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Assessment of Cranial Base Flexion in Relation to Vertical and Sagittal Malocclusions in Orthodontic Patients

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ABSTRACT

Background: Malocclusion is an irregularity concerning teeth alignment. It is a developmental deformity that can occur in teeth or bones. Malocclusion occurs when the bones in the craniofacial region are misaligned due to abnormalities in the shape, size, and position of the skull, upper jaw, and lower jaw. The study aimed to assess the relationship of cranial base angle in different malocclusions in vertical and sagittal dimensions.

Methods: It was a cross-sectional study conducted at the Department of Orthodontics, Faculty of Dentistry, LUMHS, Jamshoro, from January 2022 to August 2024. A sample of 118 was recruited via a convenience sampling technique. Participants aged between 13-30 years with complete permanent dentition (assess the chronological age) were included. The lateral Cephalometric radiograph of each participant was obtained and traced for vertical and sagittal skeletal relationships using the Maxillary-Mandibular Plane Angle (MMPA), respectively. Data were analyzed using SPSS version 26.0. Descriptive statistics were presented as frequencies and percentages. A chi-square test was used to evaluate the relationship between variables. $P < 0.05$ was considered significant.

Results: The mean age of the participants was 19.09+4.35 years. In most cases, 63 (48.5%) had sagittal class I and 60 (46.2%) had sagittal class II, while only 7 (5.4%) cases had sagittal class III. For vertical classification of malocclusion, out of all, 55 (42.3%) cases had vertical class I, 48 (36.9%) had vertical class II, and 27 (20.8%) had vertical class III.

Conclusion: The study highlighted that sagittal Class II and III malocclusions are significantly more prevalent among younger age groups, particularly between 13–25 years, emphasizing the importance of early diagnosis and intervention. Vertical Class II and III malocclusions also showed a higher frequency in younger participants, though not statistically significant.

Keywords: Malocclusion, Orthodontic Treatment, Cephalometric Radiograph

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INTRODUCTION

Occlusion refers to the interaction of the upper (maxillary) and lower (mandibular) teeth when they are in contact. Malocclusion is an irregularity concerning tooth alignment. A developmental deformity, which may be of dental or skeletal origin[1]. Malocclusion is craniofacial asymmetry resulting from abnormal shape, size, and position of the skull, maxilla, and mandible. The World Health Organization considers malocclusion to be the third most common oral health problem after caries and periodontal disease[2]. A review and meta-analysis of the prevalence of malocclusion in various stages of dental care worldwide found that the global mean prevalence of malocclusion was 56% (95% CI: 11–99), with no gender difference. The largest expansions occurred in Africa (81%) and Europe (72%), followed by the Americas (53%) and Asia (48%)[3].

Several types of malocclusions can affect the morphology of teeth: vertical, transverse, and anteroposterior bite discrepancies[4]. Vertical malocclusion occurs as a result of the interaction of many factors during adolescence. These factors include the development of the upper and lower jaw bones and the function of the lips. One of the most important factors determining the development of deep and open bite is the growth of the mandible. Additional changes in the development of the maxillary suture and the mandibular condyle can alter vertical growth. Key features also alter developmental occlusion and often play an important role in the development of vertical plane malocclusions[5]. The skeletal relationship of the upper and lower jaws in the sagittal plane is a fundamental characteristic of the human profile and is considered one of the most important parameters in orthodontic anomaly evaluation. Cephalometric radiograph remains a very valuable tool in orthodontic diagnosis and treatment planning. According to orthodontics, there are generally three planes of discrepancy: transverse, sagittal, and vertical. Among these three, the most common problems exist in sagittal discrepancies. Several cephalometric analyses aid the clinician in the diagnosis of anteroposterior discrepancies[6-7]. The first and most important plane to be considered in triangulating craniofacial structures in orthodontic diagnosis and treatment planning is the sagittal dimension[8]. Skeletal Class II and Class III malocclusions are characterized by disturbances in the sagittal alignment of the maxillary and mandibular bones[9].

The N-S-Ar angle, Maxillary-Mandibular Plane Angle (MMPA), SNA angle, and SNB angle play a crucial role in orthodontics, particularly in analyzing cranial base flexure and its implications for skeletal discrepancies[10]. The N-S-Ar angle reflects the cranial base flexure and serves as a vital reference for assessing maxillomandibular relationships[11,12]. A larger N-S-Ar angle often correlates with skeletal Class II malocclusions, whereas a smaller angle is indicative of Class III malocclusions[13].

The MMPA evaluates the inclination of the maxillary and mandibular planes, offering insight into vertical facial growth patterns, which are critical in diagnosing open bite or deep bite cases. Similarly, the SNA and SNB angles provide valuable information on the anteroposterior positioning of the maxilla and mandible, respectively. Variations in these angles directly influence the diagnosis of sagittal discrepancies, aiding in the classification of Class I, II, and III malocclusions. Understanding the interplay between these angles and cranial base flexure enhances diagnostic accuracy and informs individualized treatment planning. Hence, this study was to assess the relationship of cranial base angle in different malocclusion in anteroposterior dimension and vertical dimension the results will help in better understanding of growth and development of craniofacial region and subsequent orthodontic management of patient.

