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Correlation between Cranial Base Morphology and Various Types of Skeletal Anomalies

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ABSTRACT

Background: Previous studies regarding various types of malocclusions have found correlations between the angle of the base of the skull and prognathism. **Aim of the study:** This cephalometric study sought to investigate the function of the cranium base angle in different types of malocclusion on a group of Romanian subjects. **Materials and methods:** Forty-four cephalometric radiographs were selected from patients referred to orthodontic treatment. The cephalometric records were digitized, and with the CorelDRAW Graphics Suite X5 software 22 landmarks have been marked on each radiograph. A number of linear and angular variables were calculated. **Results:** The angle of the base of the skull was found to be higher in Class II Division 1 subjects compared to the Class I group. The cranial base lengths, N-S and S-Ba, were significantly larger in both categories of Class II malocclusion than in Class I patients, but measurements were comparable in Class I and Class III. The SNA angle showed no considerable variation between Class I subjects and the other groups. SNA-SNP was significantly increased above Class I values in Class II Division1 and Class II Division 2 groups. No significant dissimilarities were observed for these lengths between Class I and Class III patients. **Conclusions:** The angle of the cranium base (S-N-Ba, S-N-Ar) does not have a major role in the progression of malocclusion. In Angle Class II malocclusion the SNA angle is increased, and SNB is increased in malocclusion Class III. The anterior skull base length is increased in Class II anomalies. The length of the maxillary bone base is increased in Class II malocclusions type; in Class III type of malocclusion the length of the mandible bone is increased.

Keywords: malocclusion, cranial base, skeletal anomalies, orthodontics

INTRODUCTION

There are several contradictions in the literature relating the length, the angulations of the skull base types of malocclusions and the extent of mandibular prognathism. One group argues that the cranial base flexure has no effect on the class of malocclusion or mandibular prognathism, whereas others state that the cranial base flexure is a determining factor.[1] For cephalometric measurement purposes, the maxillary bone is attached to the anterior part of the base of the skull that extends from the sella turcica (S) to the frontal-nasal suture (N). The

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mandible is attached to the posterior leg extending from the sella turcica (S) to the anterior margin of the foramen magnum, termed as basion (Ba). Consequently, geometric logic would dictate that any change in angulation between the anterior and posterior cranial base could influence the interaction between the maxillary and mandibular bones and affect the type of malocclusion.[2]

The cranial base angle, or saddle angle, is generally measured as the angle between the Basion-Sella-Nasion points on a radiograph, although the Articulare and Bolton points have also been used to describe the posterior limit, making it difficult to compare the results of different studies. At birth, the angle is approximately 142°, afterwards it decreases to 130° at 5 years of age. At the age of 5 to 15 years, the cranial base angle is relatively stable.[3] Therefore, the value of the skull base angle at the age of five could precisely predict the possible occlusal type of the patient at the age of 15 years.[4]

Previous studies regarding various types of malocclusions have found correlations between the angle of the base of the skull and prognathism, including a linear association involving the angle of the base of the cranium and prognathism.[5] Other researchers have obtained conflicting evidence, that there is no connection among the skull base angle and Angle's class I or class III. Evidently, the angle of the base of the skull is not the single aspect implicated in the development of malocclusion. Some authors have stated that, in individual cases, several factors might influence the static position of the mandible and the grade of prognathism.[6]

In view of the conflicting evidence, this cephalometric study sought to investigate the function of the skull base angle in different categories of malocclusion, on a group of Romanian subjects.

MATERIALS AND METHODS

Forty-four cephalometric x-rays were selected from patients referred to orthodontic treatment. Cephalograms were taken in centric relation, then surveyed and classified by the size of the A point–nasion–B point (ANB) angle into Angle's four categories and the skeletal sagittal classification (11 radiographs for each malocclusion group, with an age range between 8–12 years.)

- Class I – ANB angle between 2–4°;
- Class II – ANB angle is larger than 4°;
  - Division 1 – interincisal angle smaller than 135°;
  - Division 2 – interincisal angle larger than 135°;
- Class III – ANB angle is smaller than 2°.

Each group contained similar numbers of males and females.

