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Comparison between Cranial Base Morphology and Different Maxillofacial Relationships in People of Northern Iran

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ABSTRACT

Introduction: The comparison between the morphology of cranial base and different jaw relationships helps to increase awareness about the way of maxillofacial development and its relationship with the types of skeletal malocclusion. This study aims to examine the relationship between the morphology of the cranial base and different maxillofacial relationships in the sagittal dimension.

Materials & Methods: For this study, 180 lateral cephalometric radiographs were selected from the records of patients aged 18-25 years. The patients were categorized into three equal groups based on skeletal relationship distributions. Linear and angular cephalometric variables were measured and recorded.

Results: There were significant differences between the study groups in certain linear and angular variables. In particular, differences were seen in the S-N (p = 0.049), Ar-ANS (p = 0.001) and Ar-Pog (p = 0.001) for linear variables, and in saddle angle (p = 0.006) and gonial angle (p = 0.001) for angular variables.

Conclusion: Based on the results of this study, the morphology of the cranial base is different in the jaw relations in the sagittal dimension, and there is a possibility that the pattern of the morphology of the cranial base determines the type of jaw relations in the future.

Keywords: Cranial Base, Cephalometry, Maxillofacial

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Introduction

The position of the maxilla and mandible is highly determined by the cranial base, which in turn affects the overall skeletal structure and dentition. [1] The cranial base is a crucial anatomical structure that separates the complex neural tissues of the brain from the structural components of the face. It plays a significant role in the overall dynamics of cranial growth. Researchers have been studying the comparison between cranial base features and malocclusion due to the importance of the cranial base in both the functional and aesthetic considerations of the craniofacial complex. [2] The cranial base includes both the anterior and posterior cranial bases. The anterior cranial base is associated with the position of the maxilla, while the posterior cranial base is associated with the position of the glenoid fossa and mandible. [3]

Deviations of the cranial base angle from normal value, as well as changes in the anterior and posterior lengths, could potentially lead to abnormality in facial growth and consequently leads to malocclusion.The configuration of the cranial base plays a significant role in the sagittal alignment between the maxilla and mandible. [4] Previous research has explored the intricate relationship between the cranial base and the maxillofacial complex, but the results have been inconclusive, leading to various hypotheses. [5] For instance, a particular study showed that linear and angular measurements of the cranial base decrease in individuals with Class III malocclusion. However, other studies have failed to prove a reduction in cranial base length in Class III skeletal cases. [6]

It is important to note that environmental factors and genetic variations among different ethnic populations may affect the dimensional features of the cranial base. [7] According to Proff et al., individuals with Class III sagittal relationships experience a decrease in both the length and angle of the cranial base compared to those with other skeletal relationships. [6] Moreover, Chin et al. suggested that as the skull base angle increases, the SNB angle decreases. They specified that individuals with Class III skeletal pattern have a greater SNB angle than those with Class I, while Class II exhibits the lowest angle. [4]

Previous studies have yielded conflicting results, and there is no clear consensus on the relationship between cranial base morphology and various maxillofacial relationships in the sagittal dimension. This research aims to conduct a detailed investigation to explore comparisons, differences, and anatomical factors that may influence observed changes in sagittal maxillofacial relationships. The goal is to identify factors that can aid treatment planning and decision-making for individuals with various skeletal patterns, ultimately leading to significant outcomes in patient improvement.

Materials & Methods

This study was a descriptive–analytical study and approved by the Ethics Committee of Babol University of Medical Sciences (ethical code: IR.MUBABOL.HRI.REC.1401.063). We analyzed 180 lateral cephalometric radiographs from the records of patients aged 18-25 including 135 females and 45 males who had treated in the School of Dentistry between 2011 and 2022. In the study, there were 60 participants in each skeletal class, which was categorized according to the skeletal classification. The selected cases only included people from the north of Iran (Mazandaran, Gilan and Golestan provinces). The sample size of 60 can detect a standard effect size of 0.7 with a test power of 80% and a 95% confidence level for sagittal skeletal patterns. [8]

The study included individuals with a normal facial height, as indicated by a Frankfort Mandibular Plane Angle (FMA) measurement within the range of 22 to 28 degrees and a Jarabak index within the range of 61% to 65%. Participants who had undergone orthodontic treatment, facial surgery, significant facial trauma, or had noticeable facial asymmetry were excluded from the study. Additionally, those with low-quality radiographs that could hinder proper diagnosis were excluded.

