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Evaluation of Oxygen Saturation Levels in Different Vertical Facial Patterns Associated with Antero-Posterior Angle's Classification

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Abstract

Aim: To evaluate and compare oxygen saturation levels in different facial patterns (average, horizontal, and vertical) existing in different anterior-posterior planes of space (Angle's Class I, Class II, and Class III) by comparing the amount of hemoglobin bound to oxygen (SPO2) to the total amount of hemoglobin in the blood.
Methods: A prospective observational study involving a sample size of 180 adults aged 18–30 was categorized into nine different groups based on their skeletal jaw relationships in the anteroposterior plane occurring in different facial types: average, horizontal, and vertical. The study was conducted using a portable pulse oximetry device (Biosys, BPM-200) to assess the level of saturated hemoglobin in the blood (SPO2).
Results: The mean SPO2 measured was found to be in the range of 95–98%. Comparison between groups showed a statistically significant difference in the mean SPO2 (P=0.002). However, post hoc analysis showed group H had statistical significance.
Conclusion: Based on the analysis of the results obtained from the study, it was concluded that in all facial growth patterns, SPO2 levels were in the normal range. However, the class II skeletal base with a vertical skeletal pattern showed the lowest SPO2 levels. The study also supported the fact that blood oxygen saturation levels are not a concern in any type of facial pattern; hence, no orthodontic intervention as such is indicated to improve their SPO2 levels.

Keywords: Blood hemoglobin, Skeletal growth pattern, Pulse oximetry device

Background

Facial growth is believed to be affected by multiple factors such as respiratory modifications, mandibular position (1), head posture, and tongue function, all of which can act independently or synergistically to bring about changes to the stomatognathic system and conditioning diagnosis (2). Physiological respiration is believed to have a functioning role in harmonious craniofacial development. However, when external factors cause any change in the respiratory pattern, it influences the normal development of the skull, leading to functional and skeletal alterations that can result in the development of various abnormal craniofacial patterns (3,4). As the mode of breathing and the development of craniofacial patterns are intricately related to each other, the form can follow function, and function can follow form (5). The functional matrix theory by Melvin Moss (6,7), suggested that nasal breathing permits suitable growth and development of the craniofacial and dentofacial complex. The reason for this is that normal nasal respiratory activity affects the development of craniofacial structures, assisting their congruent growth and development by satisfactorily interacting with mastication, swallowing, and other mechanisms of the head and neck region, as mouth breathing individuals demonstrate a tendency for increased Y axis

(dolichofacial) growth patterns (8).

Numerous longitudinal studies (9-12), on both human and animal subjects have demonstrated the ill effects of altered obstructed nasal respiration and its close association with aberrant facial forms and dental malocclusions characteristic of long and narrower faces with retrognathic jaws (13,14). Multiple cross-sectional studies have documented the effects of altered breathing and its effects on craniofacial development by assessing them clinically and cephalometrically (15). Lin et al. have reported that these individuals are usually found to have increased values of upper and lower anterior facial heights, and all the cranial angular measurements were greater with an increased gonial angle (16), besides clockwise rotation of the maxilla and mandible with a steep occlusal plane. This suggests a stronger and definite relationship between mouth breathing and altered facial growth associated with a significant amount of skeletal and dental malocclusion (17-19).

Considering the outcome of mouth breathing and hypoxia on skeletal, functional, and dentofacial alterations, as well as constricting of the maxilla, underdevelopment of the mandible, modifications in the placement of the head about the neck, projection of the upper incisors, and distal placement of the mandible about the maxilla, this study can be of relevance as no research has been reported in the literature comparing the different facial patterns and their oxygen saturation levels in blood. Mouth breathers have a lower oxygen concentration in their blood, which is called hypoxia. Over 60% of mouth breathers breathe through the oral and nasal cavities, and merely 4.3% are actually mouth breathers (20).

The routine method to evaluate arterial blood gases is invasive, high-priced, and laborious. However, a pulse oximetry device may well be a satisfactory and trouble-free approach to screen and diagnose hypoxic patients (21).