The cephalometric records were digitized and 22 landmarks have been marked on each radiograph using the CorelDRAW Graphics Suite X5 software. A number of linear and angular variables were calculated:

- cranium base flexure (N-S-Ba, N-S-Art);
- maxilla and mandible position (SNA, SNB angles);
- skeletal pattern (ANB angle, maxillary mandibular planes angle);
- dento-alveolar pattern (upper incisors to maxillary plane angle, lower incisor to mandible plane angle, interincisal angle);
- cranial base lengths (N-S, S-Ba);
- maxilla and mandible lengths (Cd-SNA, Cd-Pog, Art-SNA, Art-Pog, SNA-SNP, Me-Go).

The error of the method was estimated using the Dahlberg formula. The variability was investigated using one-way analysis of variance (ANOVA). The group variable means for the Class II and Class III groups were compared with the Class I group by means of an independent t-test.

RESULTS

The results are shown in Tables 1 and 2. First, it was necessary to demonstrate that the data for each variable showed significant variance in the four malocclusion groups so as not to invalidate comparisons between individual malocclusion groups.

The cranial base angle was found to be significantly larger in Class II Division 1 subjects than in the Class I group. This difference was not found between Class I subjects and the other two malocclusion groups.

The cranial base lengths, N-S and S-Ba, were significantly larger in both divisions of Class II malocclusion than in Class I individuals, but measurements were similar in Class I and Class III.

The SNA angle showed no considerable variation between Class I subjects and the other groups. SNA-SNP was significantly increased above Class I values in Class II Division 1 and Class II Division 2 categories. No significant differences were observed for these lengths between Class I and Class III patients.

Mandibular length measurements (Gn-Go) were comparable in Class I and Class II patients, while it was significantly larger in the Class III group.

There was an inverse correlation involving the cranial base angle and the SNA and SNB angles. The cranial base

TABLE 1. Differences between skeletal parameters in Class I and Class II malocclusions

	Angle Class I			Angle Class II/Division 1				Angle Class II/Division 2			
Variable	**Mean**	**SD**	**SE**	**Mean**	**SD**	**SE**	**t**	**Mean**	**SD**	**SE**	**t**
N-S-Ba	131.2	4.8	0.6	136.4	4.95	0.7	−3.1**	134.6	4.5	0.64	−1.2
N-S-Art	124.7	4.99	0.7	128.2	5.4	0.77	−3.4**	124.9	4.57	0.64	−0.2
SNA	79.83	3.31	0.46	79.5	3.93	0.55	0.4	80.42	4.19	0.59	−0.7
SNB	76.93	3.11	0.44	74.37	3.56	0.5	3.84**	76.33	3.55	0.5	0.9
ANB	2.9	2.08	0.29	5.15	1.59	0.22	−6.1**	4.07	2.03	0.28	−2.9**
MMA	29.13	5.7	0.8	30.19	5.7	0.8	−0.9	24.98	4.39	0.62	4.1***
Imx	106.9	7.86	1.11	111.7	7.4	1.05	−3.14**	92.76	5.26	0.74	10.06***
Imn	90.72	6.46	0.91	92.96	6.4	0.9	−1.75	84.27	6.76	0.95	2.9***
I/I	133.2	11.5	1.62	126.1	9.86	1.39	3.33**	157.9	8.09	1.14	−12.49***
N-S	70	3.73	0.52	72	3.01	0.42	−2.9**	72.2	4.35	0.61	−2.83***
S-Ba	42.8	2.5	0.36	44.88	3.25	0.46	−3.56***	44.3	3.65	0.51	−2.5*
Cd-SNA	88.41	4.82	0.68	90.9	4.13	0.58	−2.84**	92.2	5.8	0.8	−4.06***
Cd-Pog	110	6.07	0.5	110.5	5.65	0.79	−0.34	113	7.79	1.1	−2.06*
Art-SNA	88.13	4.56	0.64	91.42	4.17	0.59	−3.8***	91.8	5.67	0.8	−3.61***
Art-Pog	102.1	5.56	0.78	103.1	5.51	0.78	−0.91	104.6	7.35	1.2	−1.9
SNA-SNB	51.63	3.33	0.46	53.6	3.07	0.43	−3.21**	54.07	3.58	0.5	−3.6***
Me-Go	68.26	5.67	0.8	68.35	4.31	0.6	0.01	69.51	5,47	0.77	−1.12
SNA-SNB / Me-Go	0.76	0.06	0.008	0.79	0.04	0.006	−3.0*	0.78	0.05	0.007	−1.87