Participants were classified into three groups with similar skeletal relationship distributions based on their ANB angle. Group 1 included patients with ANB angles ranging from 0° ≤ ANB ≤ 4° (Class I), Group 2 included patients with ANB angles greater than 4° (Class II), and Group 3 included patients with ANB angles less than 0° (Class III). [9] A dentistry student traced cephalometric landmarks (Figure 1), lines and angles using pencil and paper, which were then verified by an orthodontist. The magnification factor of the cephalometric device was also considered for linear measurements using a ruler alongside each radiograph.

The study involved taking linear measurements such as Wits appraisal and lines anterior cranial base(S-N), posterior cranial base (S-Ba), total cranial base (N-Ba), the effective length of maxilla(Ar-ANS), the effective length of mandible(Ar-Pog), as well as angular measurements like N-S-Ba, S-Ba-FH, S-N-FH, Saddle angle (Ar-S-N), Articular angle (S-Ar-Go), and Gonial angle (Ar-Go-Me). These measurements were then analyzed using ANOVA, Independent-Samples T-test and Tukey's post hoc test in SPSS (IBM SPSS Statistics Version 22) with a significance level set at p-value < 0. 05.

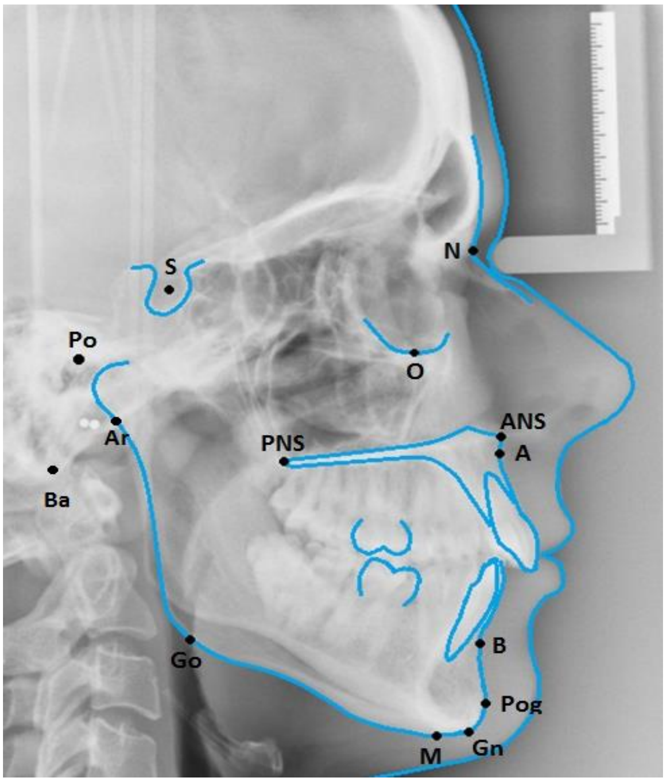

Figure 1. Cephalometric landmarks

Results

The mean FMA and Jarabak Index were 25.87 ± 2.07 and 63.60 ± 1.29, respectively. The mean and standard deviation of age and other cephalometric variables in the study groups are presented in Table 1.