Methods

Methods of data collection

The study was done on 180 male and female patients ranging from 18 to 30 years old who were referred to our Research Centre for Orthodontic Treatment, which is located at Sri Hasanamba Dental College and Hospital in Karnataka, India. This age group was chosen to eliminate any further growth changes that may alter the skeletal growth pattern in either the vertical or antero-posterior plane.

Sampling size estimation

Based on the pilot study conducted in our Research and Training Institute in the Department of Orthodontics using a smaller sample size, the following formula was used to ascertain the actual sample size for the present study:

$$n = \frac{(Z\alpha + Z\beta)^2 \times \sigma^2}{d^2}$$

Where n was the number of samples, Zα was the confidence level, and Zβ was the power. σ was the standard deviation of the outcome variable, which is the same for all groups and d was the effect size obtained from the pilot study that resulted in a sample size of 180 samples.

Groups

One-hundred and eighty samples based on the above statistical calculations were included and were assigned to nine groups based on the growth types of the individuals.

Groups A, B, and C: Subjects with **average facial type** (Y axis 53-63°) associated with angle's class I, class II, and class III skeletal bases, respectively.

Groups D, E, and F: Subjects with **horizontal facial type** (Y axis <53°) associated with angle's class I, class II, and class III skeletal bases, respectively.

Groups G, H, and I: Subjects with **vertical facial type** (Y axis >63°) associated with angle's class I, class II, and class III skeletal base relationships, respectively.

Inclusion criteria

Subjects between 18–30 years old.

Subjects with different skeletal patterns in the anterior-posterior and vertical dimensions.

Subjects willing to take part in the study.

Subjects whose orthodontic treatment was yet to be started.

Exclusion criteria

Subjects with any previous history of orthodontic treatment.

Subjects with any systemic diseases.

Subjects with any craniofacial anomalies and a history of craniofacial trauma.

Subjects with previous tonsil and/or adenoid surgery or previous maxillofacial surgery.

Subjects with cleft lips and palates.

Subjects who were on long-term medication.

Subjects who donated blood in the last three months.

Subjects with a history of smoking.

Female subjects with nail varnish or paint

Pregnant and lactating women

Patient selection and study design: *The study* subjects were briefed on the aim of the research,

and all the subjects gave their consent to proceed with the study design. This study comprises nine groups with different facial patterns in the anterior-posterior and vertical dimensions.

As the study samples were patients from the Research Institute (Department of Orthodontics and Dentofacial Orthopaedics), their lateral cephalograms were available as part of their basic diagnostic records by using the radiographic machine (Kodak 8000 YCA 1583, Carestream Health, Inc., 150 Verona Street, Rochester, NY) with standardized settings and an exposure parameter: kVp: 76, mA: 10, 0.800 sec. Lateral cephalograms of all the subjects were utilized to evaluate the various skeletal patterns and were traced with a 0.3mm lead pencil on a sheet of 0.10-mm matte acetate tracing paper.

The following cephalometric measurements were assessed for this study (Fig.1):

Jarabak's ratio
Y-axis
SNA
SNB
ANB
GO-GN-SN
Beta angle

Estimation of oxygen saturation levels

Red blood cells comprise hemoglobin and one molecule of hemoglobin can transmit a maximum of four molecules of oxygen, subsequently, it is depicted as being saturated with oxygen. Hemoglobin has a saturation of 100% (22) provided

