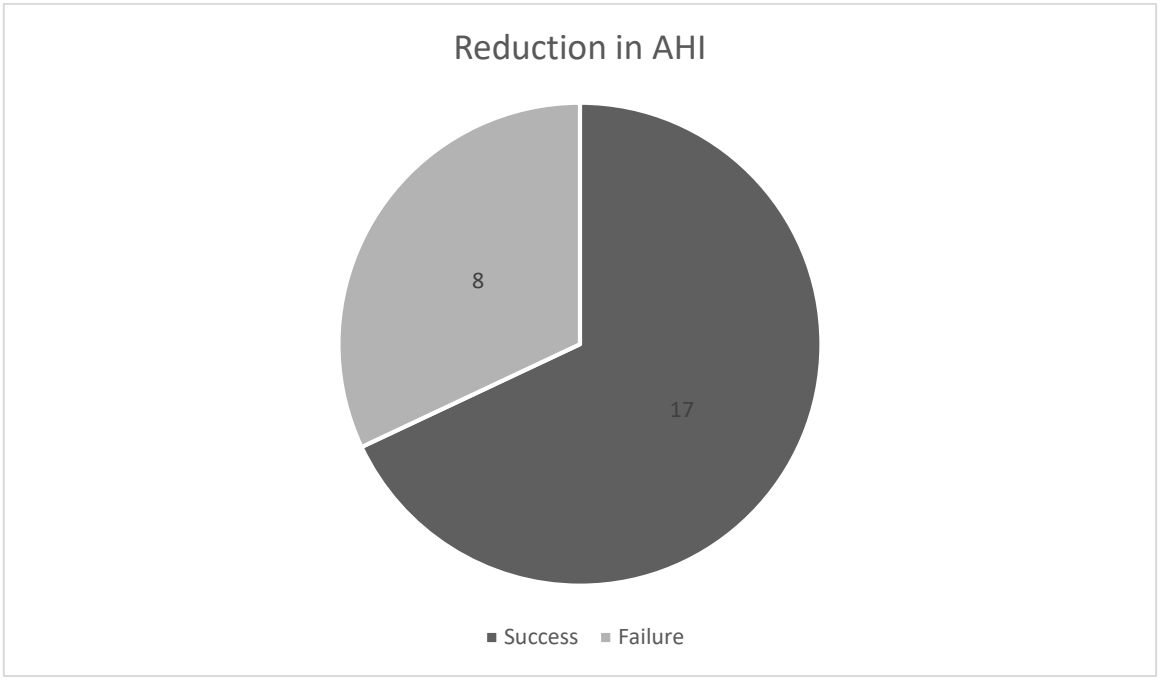
Distribution according to Friedman's system:

Using the data collected regarding tonsil size and Friedman palate position, the patients were classified using Friedman's system. 11 patients were classified as stage 1, 10 patients were classified as stage 2, 4 patients were classified as stage 3. There were no patients in stage 4 as patients with BMI > 40 were excluded from this study.



Success Rate:

Using the standard criterion of 50% postop reduction in AHI, 8 cases were deemed to have failed. In the remaining cases, the criterion was achieved producing a success rate of 68%.



The sample was also stratified using the Friedman staging system and the success rate for each stage was calculated.

Comparison of AHI:

When the AHI was compared preoperatively and postoperatively in all the patients, there was a statistically significant difference in values.

	Mean	**N**	**Std. Deviation**	**Std. Error Mean**
AHI PRE -OP	46.9480	25	25.67684	5.13537
AHI POST-OP	16.6080	25	8.44289	1.68858

Paired Differences							
			95% Confidence Interval of the Difference				
Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	**P value** Sig. (2-tailed)
3.03400E1	23.59101	4.71820	20.60211	40.07789	6.430	24	.000

When the AHI was compared preoperatively and postoperatively in the successful and unsuccessful groups, a statistically significant difference was noted in both groups.

Group	**Number**	**Pre-op AHI**	**Post-op AHI**	**P value**
Success	17	52.1000 ± 26.79573	13.5471 ± 5.25073	.000
Failure	8	36.0000 ± 20.44127	23.1125 ± 10.50108	.010

Comparison of Arousal Index:

When the arousal index was compared before and after surgery for the entire sample, a statistically significant difference in values was obtained.

	Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Arousal Index pre-op	27.8720	25	12.40449	2.48090
Arousal Index post op	12.2080	25	5.60758	1.12152

Paired Differences							
			95% Confidence Interval of the Difference				**P value**
Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
1.56640E1	10.34343	2.06869	11.39444	19.93356	7.572	24	.000

When the Arousal Index was compared preoperatively and postoperatively in the successful and unsuccessful groups, a statistically significant difference was noted in both groups.

