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Original Article

Evaluating Oxygen Saturation Variations in Adults with and Without Mandibular Retrognathism as a Predictor for Obstructive Sleep Apnea

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Abstract

Introduction: Skeletal Class II malocclusion due to retrognathic mandible usually presents with a small-sized or a backward-positioned lower jaw when compared to adults with skeletal Class I malocclusion. This constricts the tongue space within the oral cavity and causes the tongue to fall back into the airway while the adult sleeps in a supine position. The purpose of this study was to compare the changes in oxygen saturation (SpO_2) levels recorded through continuous nocturnal pulse oximetry in adults with skeletal Class I and Class II malocclusions.

Methods: One hundred subjects admitted to a tertiary care centre for elective surgery and with no history of pulmonary or cardiac conditions were screened and selected for skeletal Class I [Group 1(n=50)] and Class II [Group 2(n=50)] facial patterns. Continuous nocturnal pulse oximetry data were recorded during sleep with the help of a pulse oximeter and the data were analysed. The statistical test used for determining significance was Mann-Whitney U test.

Results: The mean SpO_2 recorded in group 1 was 97.83% and in group 2 was 95.46% which was significantly lower than in Group 1 ($P<0.001$).

Conclusion: The mean SpO_2 in adults with Class II skeletal pattern was significantly reduced when compared with adults having Class I skeletal pattern. Continuous nocturnal pulse oximetry can serve as an essential screening tool prior to polysomnography to help differentiate the severity of sleep apnea.

Introduction

Oxygen saturation (SpO_2) in blood is indicative of the of airflow reaching the lungs and is affected by the patency of the upper airway. Obstruction in the upper airway leads to hypoxia and hypercapnia. Oxygen desaturation may result in an increase in the heart rate and blood pressure momentarily causing hyperactivity of the sympathetic nervous system resulting in stimulation of pharyngeal dilator muscles. This, in turn, causes the airway to open and restores the blood gases to normal. As this cycle repeats, the sleep of the individual is affected, presenting with symptoms of loud snoring, sleep apnea, and increased daytime sleep.[1]

Skeletal Class II pattern is characterized by either mandibular retrognathism, maxillary prognathism, or a combination of both. A retrognathic mandible is usually a result of either underdevelopment or retropositioning of a normally developed lower jaw. This reduces the pharyngeal airway volume at the level of the hypopharynx resulting in decreased air intake when the individual lies in a supine position. This is further exacerbated by posterior displacement of the tongue during sleep due to space restriction within the oral cavity, ultimately leading to sleep apnea. The incidence of sleep apnea in adults with Class II skeletal malocclusion is reported to be 26.5%.[2]

The gold standard for diagnosis of sleep apnea is Polysomnography (PSG), but it has a low acceptance rate among the general population due to its low availability, increased discomfort, and high cost.[3] Hence, a simpler, readily available, and low-cost tool can help in screening patients for sleep apnea severity before confirming with PSG. Furthermore, establishing a correlation between the facial skeletal pattern and SpO_2 can help clinicians identify the population group more susceptible to developing sleep apneaimplement preventive measures to reduce its occurrence and severity.

Hence, the purpose of the study was to compare the continuous nocturnal pulse oximetry findings in adults with Class I and Class II skeletal patterns.

Methods

A cross-sectional comparative study consisting of two

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Study Highlights

What is current knowledge?

- Skeletal Class II malocclusion with mandibular retrognathism is associated with reduced upper airway dimensions and an increased risk of OSA.
- Continuous nocturnal pulse oximetry can been used as a simple, non-invasive screening tool to detect oxygen desaturation related to sleep-disordered breathing.

What is new here?

- This study demonstrates significantly lower nocturnal SpO_2 levels in skeletal Class II adults with mandibular retrognathism and highlights continuous pulse oximetry as a simple screening tool for early OSA risk detection.

study groups with fifty subjects each was conducted. Ethical approval was obtained from the Ethics Committee of *(blinded). Patients admitted to the tertiary care centre were screened for mandibular retrognathism and those satisfying the inclusion criteria were included in the study. The inclusion criteria consisted of adults aged between 18 and 40 years and having Class I or Class II skeletal patterns.

The presence of convex profile, vertical growth direction, and retrognathic mandible is a risk factors for sleep disordered breathing.[4] Exclusion criteria consisted of patients admitted for emergency care, patients with cardiac or pulmonary disorders, patients taking medications such as muscle relaxants, vasoconstrictors, sedatives, etc., patients with dentofacial deformities or any medical condition contraindicating the conduct of the study. All the patients included were non-anaemic, and were advised against the use of nail polish and henna during the period of study to prevent its effect on the oximeter reading.