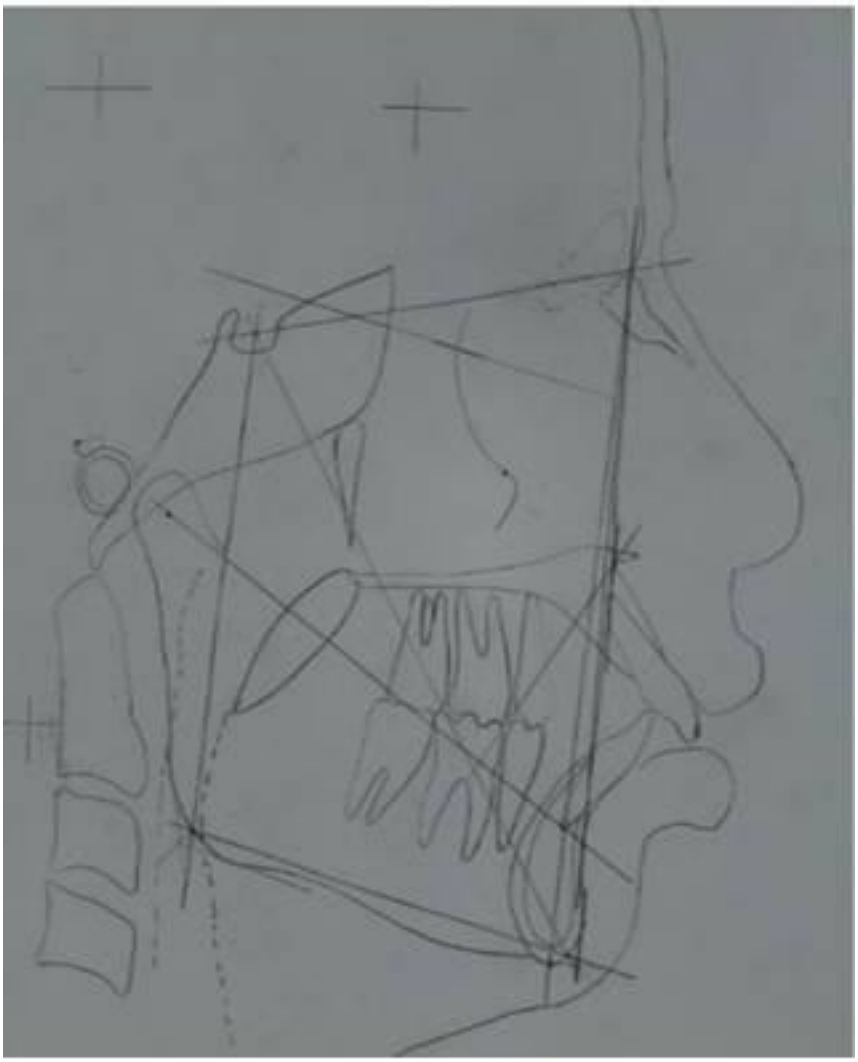

Figure 1. Cephalometric analysis

Figure 2. Examination of oxygen saturation level (SPO2)

every binding site on the hemoglobin molecule is transporting oxygen. The majority of the hemoglobin in the blood intermixes with oxygen when it moves through the lungs, resulting in an arterial oxygen saturation of 95–100% in a healthy individual with normal levels of hemoglobin (23) (Fig.2). As per the study protocol, the SPO2 saturation for every patient was recorded. A portable pulse oximetry device (Biosys, BPM-200) was used in this study as a substitute for arterial blood sampling. After connecting the optical diodes to the patient's finger, the SPO2 values of all the subjects were documented as the percentage of hemoglobin oxygen saturation.

Because the threshold was 95% saturation level, lower values were taken as hypoxemic. Oxygen saturation levels were checked at the first three consecutive appointments of the one-month gap. At each appointment, the test was carried out three-fold for all the subjects with ten-minute interludes and the average value was calculated as the SPO2, which was recorded in the morning hours in all the patients.

The following criteria were considered to determine the level of oxygen saturation percentage (24):

SPO2Level	Severity
95-100%	Normal
94%orlower	Hypoxic
Lessthan90%	Severely hypoxic

Statistical analysis

The current study used descriptive statistics to present the mean and standard deviation and inferential statistics wherein the chi-square test tabulated variables into categories and computed chi-square statistics. This goodness-of-fit test compared the observed and expected frequencies in all categories to test if all categories had the same proportion of values or that all categories contained a user-specified proportion of values. The one-way ANOVA compared the means of two or more independent groups to establish statistical evidence that suggests the associated population means are significantly different. Duncan's post hoc (multi-range test) is a multiple comparison procedure that uses the studentized range statistics qr to compare the means. The difference between any two means in a set of n means is significantly provided by the range of every subset that contains the given significant means.