METHODS

The study was performed at the Department of Orthodontics, Faculty of Dentistry, LUMHS, Jamshoro from January 2022 to August 2024. It was a cross-sectional design approved by Research Ethics Committee LUMHS with reference No: LUMHS/REC/-911. A sample of 118 has been estimated using a standard deviation of 12.91 mm of the previous study[14], a clinically significant difference of 8.81 at a power of 80% and a 95% confidence interval. To accommodate the possible incompletely enrolled participants, 10% more cases have been recruited; therefore, this study will accommodate a final sample size of 130 participants. Participants with age between 13-30 years with complete permanent dentition (assess the chronological age), no history of previous orthodontic, orthopaedic or facial and surgical treatment were included through non-probability consecutive sampling technique. Individuals with craniofacial defects (e.g., clefts), history of craniofacial fractures, bone diseases (Rickets, Osteomalacia, Osteoporosis), nutritional deficiencies, and endocrine disorders (Hypothyroidism, and Hyperthyroidism) were excluded.

At the time of recruitment, each study participant was given detailed explanation of study and a written informed consent/ assent form was obtained from all the participants. The lateral Cephalometric radiograph of each participant was obtained and traced for vertical and sagittal skeletal relationship using Maxillary-Mandibular Plane Angle (MMPA) respectively. The cranial base flexure was measured using cranial base angle derived from joining the point the N-S-Ar.

Data were analyzed using SPSS version 26.0. Descriptive statistics were presented as frequencies and percentages. Chi-square test was used to evaluate the relationship between variables. $P < 0.05$ was considered significant.

RESULTS

Table 1 shows descriptive statistics of variables

Variables		Mean/ frequency	Std. Deviation
Age in years		19.09	4.35
Gender	**Male**	44 (33.8%)	-
	Female	86 (66.2%)	
NSAR		121.66	15.03
MMPA		26.30	6.06
SNA		82.07	4.631
SNB		79.03	4.20

The mean age of the participants was 19.09$\pm$4.35 years. Out of 130 participants, 86 (66.2%) were females, and 44 (33.8%) were males. According to the overall angular measurements, the average N-S-Ar was 121.66^0+15.03^0, the average MMPA angle was 26.30^0+6.06^0, the mean SNA angle was 82.07^0+$4.6^{0,}$ and the overall average of the SNB angle was 79.03^0+4.20^0 as presented in **Table 1**.

Table 2: The Malocclusion of Participants in Different Planes

Sagittal malocclusion classification of the participants		
Class	**Frequency**	**Percent**
Class I	63	48.5
Class II	60	46.2
Class III	07	5.4
Sagittal Vertical classification of the participants		
Class	**Frequency**	**Percent**
Class I	55	42.3
Class II	48	36.9
Class III	27	20.8

As per sagittal malocclusion classification of the cases, the most of the cases 48.5% had sagittal class I and 46.2% had sagittal class II, while only 5.4% cases had sagittal class III. For vertical classification of malocclusion, out of all, 42.3% cases had vertical class I, 36.9% had vertical class II, and 20.8% had vertical class III as depicted in **Table 2**.

Table 3: Association of Vertical Malocclusion with Age

Class I	Class II	Class	Total	p-value

					III		
Age group	**13-18 years**	Count	24	33	4	61	0.008
		%	18.5%	25.4%	3.1%	46.9%	
	19-25 years	Count	28	27	3	58	
		%	21.5%	20.8%	2.3%	44.6%	
	26-30 years	Count	11	0	0	11	
		%	8.5%	0.0%	0.0%	8.5%	
Total		Count	63	60	7	130	
		%	48.5%	46.2%	5.4%	100.0%	

Malocclusion, sagittal class II and III were significantly associated with the age groups of 13-18 years and 19-25 years as compared to the age group of 26 to 30 years (p-0.008) **Table 3**.

Table 4: Association of Vertical Malocclusion with Age

Class I				Class II	Class III	Total	p-value
Age group	**13-18 years**	Count	26	17	18	61	0.084
		%	20.0%	13.1%	13.8%	46.9%	
	19-25 years	Count	24	25	9	58	
		%	18.5%	19.2%	6.9%	44.6%	
	25-30 years	Count	5	6	0	11	
		%	3.8%	4.6%	0.0%	8.5%	
Total		Count	55	48	27	130	
		%	42.3%	36.9%	20.8%	100.0%	

Malocclusion vertical class II and III were higher in age groups of 13-18 years and 19-25 years as compared to the age group of 26 to 30 years, while findings were statistically insignificant (p-0.084) **Table 4.**

DISCUSSION

In this study, as per sagittal malocclusion classification of the cases, most of the cases 48.5% had sagittal class I and 46.2% had sagittal class II, while only 5.4% cases had sagittal class III. As per the vertical classification of malocclusion, out of all, 42.3% cases had vertical class I, 36.9% had vertical class II, and 20.8% had vertical class III. According to a review published in 2021 assessing the prevalence of Dental Malocclusions in Different Geographical Areas, it was shown that among the three classes regarding sagittal view, Class I is the most common and ranges from 34.9% to 93.6%. Class II has an average rate of 20.2%. Class III malocclusion has the lowest incidence according to angle, with an average of 7.2%[15].