* p <0.05; ** p <0.01; *** p <0.001

TABLE 2. Differences between skeletal parameters in Class I and Class III malocclusions

	Angle Class I			Angle Class III			
Variable	**Mean**	**SD**	**SE**	**Mean**	**SD**	**SE**	**t**
N-S-Ba	131.4	4.84	0.67	128.49	5.8	0.82	−1.5
N-S-Art	124.7	4.99	0.7	123.7	5.64	0.79	0.95
SNA	79.83	3.31	0.46	78.98	3.52	0.49	1.26
SNB	76.93	3.11	0.44	80.11	3.69	0.52	−4.67**
ANB	2.9	2.08	0.29	−1.14	3.06	0.43	7.79**
MMA	29.13	5.7	0.8	28.77	4.77	0.67	0.34
Imx	106.9	7.86	1.11	112.4	7.91	1.11	−3.5***
Imn	90.72	6.46	0.91	87.03	6.31	0.89	2.9***
I/I	133.2	11.5	1.62	131.8	11.25	1.59	0.62
N-S	70.0	3.73	0.52	70.16	3.03	0.42	−0.24
S-Ba	42.8	2.59	0.36	42.26	3.17	0.44	0.95
Cd-SNA	88.4	4.82	0.68	87.57	4.5	0.64	0..78
Cd-Pog	110.1	6.07	0.85	115.5	7.08	1.00	−4.11**
Art-SNA	88.13	4.56	0.64	86.97	4.5	0.64	1.3
Art-Pog	102.1	5.56	0.78	107.8	6.76	0.95	−4.64**
SNA-SNB	51.63	3.3	0.46	52.1	2.29	0.41	−0.08
Me-Go	68.26	5.67	0.8	71.41	5.73	0.81	−2.78***
SNA-SNB / Me-Go	0.76	0.06	0.008	0.72	0.05	0.007	3.74**

* p <0.05; ** p <0.01; *** p <0.001

angle and jaw lengths showed a weak correlation. The correlation between maxillary length and the SNA angle was small, but statistically significant. The correlation between mandibular length and the SNB angle was somewhat stronger. There was no apparent link between the cranial base angle and skeletal base pattern as indicated by vari-

TABLE 3. Correlation coefficients for the values from this study

	N-S-Art	N-S-Ba	N-S	SNA	SNB
SNA	−0.53**	−0.54**	−0.17**	–	–
SNB	−0.55**	−0.48**	−0.18**	–	–
ANB	0.06	0.03	0.33	–	–
SNA-SNP	0.07	0.04	0.51**	0,26**	0.02
Me-Go	0.02	0.003	0.42**	0.19	0.41**

TABLE 4. Correlation coefficients for Angle Class I

	N-S-Art	N-S-Ba	N-S	SNA	SNB
SNA	−0.48**	0.54**	−0.24	–	–
SNB	−0.45**	−0.56**	−0.22	–	–
ANB	−0.06	−0.08	−0.07	–	–
SNA-SNP	0.02	−0.20	0.42**	0.10	0.03
Me-Go	−0.02	−0.07	0.48**	0.18	0.31**

able ANB. Posterior cranial base length (S-Ba) was not associated with mandibular prognathism as measured by the SNB angle. There was no connection regarding the anterior length of the cranial base (N-S) and maxillary and mandibular prognathism, as measured by the SNA and SNB angles.