Results

Comparison of SPO2 between the groups over the months (Tables 1 and 2)

The results indicate that there was no statistical significance observed in the mean SPO2 values between the different months, even after group and month interactions. However, the mean SPO2 values were statistically significant between the groups in the second and third months (P=0.007 and P=0.001), respectively (Fig. 3).

Table1. Mean and standard deviation for age in different groups

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Gr A	12	20.0000	2.00000	.57735	18.00	24.00
Gr B	10	21.2000	4.56557	1.44376	18.00	30.00
Gr C	3	22.0000	6.92820	4.00000	18.00	30.00
Gr D	23	21.6957	3.57307	.74504	18.00	28.00
Gr E	20	22.1500	4.90193	1.09611	18.00	30.00
Gr F	22	22.5000	4.38341	.93455	18.00	30.00
Gr G	4	18.7500	.95743	.47871	18.00	20.00
Gr H	23	19.6957	2.16238	.45089	18.00	25.00
Gr I	3	20.3333	4.04145	2.33333	18.00	25.00
Total	120	21.2000	3.85144	.35159	18.00	30.00

*p <0.05

Table 2. Descriptive Statistics for SPO2 between the groups over the months

	groups	Mean	Std. Deviation	N
spo2_m1	Gr A	96.8333	.93744	12
	Gr B	97.1000	1.28668	10
	Gr C	97.3333	1.15470	3
	Gr D	97.1304	1.25424	23
	Gr E	96.9000	1.20961	20
	Gr F	96.5455	1.05683	22
	Gr G	97.7500	.50000	4
	Gr H	96.0000	1.53741	23
	Gr I	97.6667	.57735	3
	Total	96.7750	1.27327	120
spo2_m2	Gr A	97.1667	.83485	12
	Gr B	97.4000	1.17379	10
	Gr C	97.6667	.57735	3
	Gr D	96.9565	1.02151	23
	Gr E	96.8000	1.70448	20
	Gr F	97.2727	.93513	22
	Gr G	97.7500	1.25831	4
	Gr H	95.9130	1.47442	23
	Gr I	97.3333	.57735	3
	Total	96.9000	1.31187	120
spo2_m3	Gr A	97.2500	.75378	12
	Gr B	97.6000	.84327	10
	Gr C	98.3333	1.15470	3
	Gr D	97.0870	1.04067	23
	Gr E	97.1500	1.63111	20
	Gr F	96.9545	.84387	22
	Gr G	97.7500	.50000	4
	Gr H	95.8696	1.54638	23
	Gr I	97.0000	.00000	3
	Total	96.9500	1.29543	120

*p<0.05

Comparison of mean SPO2 within the groups (Tables 3 and 4)

The mean SPO2 values showed variation between the groups, which was clinically non-significant since all the values were above the set limit of 95%. ANOVA showed a p-value of 0.002 for the mean difference in SPO2 values between the groups, which was statistically significant (Fig. 4).

Since ANOVA showed a p-value that was significant (<0.05), Duncan's multiple range test was done to ascertain the difference between the groups. In Duncan's multiple range test, group H was found to have the lowest mean SPO2 value (95.92) and the test yielded a subset for alpha 0.05. Therefore, compared pairing was done between group H and the other groups. The result of the compared pairing shows that group H vs group I was significant (p value<0.05), and in group H vs group B, group G and C was significant (p value<0.05) (Table 5). Hence, in this study statistical significance was shown when group H was compared with groups C, G, B, and I.