After an initial pilot study with 20 subjects (10 in each group), it was decided to include one hundred subjects to obtain a statistically significant value. Thus, 124 patients were screened and 100 patients who conformed to the inclusion and exclusion criteria were selected for the final sample after obtaining their informed consent. They were then divided into two groups of 50 subjects each having Class I skeletal pattern (Figure 1A) in Group I and Class II skeletal pattern with retrognathic mandible in Group II. The presence of a retrognathic mandible was confirmed through visual examination of the mandibular position in the profile photo taken (Figure 1B).[5]

To confirm the skeletal class of the subject, portrait photographs were taken of the subjects' right profiles with a digital single lens reflex (DSLR) camera (Canon1500D) with 100mm Macro lens, with their heads held in natural head position (NHP)with their eyes looking into the distance. For standardization, all the photographs taken were such that the position of the camera was in line with the head of the subject, the focal spot was on the tragus, and the margins of the image were set above the head and below the neck. The best photograph of each subject was used for evaluating the skeletal class based on the landmarks: soft-tissue pogonion (Pog'), soft-tissue glabella (G') and subnasale (Sn). This was in accordance with the study by Sajjadi et al.[6] Class II skeletal pattern was defined by a profile angle of $< 164^0$, while a Class I skeletal pattern required a profile angle of 164^0-172^0.[7] Photographic profile analysis was performed using ImageJ Software (National Institute of Health, USA) (Figure 1).

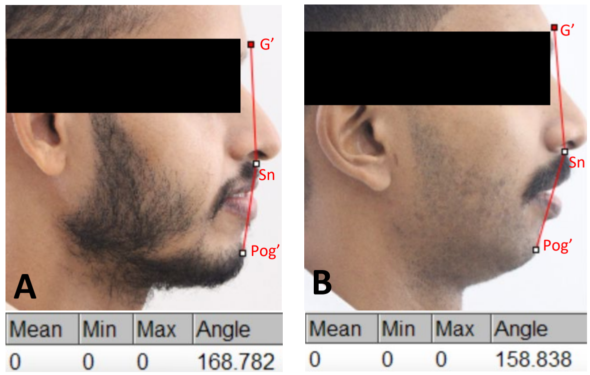

Figure 1. Profile angle measured between the three points- Glabella (G'), Subnasale (Sn) and Pogonion (Pog'). **(A)** Class I Skeletal Pattern. **(B)** Class II Skeletal Pattern

Once the subjects were selected, continuous nocturnal pulse oximetry was performed with a handheld pulse oximeter (Adnox Healthcare Pvt Ltd.), connected to the subject through an optical finger sensor (Figure 2). The pulse oximeter was set to record the SpO_2 of the patient every five minutes while sleeping and was disconnected once the patient woke up after a full night's sleep. The readings were transferred to the computer for further analysis.

The collected data were analyzed for the highest and lowest SpO_2, the frequency of SpO_2 falling below 90%, the time duration for which SpO_2 remains below 90%, and the mean SpO_2 recording during the total sleep time. If the recorded data were for less than five hours of continuous sleep time, the recording was repeated. The data obtained were compared between the two study groups.

Statistical analysis

Statistical analysis was performed using IBM SPSS version 20.0 software (SPSS Inc, Chicago, USA). Categorical variables were presented using frequency and percentage. Numerical variables were presented using mean and standard deviation. To determine the statistical significance of the difference in the mean values of all continuous variables between groups, the Mann-Whitney U test was used. A P value of < 0.05 was considered to be statistically significant.

Results

Group 1 consisted of fifty adults (22 males, 28 females) (mean age 32.88Y) with Class I skeletal base and Group

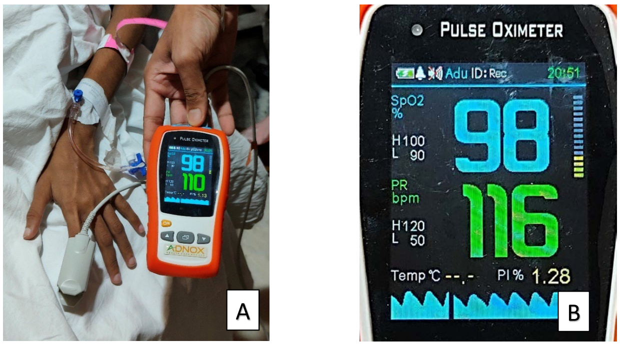

Figure 2. (A) Bedside Pulse Oximeter connected to the subject with optical finger sensor. **(B)** Oximeter Display showing oxygen saturation (blue) and pulse rate (green)

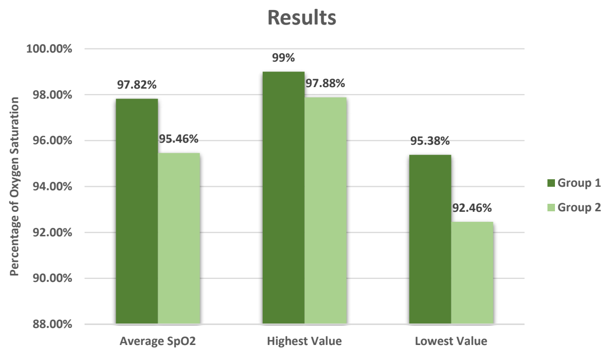

Figure 3. Graph depicting differences in study variables between the two groups

Table 1. Demographic data of the sample subjects

Subject Demographics	Group I	Group II
Gender Distribution	22 males, 28 females	29 males, 21 females
Mean Age	32.88 years	34.08 years
Skeletal Relation	Class I	Class II

Table 2. Test Results

Study Parameters	Mean	SD	*P* value
Mean SpO2	96.61	3.475	<0.001
Highest Value	98.44	1.647	<0.001
Lowest Value	93.92	4.865	<0.001

SD: Standard Deviation.