DISCUSSION

The study evaluated 44 lateral cephalometric x-rays. The study population was divided into four clusters of malocclusions (according to Angle's classification). The data from group 1 (type I of malocclusion) was very similar with other findings from previous studies.[7,8]

Although the distance between S-N is used to measure the anterior cranial base, some authors claim that using point Ba or Ar is more accurate.[9] On the other hand, Bjork says that point Ar should be included in the analysis due to its easier identification on radiographs.[10] Varjanna *et al.* used point Ba in their research because they considered that there is a larger distance between Ar and the cranial base.[11]

In this study, measurements between both points were included. It was observed that only the group with Angle Class II Division 1 type of malocclusion illustrated considerable differences for parameters N-S-Ba and N-S-Ar, compared to groups with Class I malocclusion.

Enlow showed that the growth of the maxillary bone is influenced by the cranial base, which is under the influence of the growth of the brain.[12] On the other hand, the mandible is not under the effects of these signals, although the contact with the cranial base through the glenoid fossa could encompass an influence in the growing process.

In previous studies it was shown that the degree of flexion at the cranium base does not influence the development of malocclusions.[13] However, the negative statistically significant correlation between the cranium base angle and the SNA and SNB angles implies that once the degree of flexion increases, skeletal and alveolar parts of the mandible are in a more distal position, like in a typical Class II Division 1 malocclusion.[14]

Similar findings with this study were found by Dhopatkar *et al.*, suggesting for example, that there is no connection between the length of the posterior cranium base and the degree of mandibular prognathism, but there is a positive correlation with the SNA angle. Another similar finding is that the S-N distance is correlated with the value of the SNA and SNB angles (with maxillary and mandibular prognathism).[15] This study was compared to Dhopatkar's research because similar cephalometric parameters were analyzed. The differences between these two studies are the number of cephalometric radiographs and a different method of digitization (direct online digitization).

This correlation between the SNA and SNB angles and the angle of the cranial base was similar to those found by Bjork and Kasai *et al.*, who demonstrated a relation between these angles and facial prognathism.[16,17] If the correlation is analyzed, we can conclude that the smaller the angle of the cranial base is, the mandible is in a more mesial position. Nevertheless, it is unattainable to know the cause-effect relationship of our results because other

TABLE 5. Correlation coefficients for Angle Class II Division 1

	N-S-Art	N-S-Ba	N-S	SNA	SNB
SNA	−0.51**	−0.58**	−0.31*	–	–
SNB	−0,50**	−0.55**	−0.19	–	–
ANB	−0.15	−0.22	0.22*	–	–
SNA-SNP	−0.05	−0.09	0.39*	0.22	0.29*
Me-Go	0.14	0.09	0.39*	0.13	0.24

TABLE 6. Correlation coefficients for Angle Class II Division 1

	N-S-Art	N-S-Ba	N-S	SNA	SNB
SNA	−0.71**	−0.65**	−0.22	–	–
SNB	−0.69**	−0.65**	−0.16	–	–
ANB	−0.26	−0.22	−0.17	–	–
SNA-SNP	−0.06	−0.11	0.57**	0.34*	0.27
Me-Go	−0.03	−0.10	0.53**	0.22	0.39*

TABLE 7. Correlation coefficients for Angle Class III

	N-S-Art	N-S-Ba	N-S	SNA	SNB
SNA	−0.55**	−0.47**	0.01	–	–
SNB	−0.46**	−0.42**	0.17	–	–
ANB	−0.09	−0.03	−0.18	–	–
SNA-SNP	0.23	0.35*	0.53**	0.28*	0.09
Me-Go	0.01	0.07	0.49**	0.34	0.55**

factors might be implicated. On the other hand, maxillary bone is also under the same influence of this cranial angle.[18]

CONCLUSION

The angle of the cranium base (S-N-Ba, S-N-Ar) does not have a significant role in the development of malocclusion. There is a positive correlation between the SNA and SNB angles and the length of the maxilla and mandible. The SNA angle is increased in Angle Class II malocclusion, while the SNB angle is increased in Class III malocclusion. The length of the anterior cranial base is increased in Class II anomalies, and is almost the same in Class I and Class III anomalies. The length of the maxillary bone base is increased in Class II malocclusions type; in Class III malocclusion the length of the mandibular bone is increased. The angle of the cranium base (N-S-Ba) is in a reverse correlation with the SNA and SNB angles; the correlation between N-S-Ba and the length of the bone is not significant.

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