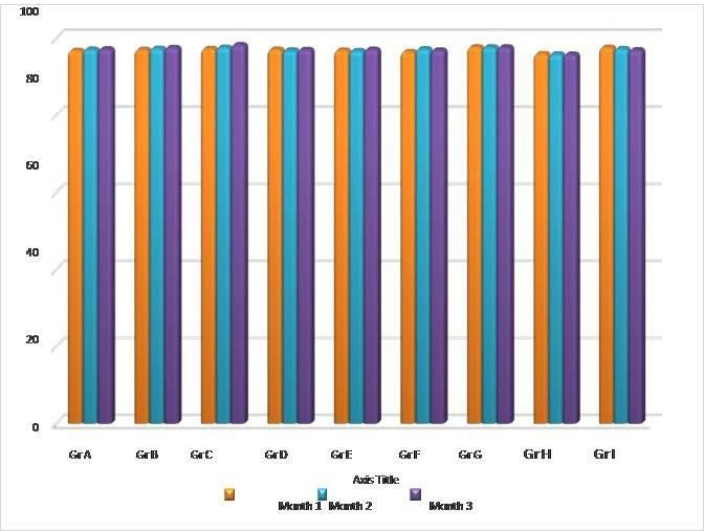

Figure 3. Comparison of SPO2 between the groups within the months

Table 3. Descriptive Statistics for SPO2 between the groups within the months

		N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
spo2_m1	Gr A	12	96.8333	.93744	.27061	95.00	98.00
	Gr B	10	97.1000	1.28668	.40689	95.00	99.00
	Gr C	3	97.3333	1.15470	.66667	96.00	98.00
	Gr D	23	97.1304	1.25424	.26153	95.00	99.00
	Gr E	20	96.9000	1.20961	.27048	94.00	98.00
	Gr F	22	96.5455	1.05683	.22532	95.00	98.00
	Gr G	4	97.7500	.50000	.25000	97.00	98.00
	Gr H	23	96.0000	1.53741	.32057	93.00	98.00
	Gr I	3	97.6667	.57735	.33333	97.00	98.00
	Total	120	96.7750	1.27327	.11623	93.00	99.00
spo2_m2	Gr A	12	97.1667	.83485	.24100	96.00	99.00
	Gr B	10	97.4000	1.17379	.37118	96.00	99.00
	Gr C	3	97.6667	.57735	.33333	97.00	98.00
	Gr D	23	96.9565	1.02151	.21300	95.00	98.00
	Gr E	20	96.8000	1.70448	.38113	94.00	98.00
	Gr F	22	97.2727	.93513	.19937	95.00	99.00
	Gr G	4	97.7500	1.25831	.62915	96.00	99.00
	Gr H	23	95.9130	1.47442	.30744	94.00	98.00
	Gr I	3	97.3333	.57735	.33333	97.00	98.00
	Total	120	96.9000	1.31187	.11976	94.00	99.00
spo2_m3	Gr A	12	97.2500	.75378	.21760	96.00	98.00
	Gr B	10	97.6000	.84327	.26667	96.00	99.00
	Gr C	3	98.3333	1.15470	.66667	97.00	99.00
	Gr D	23	97.0870	1.04067	.21700	95.00	99.00
	Gr E	20	97.1500	1.63111	.36473	94.00	99.00
	Gr F	22	96.9545	.84387	.17991	96.00	98.00
	Gr G	4	97.7500	.50000	.25000	97.00	98.00
	Gr H	23	95.8696	1.54638	.32244	94.00	98.00
	Gr I	3	97.0000	.00000	.00000	97.00	97.00
	Total	120	96.9500	1.29543	.11826	94.00	99.00
	Gr D	23	96.9565	1.02151	.21300	95.00	98.00
	Gr E	20	96.8000	1.70448	.38113	94.00	98.00
	Gr F	22	97.2727	.93513	.19937	95.00	99.00
	Gr G	4	97.7500	1.25831	.62915	96.00	99.00
	Gr H	23	95.9130	1.47442	.30744	94.00	98.00
	Gr I	3	97.3333	.57735	.33333	97.00	98.00
	Total	120	96.9000	1.31187	.11976	94.00	99.00

Table 4. One–way ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
spo2_m1	Between Groups	26.412	8	3.301	2.201	.033
	Within Groups	166.513	111	1.500		
	Total	192.925	119			
spo2_m2	Between Groups	34.304	8	4.288	2.792	.007
	Within Groups	170.496	111	1.536		
	Total	204.800	119			
spo2_m3	Between Groups	41.694	8	5.212	3.661	.001
	Within Groups	158.006	111	1.423		
	Total	199.700	119			