Group	**Number**	**Pre-op arousal index**	**Post-op arousal index**	**P value**

Success	17	27.6000 ± 11.93069	10.6059 ± 4.23534	.000
Failure	8	28.4500 ± 14.20020	15.6125 ± 6.87967	.025

Comparison of Awakenings Index:

When the awakenings index was compared before and after surgery for the entire sample, a statistically significant difference in values was obtained.

	Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Awakenings Index Pre-op	9.4200	25	7.24483	1.44897
Awakenings Index Post-op	2.4720	25	1.76293	.35259

Paired Differences							
			95% Confidence Interval of the Difference				
Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	**P value** Sig. (2-tailed)
6.94800	6.27960	1.25592	4.35591	9.54009	5.532	24	.000

When the Awakenings Index was compared preoperatively and postoperatively in the successful and unsuccessful groups, a statistically significant difference was noted only for the successful group.

Group	**Number**	**Pre-op index**	**Post-op index**	**P value**
Success	17	9.4353 ± 6.44641	1.8824 ± 0.65501	.000
Failure	8	9.3875 ± 9.21791	3.7250 ± 2.65263	.051

Comparison of Oxygen Desaturation Index:

When the oxygen desaturation index was compared before and after surgery for the entire sample, a statistically significant difference in values was obtained.

	Mean	**N**	**Std. Deviation**	**Std. Error Mean**
ODI pre-op	45.9529	17	31.88158	7.73242
ODI post-op	11.9941	17	6.38352	1.54823

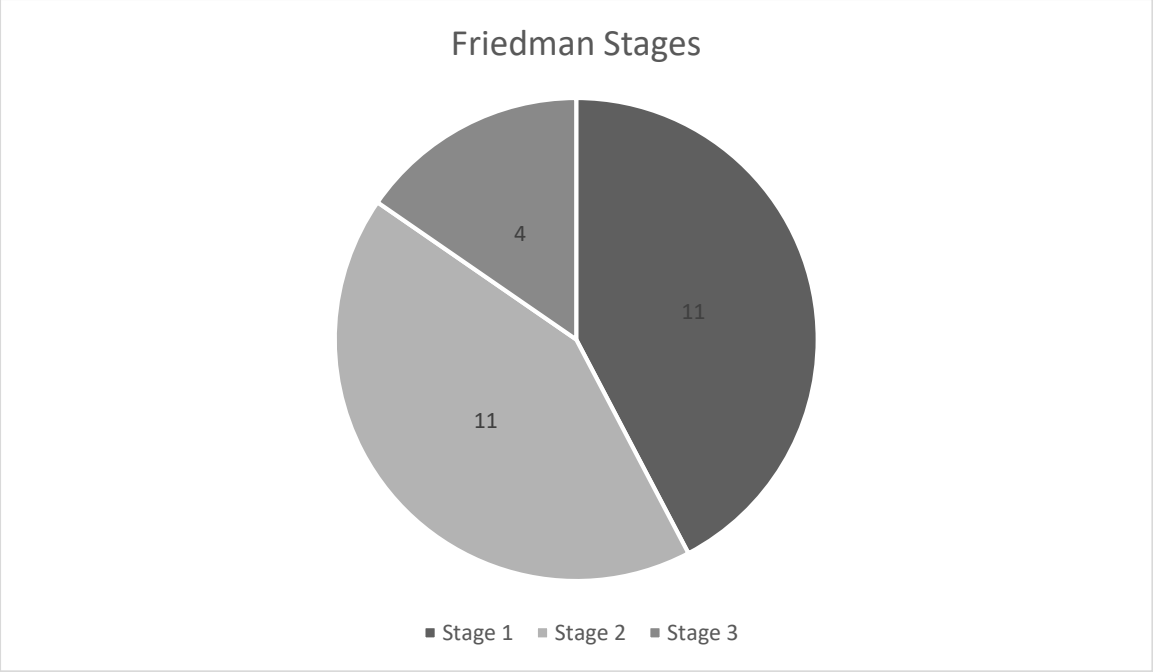
Paired Differences					t	df	**P value** Sig. (2-tailed)
Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
			Lower	Upper			
3.39588E1	27.32995	6.62849	19.90706	48.01059	5.123	16	.000