Table 1. Cephalometric Variables in Study Samples Based on Sagittal Skeletal Pattern

Sagittal relationship/variables		Cl I (Mean ± SD)	Cl II (Mean ± SD)	Cl III (Mean ± SD)
Age (years)		20.52 ± 2.67	21.28 ± 2.73	21.10 ± 2.81
Gender/Number (%)	Male (%)	14 (23.33%)	14 (23.33%)	17 (28.33%)
	Female (%)	46 (76.66%)	46 (76.66%)	43 (71.66%)
SNA (degrees)		78.63 ± 3.17	80.43 ± 2.97	79.00 ± 3.43
SNB (degrees)		76.48 ± 3.19	74.83 ± 2.97	81.46 ± 3.44
ANB (degrees)		2.14 ± 1.01	5.60 ± 1.22	-2.10 ± 2.40
FMA (degrees)		26.27± 2.03	25.59 ± 2.05	25.75 ± 2.09
Wits (mm)		0.39 ± 1.00	4.23 ± 1.75	-6.16 ± 3.58
Jarabak Index (%)		63.64 ± 1.17	63.57 ± 1.28	63.58 ± 1.41

The analysis of variance, as shown in Table 2, indicates significant statistical differences among linear variables in different groups. Specifically, there are differences in the S-N (p = 0.049), Ar-ANS (p = 0.001) and Ar-Pog (p = 0.001). The Ar-ANS measurement was found to be greater in Class II compared to other groups, while Ar-Pog exhibited a higher value in Class III. Additionally, among angular variables, only the saddle angle (p = 0.006) and gonial angle (p = 0.001) demonstrated statistically significant differences among the study groups. The saddle angle was greater in Class II compared to other groups, while the gonial angle was higher in Class III compared to the remaining groups.

Table 2. Comparison of Mean Linear and Angular Cephalometric Variables of the Cranial Base among Three Study Groups

Variable	Cl I (n=60) (Mean ± SD)	Cl II (n=60) (Mean ± SD)	Cl III (n=60) (Mean ± SD)	P-Value
S-N (mm)	67.00 ± 3.91	68.59 ± 4.09	67.16 ± 3.59	0.049*
S-Ba (mm)	42.44 ± 4.00	42.30 ± 2.93	42.41 ± 3.81	0.975
N-Ba (mm)	99.74 ± 5.51	101.60 ± 5.58	99.92 ± 5.84	0.148
Ar-ANS (mm)	83.90 ± 4.99	88.53 ± 6.00	83.24 ± 4.93	0.001*
Ar-Pog (mm)	100.90 ± 7.70	99.47 ± 6.80	107.40 ± 7.81	0.001*
N-S-Ba (degrees)	131.90 ± 5.34	132.10 ± 5.86	130.56 ± 4.91	0.25
S-Ba-FH (degrees)	57.78 ± 5.85	57.58 ± 5.14	57.81 ± 4.33	0.964
S-N-FH (degrees)	9.17 ± 2.38	9.29 ± 2.70	8.52 ± 2.92	0.243
saddle angle (degrees)	124.90 ± 5.37	125.89 ± 5.86	122.70 ± 5.16	0.006*
Articular angle (degrees)	146.30 ± 8.15	145.70 ± 6.92	143.60 ± 6.78	0.110
Gonial angle (degrees)	124.30 ± 6.51	122.90 ± 4.96	127.69 ± 4.78	0.001*

ANOVA (*: P<0.05)

Table 3 shows that there is a statistically significant difference in all linear variables in all classes (except S-Ba in class II) and all of them were greater in males than females. Also, among the angular variables, only N-S-Ba and S-Ba-FH class I had a statistically significant difference in and they were greater in females and males respectively.