Table 5. Duncan Post-hoc Test

Groups	N	Subset for alpha = 0.05	
		1	2
Gr H	23	95.9275	
Gr F	22	96.9242	96.9242
Gr E	20	96.9500	96.9500
Gr D	23	97.0580	97.0580
Gr A	12	97.0833	97.0833
Gr I	3		97.3333
Gr B	10		97.3667
Gr G	4		97.7500
Gr C	3		97.7778

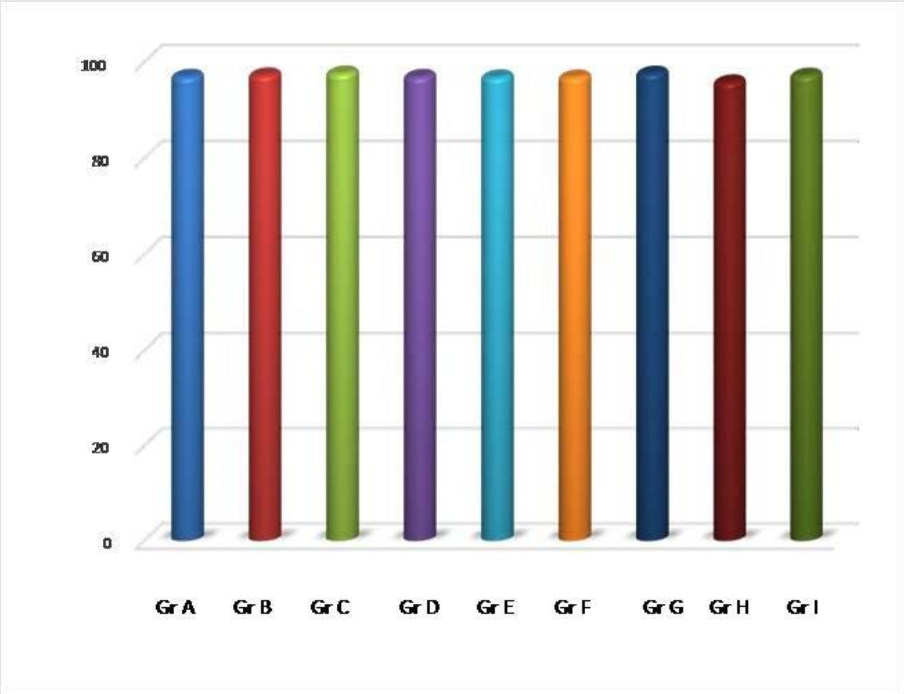

Figure 4. Comparison of meanSPO2 between the groups

Discussion

The present study revolves around the fact that reduced oxygen saturation level in the blood might be seen in various malocclusions, resulting in mouth breathing and hypoxia that in turn can have significant damaging effects on skeletal, functional, and dentofacial maturation levels. This study, hence, evaluated the oxygen saturation levels in subjects with varied skeletal patterns in the antero-posterior and vertical dimensions to establish the cause and the effect relationship with respect to the abnormal dentofacial growth pattern if associated with altered levels of blood oxygen saturation (SPO2).

Respiratory function is believed to have a

significant function in the development of the dentofacial structures, as well as a vital role in stabilizing the occlusion. As it is a known fact that chronic nasal obstruction and or constriction of the posterior airway could cause hyperdivergent facial growth patterns, known as adenoid face (25) or typically referred to as "long face syndrome," represented by a vertically larger lower facial height, this research finding confirms the possibility of a direct relationship between abnormal breathing pattern and the resultant functional disturbances in the stomatognathic system.

To confirm the effect of abnormal breathing patterns on altered dentofacial growth and on their respective groups based on the skeletal pattern in both anteroposterior and vertical dimensions, the SPO2 level for each patient was recorded using a portable pulse oximetry device (Biosys, BPM-200), which was a simple and non-invasive substitute for arterial blood sampling. After connecting the optical diodes to the patient's finger, the SPO2 value of each patient was recorded as the percentage of hemoglobin oxygen saturation.