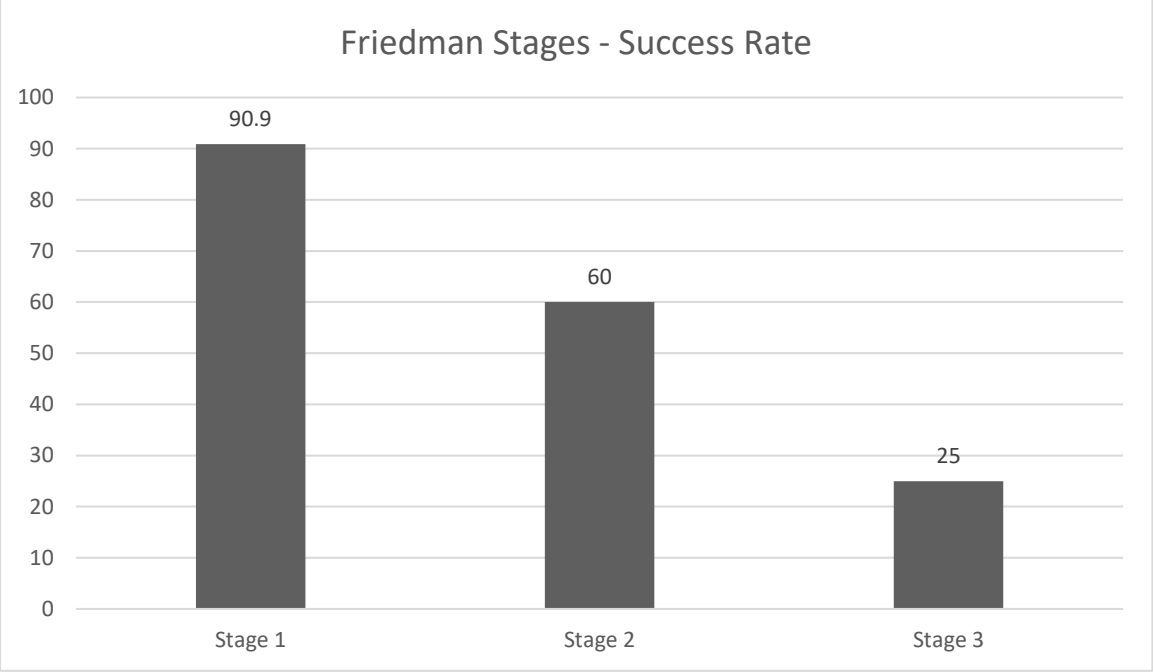
When the Oxygen Desaturation Index (ODI) was compared preoperatively and postoperatively in the successful and unsuccessful groups, a statistically significant difference was noted in both groups.

Group	**Number**	**Pre-op ODI**	**Post-op ODI**	**P value**
Success	17	45.9529 ± 31.88158	11.9941 ± 6.38352	.000
Failure	8	24.0188 ± 19.02729	15.3125 ± 12.23443	.012

Statistical Significance by Friedman's classification:

Before-After analysis was conducted on the different groups obtained by applying Friedman's classification. AHI, Arousal index, Oxygen Desaturation Index (ODI) and Awakenings Index were used. There were 11 patients each in stages 1 and 2 and 4 patients in stage 3.





Stage 1-

Of the 11 patients in Stage 1, 10 patients had a reduction in postoperative AHI > 50 %, giving a success rate of 90.9% for this stage. When AHI, Arousal Index, ODI and Awakenings Index were compared, statistically significant differences were noted.

Index	Before	After	P Value
AHI	65.5091 ± 24.69131	17.0000 ± 8.71470	.000
Arousal Index	30.4000 ± 12.57831	11.8364 ± 5.04287	.000
ODI	59.7455 ± 31.66002	15.1364 ± 9.90387	.000
Awakenings Index	9.6182 ± 6.80247	1.9000 ± .88091	.003

Stage 2-

Of the 10 patients grouped under Stage 2, 6 patients had a reduction in postoperative AHI > 50 %, giving a success rate of 60 % for this stage. When AHI, Arousal Index, ODI and Awakenings Index were compared, statistically significant differences were noted.

Index	Before	After	P Value
AHI	26.4200 ± 11.35887	12.1800 ± 4.92472	.001
Arousal Index	24.6600 ± 13.28116	10.5900 ± 4.47647	.004
ODI	19.9490 ± 16.10337	16.10337 ± 16.10337	.008
Awakenings Index	10.6900 ± 8.59450	2.8900 ± 2.29029	.006

Stage 3-

Of the 4 patients grouped in Stage 3, only 1 patient had a reduction in postoperative AHI > 50 %, giving a success rate of only 25 % for this stage. When AHI, Arousal Index, ODI and Awakenings Index were compared, a statistically

significant difference was noted only for the arousal index. The remaining indices had not changed in a statistically significant manner.

Index	**Before**	**After**	**P Value**
AHI	47.2250 ± 13.68000	26.6000 ± 6.73102	.058
Arousal Index	28.9500 ± 10.72614	17.2750 ± 7.95042	.041
ODI	29.1650 ± 10.11116	18.1500 ± 4.64076	.061
Awakenings Index	5.7000 ± 4.48182	3.0000 ± 2.09444	.139

REVIEW OF LITERATURE

There have been various studies conducted since UPPP was first originated regarding its efficacy. A number of study designs have been used and the efficacy obtained has been somewhat variable.