Table 3. Comparison of cephalometric variables between males and females between each sagittal group

Sagittal relationship/variables		Cl I (Mean ± SD)	P- value	Cl II (Mean ± SD)	P- value	Cl III (Mean ± SD)	P -value
S-N (mm)	Male	69.76 ±5.46	0.002*	71.21±4.88	0.005*	69.92±3.55	0.001*
	Female	66.15±2.89		67.78±3.50		66.06±3.00	
S-Ba (mm)	Male	44.60±4.03	0.020*	43.03±2.24	0.289	45.00±3.24	0.001*
	Female	41.78±3.80		42.07±3.10		41.39±3.55	
N-Ba (mm)	Male	102.87±6.81	0.014*	104.44±5.96	0.027*	104.72±5.72	0.001*
	Female	98.78±4.73		100.70±5.22		98.02±4.73	
Ar-ANS (mm)	Male	86.98±6.17	0.007*	92.86±7.60	0.001*	87.49±3.99	0.001*
	Female	82.96±4.22		87.20±4.78		81.55±4.22	
Ar-Pog (mm)	Male	106.94±9.85	0.001*	104.80±7.04	0.001*	114.84±6.56	0.001*
	Female	99.09±5.92		97.84±5.90		104.41±6.13	
N-S-Ba (degrees)	Male	129.21±4.51	0.031*	130.57±6.90	0.280	129.97±4.20	0.559
	Female	132.71±5.35		132.52±5.51		130.80±5.19	
S-Ba-FH (degrees)	Male	60.89±4.08	0.022*	57.28±5.94	0.812	57.47±4.80	0.708
	Female	56.83±6.01		57.66±4.94		57.94±4.19	
S-N-FH (degrees)	Male	9.21±2.12	0.945	9.10±2.03	0.773	8.32±3.02	0.740
	Female	9.16±2.47		9.34±2.88		8.60±2.91	
saddle angle (degrees)	Male	123.53±6.34	0.297	125.35±5.42	0.700	122.23±4.19	0.648
	Female	125.26±5.05		126.05±6.03		122.91±5.53	
Articular angle (degrees)	Male	147.82±6.09	0.428	146.64±6.18	0.579	144.52±5.16	0.517
	Female	145.82±8.69		145.45±7.17		143.25±7.34	
Gonial angle (degrees)	Male	124.46±4.13	0.932	122.46±5.14	0.706	127.52±4.65	0.870
	Female	124.29±7.11		123.04±4.96		127.75±4.88	

Independent sample test (*: P<0.05)

According to Table 4, the Tukey test revealed some significant differences in pairwise comparisons among linear variables. Specifically, there was a statistically significant difference in Ar-ANS between Class I and II, as well as between Class II and III. Similarly, for Ar-Pog, significant differences were found between Class I and III and between Class II and III (p = 0.001). Regarding angular variables, the saddle angle significantly differed between Class II and III (p = 0.005). In addition, the gonial angle exhibited significant differences between Class I and III (p = 0.003) and between Class II and III (p = 0.001).

Table 4. Multiple Comparisons of Cephalometric Variables in Sagittal Skeletal Groups

	S-N	S-Ba	N-Ba	Ar-ANS	Ar-Pog	N-S-Ba	S-Ba-FH	S-N-FH	Saddle angle	Articular angle	Gonial angle
CL vs CLII	0.066	0.976	0.179	0.001*	0.534	0.984	0.973	0.969	0.557	0.908	0.330
CLI vs CLIII	0.972	0.999	0.983	0.772	0.001*	0.367	1.00	0.381	0.086	0.115	0.003*
CLII vs CLIII	0.110	0.983	0.245	0.001*	0.001*	0.282	0.967	0.262	0.005*	0.225	0.001*

Tukey's Post Hoc test (*: P<0.05)

Discussion

The study results indicate significant differences in the linear variable S-N among sagittal skeletal Classes. The size of this variable was greater in individuals with Class II malocclusion compared to other groups. However, there were no significant differences in the S-N between Class I and II, Class I and III, and Class II and III.