The SPO2 level between 95% and 100% was considered normal; 94% or lower was considered hypoxic, and less than 90% was considered severely hypoxic. Oxygen saturation levels were checked at the first three consecutive appointments of the one-month gap. At each appointment, the test was carried out three times for each subject at ten-minute intervals, and the average value was calculated as SPO2 (26,27). The multifunctional pharyngeal airway regulates many physiologic processes such as deglutition, vocalization, and respiration. Muscles and membranes make the pharyngeal airway, and the pharynx consists of three parts: nasopharynx, oropharynx, and laryngopharynx.

Abnormal airway function at some stage in the growth spurt interval can have a strong impact on facial development (28,29). Soft tissue size and development encompassing the craniofacial skeletal structures decide the size of the pharyngeal space. The depth of the nasopharynx enlarges as its posterior wall narrows (30). A natural and anatomical disposition of the airway to narrow exists because of the suggestion that those with class I and class II malocclusions and vertical growth patterns have considerably narrower upper pharyngeal airways when compared with subjects with normal growth patterns (31). If the upper airway becomes narrower, airflow resistance may increase, also increasing the possibility of snoring or obstructive sleep apnea (32).

El and Palomo (33) conducted a study to evaluate the nasal passage (NP) and oropharyngeal (OP) volumes of subjects with diverse dentofacial skeletal patterns. The study concluded that oropharyngeal airway volumes in class II patients were smaller when compared with those in class I and class III patients. Several studies (34-36) concluded that the differences in the upper and lower pharyngeal airways between a normal and vertical growth pattern among class I, class II, and class III malocclusions were statistically significant. Furthermore, a relationship was determined between pharyngeal airway measurements and vertical skeletal parameters (37,38) in those with adult skeletal class II malocclusions with vertical growth patterns that had considerably narrower pharyngeal airways compared to subjects with normal or horizontal growth patterns.

Fastuca et al. (39) concluded that when rapid maxillary expansion treatment is advised, it results in a significant increase in the upper, middle, and lower airway compartment volumes. Lower baseline airway volumes in the middle and lower compartments were associated with a greater increase in SPO2. Salehi et al. (40) concluded that there was no association between airway volume and vertical facial growth pattern based on the cone-beam computed tomography data. Nevertheless, Silva (41) concluded that those with mandibular class II malocclusion had reduced upper airway measurements, and a correlation existed between mandibular length and position and the size of the oropharynx and nasopharynx. These findings therefore indicated the presence of a clinically significant correlation between the upper airway volume and the vertical facial growth pattern.

In two separate studies, Alhammadi and Korayem (42,43) evaluated the upper pharyngeal airway spaces in adults with different anteroposterior and vertical skeletal malocclusions and concluded that skeletal class II malocclusion, because of an inherent backward positioning of the mandible, was accompanied by a decrease in the upper pharyngeal airway spaces. The individuals with mandibular growth deficiency had less airway volume, a smaller minimum axial area, and constricted posterior airway space than the patients with good growth and an anteroposterior relationship between maxilla and mandible.

Various research studies (44-46), have reported high statistically significant differences between class I, class II, and class III groups for the upper and middle pharyngeal airways. The dimensions of oropharyngeal and hypopharyngeal airways were reported to be decreasing with an increase in the ANB angle, and the mean total airway volume in patients with retrognathic mandibles was

significantly lower than in subjects with normal mandibles. They also determined that the CBCT is a more convenient alternative diagnostic tool compared to PSG (polysomnography) to diagnose OSA (obstructive sleep apnea) so that further progression of OSA can be prevented by orthodontic intervention if needed.

The present study revolves around the fact that reduced oxygen saturation levels in the blood might be observed in various malocclusions resulting in mouth breathing and hypoxia, which in turn can have significant damaging effects on the skeletal, functional, and dentofacial maturation levels of the individuals presenting with different types of growth patterns (horizontal, average, and vertical). Hence, this study was designed to evaluate the oxygen saturation levels in subjects with different skeletal patterns in the anterior-posterior and vertical dimensions to establish the cause-and-effect relationship with respect to the abnormal dentofacial growth pattern if it is associated with any altered levels of blood oxygen saturation (SPO2).