Choi et al(76) studied 20 patients from South Korea in 2013 with Obstructive Sleep Apnea who had underwent Uvulopalatopharyngoplasty regarding its effect on objective Polysomnography data as well as on subjective symptoms using a Before – After analysis. Subjective symptoms, such as daytime sleepiness, morning headache and daytime fatigue were scored using a questionnaire and a 7-point Likert scale. The Epworth sleepiness score was also calculated. This was done preoperatively and 3 months post op. Using the standard 50% reduction in AHI criterion, 55% of their patients had a successful outcome. They noted a significant improvement in certain subjective symptoms in even the unsuccessful group but not to the extent of the successful group. They did not use any technique to find the level of upper airway obstruction prior to surgery.

Sommer et al(77) performed a randomised controlled trial in Germany in 2016 with 42 patients diagnosed with Moderate and Severe grades of Obstructive Sleep Apnea by Polysomnography. These patients also had Tonsillar Hypertrophy on clinical examination. 23 patients were selected randomly into the treatment group, and 19 were placed in the control group. Patients in the treatment group underwent Uvulopalatopharyngoplasty within 1 month of inclusion and follow up PSG after 3 months. Patients in the control group underwent repeat PSG after 3 months followed by Uvulopalatopharyngoplasty and then a follow up PSG after another 3 months. The

primary target parameter was the Apnea Hypopnea Index. Secondary parameters include the Epworth Sleepiness Scale, the RDI, RERA, Mean SpO_2, Min SpO_2 as well as snoring scored by the patient and by the bed partner according to a visual analogue scale. There was a reduction in AHI in 90 % of their patients with 64.5 % meeting the criterion for surgical success. There were statistically significant improvements in daytime sleepiness and in snoring following surgery.

Baradaranfar et al(78) in 2014 performed a study on 48 patients in Iran. They selected patients diagnosed with OSA by Polysomnography, who had failed to respond to CPAP and had a positive Muller's manoeuvre. The Epworth sleepiness score was also calculated. After Uvulopalatopharyngoplasty, the patients were re-evaluated after 6 months. PSG variables which were considered were the AHI, RDI, mean SpO_2, minimum SpO_2 and the Snoring Index. The success rate of intervention in this study was 64.6 % using the criteria of decrease in AHI by 50% and a decrease in absolute value to less than 20. They reported a statistically significant decrease in AHI, RDI and increase in mean SpO_2, and minimum SpO_2. They also reported a statistically significant decrease in daytime sleepiness with the Epworth scale.

Senior et al(79) in 2000 retrospectively analysed 25 patients with mild OSA who had undergone Uvulopalatopharyngoplasty with no attempt to locate the level of obstruction. Follow up Polysomnography was obtained 40 weeks following the surgery. They used a Respiratory events index (REI) to compare and also a subjective assessment of sleepiness with the Sleep-wake activity inventory. 40% of their patients had postoperative reduction in REI of more than 50%. In those patients in whom the surgery failed, they reported an increase in the REI. Similar results were shown with

the sleepiness score. They concluded that the level of obstruction must be discerned in order to get better surgical outcomes.

Sher et al(80) performed a meta-analysis in 1995 of different surgical treatments for OSA. They analysed 37 papers on UPPP published till 1995. Using techniques to combine p values across the studies after appropriate weighting, they found that the changes in AI, RDI and minimum SpO_2 were all highly significant. The terms AHI and RDI were used interchangeably in this study. 9 of the studies in this meta-analysis had calculated the level of obstruction using different techniques such as awake endoscopy with Muller's maneouver, cephalometry and CT scan and results were classified using Fujita's classification. Defining successful response as a 50% reduction in AI or RDI and an AI < 10 or RDI < 20, the efficacy rate calculated in this meta-analysis was 40.7 %. For Fujita Type I the efficacy rate was calculated as 52.3 %, Type II and Type III combined had a success rate of 5.3 % only.

Study Authors	**Design**	**Sample size**	**Efficacy**
Choi et al, 2013	Before – After Analysis	20	55%
Sommer et al, 2016	Randomised Controlled Trial	42	64.5%
Baradaranfar et al, 2014	Before – After Analysis	48	64.6 %
Senior et al, 2000	Before – After Analysis	25	40 %
Sher et al, 1995	Meta-analysis	37 papers	40.7 %

Thus, 3 of the studies used a before-after analysis design, similar to our study. One was a randomised controlled trial and the other was a meta-analysis. A sample size of 25 patients was used in this study.

Study Authors	**Technique - Level of obstruction**
Choi et al, 2013	No technique was used
Sommer et al, 2016	Tonsillar hypertrophy on clinical examination
Baradaranfar et al, 2014	Awake endoscopy with Muller's maneouver
Senior et al, 2000	No technique was used
Sher et al, 1995	9 papers selected patients using awake endoscopy, cephalometry, CT scan.