A study conducted by Ardani et al. evaluated the S-N length in individuals with skeletal Class II malocclusion in comparison to normal individuals. The study reported an increased distance in individuals with skeletal Class II malocclusion compared to normal individuals. [10] However, Polat et al. found no significant differences in the S-N lengths among different malocclusions. In contrast, Monirifard et al. found that the S-N length in individuals with Class II malocclusion was significantly greater than in other groups, which was not the case in our study. They found that the S-N length in individuals with Class II malocclusion was significantly greater than in Class I patients. However, this difference was not significant between Class I and III or between Class II and III. [5]

The results of this study showed a significant difference in Ar-ANS between different groups, with Class II having a higher value than the others. Among the linear variables in Ar-ANS, there was a significant difference between Class I and II, as well as between Class II and III. An increase in the distance between Ar and ANS indicates maxillary protrusion and mandibular retrusion, a characteristic of skeletal Class II malocclusion .[11] The Ar-Pog was found to be greater in Class III malocclusion. Additionally, there was a significant difference in Ar-Pog measurement between Class I and III and Class III and II. A study conducted by Ramezanzadeh et al. also showed greater Ar-Pog in Class III malocclusion groups. [12]

Statistically significant differences were observed only in the saddle and gonial angles among the study groups in angular variables. The Class II group exhibited a greater value compared to other groups in the saddle angle, and a significant correlation was observed in the saddle angle between Class II and III. Shah et al. and Thiesen et al. did not observe any significant differences between the saddle angle and various skeletal malocclusions in their studies. [13-14] Al Maaitah et al. found that the saddle angle is significantly larger in Class II malocclusion than in Class III malocclusion, which is consistent with the results of the current study. [15]

However, it should be mentioned that the studies that found no correlation between the saddle angle and the skeletal class III, or that did not agree with the results of the current study regarding the relationship between the cranial base and the mandibular position, especially during prognathism, were because those studies were performed on a sample that not included class III cases or had very few number of class III cases. In addition, other studies with negative correlation between the cranial base angle and the antero posterior skeletal jaw relationships, did not use skeletal landmarks as point A and point B in the analysis of the sagittal relations, instead they used either skeletal sagittal classification or British Standards Institute incisor classification. [16]

The Gonial angle were traced because they are in a direct relation with the sagittal position of the mandible and its relation with the maxilla. [17]

Our study found that the gonial angle was greater in Class III patients compared to other groups. We also observed a significant difference in the gonial angle between Class III and I, as well as between Class II and III. This aligns with the findings of Gasgoos et al., who reported a larger gonial angle in the Class III group. [18] One of the problems of our study was the higher ratio of females to males, which can affect the results. It is suggested that this case be considered in future studies and an equal ratio between the two genders should be observed.

Only northern Iranian people were present in our study, and compared to other studies, we should also consider the racial difference. Although it was necessary to focus on adult patients (over 18 years old) to observe growth changes, the narrow age range we studied may not accurately represent a larger community with diverse craniofacial growth stages. As our study was cross-sectional, it is essential to note that causal relationships cannot be established.

One of the issues discussed in the differentiation of class II and III skeletal problems is the deficiency is in the maxilla or mandible and whether the chin is large or small, which were not mentioned in this study.Still, it can be effective in the result and the certainty of our research. It is expected that this issue will be separated in future studies. It is crucial to acknowledge the limitations of the present study and consider how future studies can provide more insights into the relationship between cranial base morphology and jaw relationships over time. In addition, it is important to note that the study did not address gender and ethnic differences, highlighting the need to pay attention to these factors in research. Finally, in future studies, artificial intelligence and related software can also be utilized for the analysis of cephalometry and CBCT.

Conclusion

Based on the results of this study, the morphology of the cranial base is different in the jaw relations in the sagittal dimension, and there is a possibility that the pattern of the morphology of the cranial base determines the type of jaw relations in the future.

Acknowledgments

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Conflicts of Interest

All authors declare no conflict of interest.

Author's Contribution

Reza Ghorbanipour and Arefe Hajian Tilaki developed the original idea and protocol, Farhan Gholamian and Maryam Johari summarized the data, drafted the manuscript, Farhan Gholamian edited the article. Karimollah Hajian Tilaki analyzed the data. The study was supervised by Reza Ghorbanipour and Arefe Hajian Tilaki.

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