2 consisted of fifty adults (29 males, 21 females) (mean age 34.08Y) with Class II skeletal base and retrognathic mandible (Table 1).

The mean oxygen saturation recorded for Group 1 was 97.83% (SD 0.61) and for Group 2 was 95.46% (SD 4.55) (Figure 3). The highest value recorded in Group 1 was 99% (SD 0) and the lowest value was 90% with an average of 95.38% (SD 1.35). In Group 2, the highest value recorded was 99% with an average of 97.88% (SD 2.20) while the lowest recorded value was 50% with an average of 92.46% (SD 6.45).

The difference between the two study groups showed a statistically significant difference with respect to mean SpO_2 ($P<0.001$), highest value ($P<0.001$) and lowest value ($P<0.001$) recorded (Table 2).

Discussion

Continuous nocturnal pulse oximetry has been proven to be an efficient tool to detect sleep disturbances and obstructive sleep apnea (OSA).[8] Mean SpO_2 recording along with duration of SpO_2 below 90% has been considered as reliable diagnostic tools in the assessment of severity of obstructive sleep apnea (OSA).[9] The study results indicate a statistically significant difference ($P<0.001$) in the mean values of the recorded oxygen saturation between the two groups. Group 1, comprising subjects with Class I skeletal base, showed a significantly higher SpO_2 recording than the subjects in Group 2 with a Class II skeletal pattern and retrognathic mandible.

The position of the maxilla and mandible in relation to the pharyngeal airway space has a direct effect on the sleep pattern and airway volume of the individual.[10] Maxillary constriction and mandibular retrognathism affect about 15% of the individuals diagnosed with OSA[11] , with orthodontic factors such as overjet and posterior crossbite significantly affecting breathing patterns during sleep.[12] Short mandibular body and backwardly positioned mandible, tongue size and location of hyoid are also related to the severity of OSA.[13] Other risk factors for OSA include obesity, hypertension, large neck size, alcoholism, and use of sedatives/ tranquilizers.[14] One main factor associating mandibular retrognathism with reduced oxygen saturation are the alterations in airway dimensions.[15] Mandibular retrognathism is also usually associated with altered tongue position which directly affects the airway.[16]

A mandibular advancement surgery in Class II adults significantly improved the oxygen desaturation index and the number of obstructive sleep apnea episodes .[17] A statistically significant increase was observed in the oxygen saturation levels of OSA patients treated with mandibular advancement device.[18] Treating patients with Class II skeletal pattern during their adolescence with maxillary expansion and mandibular advancement using functional appliance has shown to improve their nocturnal breathing pattern and increase their sleep efficiency.[19] Mandibular surgical advancement shows significant improvement in volumetric dimensions of pharyngeal airway.[20] Similarly, a mandibular setback showed a significant decrease in overnight oxygen saturation level post-surgically which gradually improved as the tissues adapted to the change.[21] However, patients with obesity, potential for sleep disordered breathing[22] or if the mandibular setback is done to a larger extent, it is seen to cause sleep disordered breathing.[23]

Improvement in the mandibular sagittal position with a customised oral appliance showed a significant improvement in oxygen saturation level.[24] Similarly, the use of functional appliance in children with oral dysfunction displayed a significant improvement in blood oxygen saturation.[25] Children treated with rapid maxillary expansion (RME) showed a significant improvement in airway volume and oxygen saturation after expansion.[26]

SpO_2 shows a significant improvement in maxillary expansion with miniscrew assisted expansion device.[27] Thus, diagnosis and treatment at an early age with orthopedic appliances to modify the growth pattern in such children can help prevent the need for complex surgeries in adulthood.

The statistically significant decrease in mean oxygen saturation observed in adults with skeletal Class II can therefore be attributed to a few possible factors, including a backwardly positioned of mandible, altered tongue position, and decreased airway dimension. Confounding factors for the study included large neck dimension, skin pigmentation, obesity, and hypertension. However, further research needs to be conducted involving multiple centres, diverse population, and controlling for the above-mentioned confounding factors.

Conclusion

The study findings indicate that adults with Class II skeletal pattern with retrognathic mandible have a significantly lower overnight oxygen saturation when compared to adults with Class I skeletal pattern. This study can further conclude that continuous nocturnal pulse oximetry can serve as an essential screening tool prior to Polysomnography to differentiate severity of sleep apnea. Thus, while treating adults with retrognathic mandible, the clinician must be cautious of the effects that the treatment might have on the airway and sleep characteristics of the patient.

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Competing Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Data Availability Statement

The data used to support the findings of this study are available from the corresponding author upon request.

Ethical Approval

Ethical approval for the study was obtained from the Ethics Committee of Amrita School of Medicine (ECASM-AIMS-2023-354).

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