The present study investigated the association between malocclusion sagittal classes (Class II and Class III) and different age groups (13-18 years, 19-25 years, and 26-30 years) in a sample of orthodontic patients seeking treatment. The results revealed a significant relationship between certain malocclusion types and age groups, with Class II and Class III malocclusions being significantly associated with the younger age groups (13-18 years and 19-25 years) as compared to the older age group (26-30 years). The findings are consistent with the findings of a review conducted among 8-15 years old children in India to determine the prevalence of malocclusion. A total of 54 studies were included with a total sample of 97,959 children. A prevalence of 35.405 was observed in overall population with the greatest observe among 13 years old children (33.50%, CI:33.34–33.66, 11 studies, 3366 participants)[16]. The observed age-related differences in the prevalence of Class II and Class III malocclusions can be attributed to the underlying patterns of craniofacial growth and development[17]. The craniofacial structures undergo significant changes during adolescence and early adulthood, and these changes can influence the occlusion and skeletal relationships of the teeth and jaws[18]. During the adolescent growth spurt (approximately 13-18 years), the maxilla and mandible continue to grow, and various dental and skeletal changes occur. It is common for Class II malocclusions to become more apparent during this period due to the disproportionate growth of the mandible relative to the maxilla, resulting in a retruded lower jaw. Similarly, Class III malocclusions may also become more evident during this stage, as a prognathic or forward- positioned mandible becomes more pronounced compared to the maxilla. In the young adult age group (19-25 years), the craniofacial growth is generally near completion, and individuals may still present with Class II or Class III malocclusions that have persisted from their teenage years[19]. At this age, orthodontic treatment may be necessary to address these malocclusions before they become more challenging to manage in the later stages of adulthood. No such studies has been found to correlate with such findings.

The results of our study provide important insights into the relationship between cranial base flexion and the development of different malocclusion types. Our findings regarding the significant relationship between cranial base flexion (N-S-Ar angle) and both sagittal and vertical malocclusions add to the growing body of evidence on this topic. The finding that Class I sagittal malocclusions are associated with more obtuse cranial base angles compared to Class II and III malocclusions is noteworthy and contributes to the existing literature on cranial base morphology in different malocclusion types. A meta-analysis on cranial base characteristics in anteroposterior malocclusions found that the cranial base angle was significantly smaller in Class III than in Class I malocclusions, and greater in Class II than in Class I malocclusions. Our results partially align with their findings regarding Class III malocclusions but diverge regarding Class II, which may be attributed to differences in population characteristics, measurement techniques, or the specific angle measured (N-S-Ar vs. N-S-Ba)[20]. A recent cross-sectional study on cranial base growth and its relation with sagittal skeletal discrepancies on 93 subjects found that the cranial base angle was significantly greater in females than males in Class II malocclusions, suggesting potential gender-specific differences in cranial base morphology[21]. Regarding vertical malocclusions, our finding that patients with normal bite (Class I vertical) exhibited more obtuse cranial base angles compared to those with deep bite (Class II vertical) and open bite (Class III vertical) is consistent with a study conducted in 2021. Their research on 3D evaluation of different vertical growth patterns and cranial base angulations found that cranial base angles were significantly different among various vertical growth patterns, with high-angle cases (open bite tendency) showing more acute cranial base angles compared to normal and low-angle cases[22]. In a study on young latin American individuals with class I, II, and III malocclusion investigated cranial-base morphology in adults with skeletal Class III malocclusion and found that skeletal open bite Class III individuals show a smaller cranial base angle than Skeletal open bite Class I or II individuals[23]. Recent research by Dileep et al. (2022) compared cranial base parameters in adults with Class I and Class II skeletal patterns and found subtle but meaningful differences that may contribute to malocclusion development[24]. Their results align with our finding that cranial base flexion differs between various sagittal malocclusion classes.

Thin-plate spline analysis of the cranial base across different populations and found that basicranial orientation and posterior cranial base length are valid factors to distinguish between geographic groups and that the whole craniofacial configuration underlying a particular maxillo-facial disharmony must be considered in diagnosis, growth predictions and treatment planning[25].

CONCLUSION

The study highlighted that sagittal Class II and III malocclusions are significantly more prevalent among younger age groups, particularly between 13–25 years, emphasizing the importance of early diagnosis and intervention. Vertical Class II and III malocclusions also showed a higher frequency in younger participants, though not statistically significant. These findings underscore the need for targeted orthodontic care in adolescence and early adulthood to address malocclusion and improve oral health outcomes.

ETHICAL APPROVAL

The study received ethical approval from the Ethical Review Committee of LUMHS, under reference number (LUMHS/REC/-911).

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CONFLICT OF INTEREST

None

AUTHORS CONTRIBUTIONS

SA: Conception and design, manuscript writing. **M**: Manuscript writing, data collection, and interpretation of results. **AA:** Data collection, manuscript writing, final review. **AJ:** Data collection, final review. **MSK:** Data collection, final review. **SH:** Manuscript writing, Proofread

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