Modern techniques to localise the level of obstruction namely Sleep MRI and Drug induced sleep endoscopy were not used in any of the studies reviewed. Our study used these methods to select patients with isolated retropalatal obstruction who are most likely to respond to UPPP.

Study Authors	**Parameters analysed**	**Follow up period**
Choi et al, 2013	AHI, subjective symptoms	3 months
Sommer et al, 2016	AHI, Epworth sleepiness scale, RDI, RERA, mean SpO_2, min SpO_2	3 months
Baradaranfar et al, 2014	AHI, RDI, mean SpO_2, min SpO_2	6 months
Senior et al, 2000	Respiratory events Index	40 weeks
Sher et al, 1995	AI, AHI, min SpO_2	varied

Only objective data namely AHI, Arousal index, Awakenings Index and Oxygen desaturation index obtained from Polysomnography was analysed in our study. In the literature, the subjective symptoms of the patient are analysed to cover the aspects which may be missed by taking only objective data into consideration.

The follow up period for a postop polysomnography has not been standardized with various periods used in the literature. In our study, polysomnography was repeated after 1 month. Thus, the long-term effects of the surgery were not analysed which is major limitation of our study.

Long term effects of Uvulopalatopharyngoplasty:

Varendh et al(81) in 2012 conducted a study on the long-term effects of UPPP. They retrospectively studied the medical records of patients who underwent the surgery in their institute between 1985 and 1991. A questionnaire was used to investigate the present health profile, side effects of surgery and present sleeping patterns of these patients. 52% of those who were contacted were satisfied with the result of the operation. 32% were unsatisfied and used CPAP to control their symptoms. 38% reported persistent side effects like problems with nasal regurgitation, swallowing, voice change and pain in the oral cavity.

Tanyeri et al(82) assessed retrospectively the long-term efficacy of Uvulopalatopharyngoplasty in 2012 in 32 patients who had undergone the surgery between 2001 and 2007 with a mean follow-up period of 56 months (36 -96 months). Snoring evaluation forms and Epworth Sleepiness Scale scores were used for

preoperative and postoperative subjective analysis. Respiratory distress index (RDI) obtained from PSG was used for objective analysis. Patients who had 50% or more reduction in RDI levels postoperatively were classified as responders. Body mass index was also analysed. In their series, snoring disappeared in 83%, did not change in 13% and deteriorated in 4%. Excessive daytime sleepiness decreased in 22 patients (68%). RDI decreased by more than 50% of the preoperative values in 15 (46.9%) of 32 patients. BMI increased over the years in non-responder patients leading them to conclude that weight gain decreases the success of the procedure over the long term.

Effect of DISE on treatment planning:

Eichler et al(83) conducted a study on 97 patients to detect the effect of DISE on treatment recommendations. A surgical plan was recommended after full clinical examination and another after DISE. There was a change in plan for 63.9% of patients.

Gillespie et al(42) conducted a study on 38 patients to compare DISE with awake endoscopy. Level of obstruction and the surgical plan obtained after both investigations were analysed. DISE showed a greater severity of collapse and more levels of obstruction. The treatment plan was changed in 62% of cases after DISE.

DISCUSSION

This study was conducted with an aim to study the effects of a particular surgical technique in Obstructive sleep apnea namely, Uvulopalatopharyngoplasty in a very selected subgroup of patients.

Since 1981 when UPPP was introduced, many paradigm shifts have taken place in the management of OSA with the introduction of Continuous Positive Airway Pressure (CPAP) and newer evaluation techniques to locate the level of obstruction.

Though CPAP is highly effective and has often been called the gold standard in treatment, it has been shown to have poor adherence which reduces its efficacy. Compliance rates have ranged from 40 – 85 % in the literature depending on how it is measured(84). CPAP also has side effects including dermatitis, epistaxis, rhinitis, congestion, barotrauma and claustrophobia. Failure of CPAP is sometimes related to specific otolaryngologic problems including various nasal pathologies and the epiglottic trapdoor phenomenon(10). These problems can easily be detected with modern endoscopic techniques. This brings into view the need for full evaluation prior to treatment and also illustrates the continued role of surgery in obstructive sleep apnea.

Sleep MRI and DISE (Drug induced Sleep Endoscopy) provide anatomical data on the dynamic state of the upper airways during sleep and have given us the ability to tailor treatment to the individual patient. These procedures have also given us an idea about the prevalence of multi-level obstruction. Sleep MRI has also recently been

used to demonstrate the post-surgical burden that may remain. Evaluation of palatal length and shape of tongue suggests the airway results of previous surgery(50).