Group A (average facial type with class I skeletal base relationship): The mean SPO2 values measured in a period of three months in group A was found to be 97.08±0.66, showing normal oxygen saturation levels that indicated no airway obstruction associated with various facial types and their malocclusions on the sagittal plane. This conclusion agreed with previous studies conducted by Shokri et al (47).

Group B (average facial type with class ii skeletal base relationship): The mean SPO2 values in group B was found to be 97.36±0.94, which showed normal oxygen saturation indicating no airway obstruction.

Group C (average facial type with class III skeletal base relationship): The mean SPO2 value in group C was found to be 97.77±0.96, which showed normal oxygen saturation indicating no airway obstruction due to a skeletal relation in the anteroposterior and vertical dimension. As per a research study by Chen et al. (48), a larger airway dimension was observed in class III malocclusions, which agreed with the results obtained in this study.

Groups D, E, and F (horizontal facial types with class I, class II and class III skeletal bases): The mean SPO2 value in groups D and E showed normal oxygen saturation indicating no airway obstruction due to the combination of horizontal facial types with various skeletal jaw base relationship in the anteroposterior dimension. Lakshmi et al. (49) showed that the horizontal facial types demonstrated more airway dimension compared to the average and vertical facial types. Similar results were obtained with group F, showing normal oxygen saturation probably due to larger airway dimensions associated with skeletal class III jaw bases.

Group G (vertical facial type with class I skeletal base): The mean SPO2 values measured in group G was 97.75±0.56, which showed normal oxygen saturation indicating no airway obstruction. Zheng (38) indicated that the nasopharyngeal airway volume of class I was significantly larger than that of patients with a class II skeletal jaw relationship.

Group H (vertical facial type with class II skeletal base): The mean SPO2 values in group H was 95.92±1.44, showing normal oxygen saturation but clinically the lowest SPO2 value calculated (93.67) indicated predisposed airway obstruction in this group. Zheng, (38) concluded that the vertical facial type associated with skeletal class II jaw bases is usually predisposed to airway obstruction because of the backward positioning of the mandible.

Group I (vertical facial type with class III skeletal base): The mean SPO2 values measured in group I was 97.33±0.33, indicating no airway obstruction due to the vertical facial type in association with class III skeletal bases (50).

Comparison between the groups and the mean SPO2: The mean SPO2 calculated in three months was compared between the groups, and there was a statistically significant difference observed. Hence, post hoc analysis was done to determine which group had significant differences. Group H was found to be statistically significant, and it had the lowest mean SPO2 level (95.92±1.44). The reduced SPO2 level could be correlated clinically to a reduced airway dimension and clockwise rotation of the mandible. These features agreed with the studies done by Zheng (38), where they observed that the nasopharyngeal airway volume of class I and class III subjects was significantly larger than that of patients with a class II skeletal pattern. Another study by Silva et al. (41) stated that individuals with skeletal class II malocclusion showed diminished upper airway measurements.

Soni et al. (51) assessed the pharyngeal airway dimensions in class I, II, and III skeletal malocclusions using CBCT and concluded that class II malocclusions had smaller airway dimensions compared to class I and class III malocclusions. The reduced airway dimension in vertical facial types; however, is related to the combination of various parameters such as reduced ramal length and clockwise rotation of the mandible (52).

Conclusion

The present study was conducted to evaluate oxygen saturation levels in subjects with different

facial types in angle's class I, II and III skeletal base relationships. Based on the analysis of the results obtained from the study, the following conclusions were made:

In all the facial types (average, horizontal, and vertical), the SPO2 levels were found to be in the normal range.

Vertical facial types with class II skeletal base relationship, however, showed the lowest SPO2 levels.

Limitations of the study

Reduced sample size because of the prevalence of certain malocclusions in this region.

Unequal distribution of sexes in the groups.

SPO2 calculation with pulse oximeter cannot be considered as a standard value for diagnosis.

Future prospects

Large scale study with equal distribution of sex and age using standardized SPO2 calculation.

Changes in SPO2 in patients with constricted airway after successful orthodontic treatment to improve the airway.

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