Sleep MRI techniques have not yet reached the level of maturation of DISE with an absence of international consensus on various aspects of the procedure. Differences in sedation, duration of scanning, monitoring during the scan and scoring has been noted in the literature(51, 53, 54, 85). With further research, it may be expected to play a bigger role in future treatment protocols. Sleep MRI has some advantages over DISE in being a non-invasive test and not requiring an operating room visit.

DISE has been recommended as a preliminary investigation whenever surgery is considered as a treatment option(35). Various studies have shown that DISE changes the treatment plan in around 60% of patients compared to clinical examination alone(42, 83). This illustrates the great impact DISE has had as an evaluation tool. With a properly selected treatment regimen, a greater chance of success is expected.

The procedure of UPPP involves remodelling the soft palate and the redundant mucosa over the tonsillar pillars. Obstruction present in the nose and at the lower levels like at the tongue base and at the epiglottis are not affected by UPPP. With this recognition, nowadays UPPP is most often performed as part of a management protocol for multi-level obstruction(75). It is also performed as a single stage procedure in isolated retropalatal obstruction. In the early years of its application, UPPP being the only procedure for OSA, was used somewhat indiscriminately. Techniques to assess the level of obstruction were also not reliable. These factors may

have contributed to the variable and poor efficacy rates described in the early literature.

In this study, the efficacy rate obtained was 68%. This was classified using the criterion of 50% reduction in AHI which was arbitrarily defined by Fujita(80). Such a definitive requirement has not been described for the other Polysomnography indices. Hence, tests of significance were applied. Using statistical techniques, the impact of the surgery on AHI, Arousal index, Awakenings index and the Oxygen Desaturation Index (ODI) were studied on the entire sample, successful and unsuccessful groups. Patients were divided on the basis of the Friedman stages and results were again analysed for each stage.

In the before-after analysis of the entire sample, statistically significant change in AHI, arousal index, oxygen desaturation index and awakenings index was noted. Similar analysis in the successful group alone yielded statistically significant results for all the indices. In the unsuccessful group, the change in the awakenings index was not significant. Other results were significant.

Success rates were calculated for each Friedman stage. Stage 1 patients had a very good success rate of 90.9 %, stage 2 had a success rate of 60 %, while stage 3 patients had a poor success rate of only 25%. Stage 1 had a similar success rate to previous studies(62) while there was an improvement in stage 2 in our study. Stage 3 results remain poor. This illustrates that selection with DISE has had some influence on results and also shows the need for more intensive search for levels of obstruction in Friedman Stage III. Statistically significant changes were obtained for all the indices in Stage I and Stage II. In Stage III, only arousal index showed a significant

change. Thus, the continuing relevance of the clinical Friedman staging system is demonstrated.

The major limitation of this study was that subjective symptoms of the patients were not analysed. Even though statistically significant change in the indices were noted for the entire sample, this may not be clinically significant. Guidelines for the amount of change to declare success have been developed only for the AHI. Thus, the analysis of subjective symptoms adds value. Such analyses have been conducted with various sleepiness scales. The Epworth sleepiness scale is the most commonly used scale for this purpose(86). This scale is in English and has been translated into various international languages. It has to be self-administered to be valid for research purposes and is also copyrighted to prevent changes without permission. This presents a problem with language constraints in our population. The development of similar scales in the vernacular Indian languages would allow assessment of subjective symptoms in future studies.

The other limitations include the sample size and the study design. Further studies with a bigger sample and with a Randomized control trial design may be conducted.

In conclusion, Uvulopalatopharyngoplasty is a valuable treatment option in OSA provided that when it is done as a single stage procedure, the patient selection is done very rigorously.

ANNEXURE- 1

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ANNEXURE – 2

Consent Form in English

CONSENT FORM

Study Title: **EFFICACY OF SURGICAL PROCEDURES IN OBSTRUCTIVE SLEEP APNEA WITH OBSTRUCTION AT THE RETROPALATAL LEVEL**

I _____ hereby give consent to participate in the study conducted by **Dr. Pradeep Ram S.S,** post graduate at **GOVT KILPAUK MEDICAL COLLEGE,** and to use my personal clinical data and result of investigation for the purpose of analysis and to study the nature of the disease and its treatment. I also give consent for further investigation.

Signature/Thumb impression of the patient/relative ***Place*** ***Date***

Patient name and Address

Signature of the investigator

Signature of the guide

ANNEXURE – 3

Consent Form in Tamil

சுய ஒப்புதல் படிவம்

சென்னை கீழ்ப்பாக்கம் மருத்துவமனை காது, மூக்கு, தொண்டை துறையில் பயிலும் முதுகலை மருத்துவர் பிரதீப் ராம் அவர்கள் மேற்கொள்ளும் இந்த ஆய்வில் பங்குகொள்ள ..... ஆகிய நான் முழுமனதுடன் சம்மதிக்கிறேன். இந்த ஆய்வை மேற்கொள்ளும் மருத்துவர் என் மருத்துவ விவரங்கள் மற்றும் மருத்துவ ஆய்வின் முடிவுகள் ஆகியவற்றை தெரிந்து கொள்ளவும், அனைத்து பரிசோதனையையும் அறிவேன். மேலும் இந்த ஆய்வின் முடிவுகளை பிரசுரிக்கவும் சம்மதிக்கிறேன்.

பங்கேற்பவரின் கையொப்பம் / கட்டைவிரல் ரேகை .....

இடம்.....
தேதி.....

பங்கேற்பவரின் பெயர் மற்றும் விலாசம் .....

ஆய்வாளரின் கையொப்பம் .....
இடம்.....
தேதி.....

பேராசிரியரின் கையொப்பம் .....
இடம்.....
தேதி.....

ANNEXURE – 4

Information Sheet in English

INFORMATION SHEET

Study Title: EFFICACY OF COBLATION ASSISTED SURGERY IN OBSTRUCTIVE SLEEP APNEA WITH OBSTRUCTION AT THE RETROPALATAL LEVEL

Investigator: Dr. Pradeep Ram, M.S (ENT) Postgraduate,
Dept of ENT, Kilpauk Medical College.
Ph: 9884838624

This document is to inform you about your participation in this study. You have been diagnosed with Obstructive sleep apnea syndrome and have been advised to undergo coblation assisted uvulopalatopharyngoplasty and have chosen to take part in this study voluntarily.

Details of this study are given below.

1. Aim : To analyze the efficacy of coblation assisted uvulopalatopharyngoplasty in obstructive sleep apnea with obstruction at the retropalatal level.
2. Method : Polysomnography will be performed initially to diagnose the disease. Afterward, sleep MRI & Drug-induced sleep endoscopy will be done to localize the level of the obstruction. After surgery, Polysomnography will be repeated after 1 month to find out the level of disease.
3. Procedure : The procedure carried out will be Coblation assisted Uvulopalatopharyngoplasty under General Anaesthesia.
4. Possible Complications : This procedure has rare complications including Nasal regurgitation, dryness of throat, Voice change, Nasopharyngeal stenosis, Recurrence & persistence of disease.
5. The confidentiality of your personal and medical records will be safeguarded.
6. Your participation in this study is voluntary and you can withdraw your participation at any time, also any further treatment required by you will not be withheld.
7. You are instructed to contact the investigator for further queries at the contact details provided.

Signature of Patient

ANNEXURE - 5

Information Sheet in Tamil

தகவல் படிவம்

Study Title: EFFICACY OF COBLATION ASSISTED SURGERY IN OBSTRUCTIVE SLEEP APNEA WITH OBSTRUCTION AT THE RETROPALATAL LEVEL

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இந்த தகவல் படிவம் முலம் உங்களுடைய பங்களிப்பு பற்றிய விவரம் தெரிவிக்கபடுகிறது. உங்களுக்கு தூக்க மூச்சி திணறல் நோய் இருப்பதால், Coblation Uvulopalatopharyngoplasty அறுவை சிகிச்சை அவசியமே என்று அறிவுரை செய்யபடுகிறது மேலும் தன்னிச்சையாக இந்த ஆராய்ச்சியில் பங்கேற்க முடிவு செய்துள்ளீர்.

ஆராய்ச்சியின் விவரங்கள்:

1. நோக்கம் : உள்நாக்கு பகுதியில் அடைப்பின் காரணமாக தூக்க மூச்சி திணறல் நோய் சரி செய்ய கையாளும் Uvulopalatopharyngoplasty அறுவை சிகிச்சையின் பலனை திறனாய்வு செய்தல்.
2. செயல் முறை : முதலில் Polysomnography மூலமாக நோய் இருப்பதை கண்டுபிடித்தல், பிறகு Sleep MRI & drug induced sleep endoscopy என்கிற பரிசோதனைகள் மூலமாக தூக்க மூச்சி திணறல் நோய் அடைப்பின் மூலாதாரம் கண்டுபிடித்தல். அறுவை சிகிச்சைக்கு 1 மாதத்துக்கு பிறகு மறுபடி polysomnography பரிசோதனை செய்யப்படும் .
3. சிகிச்சை முறை: முழு மயக்கத்தில் Coblation Uvulopalatopharyngoplasty அறுவை சிகிச்சை செய்யப்படும் .
4. ஏற்படக்கூடிய பின்விளைவுகள்: மிகவும் அரிதான பின்விளைவுகள் - முக்கில் பொரை ஏறுதல், தொண்டை வரட்சி, குரல் மாற்றம், தொண்டையில் அடைப்பு, நோய் முழுமையாக குணம் அடையாமை.
5. உங்களின் மருத்துவ ஆவணங்கள் முற்றிலும் ரகசியமாக பாதுகாக்கப்படும் .
6. இந்த ஆராய்ச்சியில் உங்களின் பங்கேறுப்பு தங்களுடைய சொந்த விருப்பத்தின் பேரில் மட்டுமே. எந்த நிலையிலும் நீங்கள் ப்ங்கேறுப்பில் இருந்து விலக்கி கொள்ளலாம். மேலும் உங்கள் சிகிச்சை எந்த காரணத்தை கொண்டும் தடைபடாது.
7. மேலும் விவரங்களுக்கு ஆராய்ச்சியாளரை அணுகவும்.

ANNEXURE-6

MASTER CHART

S.No	Name	Age	Sex	Friedman tongue position	Tonsil size	Friedman stage	BMI Pre OP	BMI Post OP	AHI Pre OP	AHI Post op	Arousal Index pre op	Arousal Index post op	ODI Pre OP	ODI Post op	Awakenings Index pre op	Awakenings Index Post op
1	Dhanasekaran	29	M	1	4	1	33	32.6	81.1	13.2	22.8	9.4	92	17.3	12.2	1.7
2	Shanthi	43	F	2	3	1	36.6	35.4	83.6	14.3	32.7	13.8	99.2	18.8	3.8	1.3
3	Subhashini	26	F	2	2	2	28.9	26.4	27.4	18.7	21.1	15.6	9.57	5.4	3.2	2.4
4	Muthukumar	26	M	2	4	1	29.3	29.3	38	9.3	32.7	8.2	28.7	7.7	22.4	2.7
5	Marimuthu	28	M	3	1	3	26.8	26.5	39.3	27.8	37.3	27.4	20.5	11.4	9.8	5.7
6	Balakrishnan	33	M	2	3	1	30.8	30.6	97.3	14.7	40.9	15.3	85.4	19.9	6.1	1.5
7	Balamurugan	24	M	2	3	1	26.9	26.2	97.5	17.3	25.2	13.8	98.7	15.4	2.3	1.3
8	Balaji	35	M	2	3	1	28.7	27.9	19.7	6.2	25.9	9.7	9.5	4	18.9	1.8
9	Selvaraj	53	M	2	2	2	30.2	29.7	52.4	18.2	32.3	17.5	37	18.6	12.4	2.7
10	Moosa	39	M	3	2	3	30.1	29.8	57.3	19.2	36.9	15.3	43.2	21.3	9.3	3.5
11	Adhi	31	M	3	2	3	33.1	32.4	32.1	24.2	27.1	18.2	23.3	18.8	2.5	1.9
12	Radhakrishnan	54	M	3	2	3	25	24.5	60.2	35.2	14.5	8.2	29.66	21.1	1.2	0.9
13	Malar	24	F	2	2	2	25.8	25.1	15.7	5.3	14.4	5.7	6.1	2.5	6.5	1.3
14	Durairaj	52	M	2	2	2	29.4	28.8	21.4	16.6	25.3	15.7	12	8.2	25.3	8.3
15	Ibrahim Sameem Khan	27	M	2	3	1	24.9	24.3	44.8	12.2	48.9	10.3	59.2	11.5	8.4	2.2
16	Harun Basha	32	M	2	2	2	32.4	31.8	18.5	13.2	11.8	6.3	25.42	14.3	1.6	0.9
17	Jayakumar	37	M	2	2	2	25.6	25.2	22.5	10.2	14.5	6.7	9.1	4.2	2.3	1.5
18	Dilara Begum	39	F	2	3	1	33.7	33.5	53.9	19.8	13.8	6.6	53	10.3	2.7	1.2
19	Elangovan	40	M	2	2	2	24.1	24.1	20.6	6.7	30.1	11.3	9.5	3.3	14	2.7
20	Joseph	52	M	2	2	2	32.1	31.7	33.9	15.5	13.6	6.7	52.1	18.9	3	1.7
21	Kannan	29	M	2	4	1	26	25.6	72.6	39.4	34.5	21.3	66.3	41.1	10.9	4.2
22	Pramila	36	F	2	2	2	35.2	34.6	35.3	7.6	27.5	8.2	33.3	9.7	18	1.9
23	Sampath	50	M	2	3	1	34.2	33.6	69.4	21.3	47.4	17.6	22.6	9.2	3.8	1.5
24	Sudhakaran	37	M	2	3	1	33.4	33.2	62.7	19.3	9.6	4.2	42.6	11.3	14.3	1.5
25	Haridass	26	M	2	2	2	22.1	22.1	16.5	9.8	56	12.2	5.4	2.2	20.6	5.5

ANNEXURE – 7

PLAGIARISM CHECK SCREENSHOT