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Relationship between cephalometric cranial base and anterior-posterior features in an Iranian population

Mohammad Monirifard[1], Saeid Sadeghian[2], Zahra Afshari[3], Elahe Rafiei[4], Asana Vali Sichani[3]

[1]Dental Materials Research Center, Department of Orthodontics, Dental Research Institute/Isfahan University of Medical Sciences, Isfahan, [2]Dental Research Center, Department of Orthodontics, Dental Research Institute/Isfahan University of Medical Sciences, Isfahan, [3]Dentist, Isfahan, [4]Department of Orthodontics, Shahid Sadoughi University of Medical Sciences, Yazd, Iran

ABSTRACT

Background: The relationship between the dimensions of the cranial base and skeletal anterioposterior problem has been controversial for years. The aim of this study was to determine the relationship between the anterioposterior cephalometric indicators and the cranial base cephalometric indicators in an Iranian population.

Materials and Methods: In this historical cohort cephalograms of 100 skeletal Class I patients, 101 skeletal Class II patients, and 98 skeletal Class III patients were selected. The cephalograms were traced manually and the indicators were measured. Finally, data were analyzed by SPSS software using the Mann–Whitney test and Pearson's correlation test. The significance level was set at 0.05. In cases that the correlation coefficient (*r*) was 0.6 or higher, linear regression was used.

Results: The dimensions of the cranial base are significantly larger in men than that in women. Anterior cranial base length (SN) showed statistically significant difference between Class I and Class II groups ($P < 0.05$). BaSN, ArSN, and SN-FH showed statistically significant differences between Class II and Class III groups ($P < 0.05$).

Conclusion: Smaller cranial base angle in the skeletal Class III malocclusion compared to skeletal Class II malocclusion has been demonstrated in this study. A significant correlation between the cranial base angle, the cranial base dimension, and the effective length of the maxilla was observed, and the smaller cranial base angle in Class III malocclusion was also confirmed. These findings indicate that the cranial base can affect the development of maxilla and mid-face.

Key Words: Malocclusion angle Class I, malocclusion angle Class II, malocclusion angle Class III, skull base

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Address for correspondence:
Dr. Asana Vali Sichani,
No. 554, Chahar
Bagh Bala Avenue,
Hale Alley, Isfahan, Iran.
E-mail: asanavalisichani@gmail.com

INTRODUCTION

The relationship between cranial base morphology and prognathism has been a point of interest for researchers.[1] Young and Bryce (1917) were the first to suggest the possibility of a link between the cranial base and malocclusion.[2] Bjork (1951) and Graber *et al*. stated that individuals with Class III malocclusion show abnormalities in their cranial base.[3-5]

The cranial base forms the floor of the cranial cavity; it is limited to foramen cecum in the anterior and to basioccipital in the posterior.[1] The sella(s) point is

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one of the most common cranial base landmarks for cephalometric evaluation. It is the reference point for assessing the position of the jaws in relation to the cranial base.[6] Sella is approximately in the middle of the cranial base and divides it into anterior (S-N) and posterior (S-Ba) portions.[1] The upper jaw is connected to the anterior portion, while the lower jaw is connected to the posterior portion.[7] According to geometrics, any change in the cranial base can affect the position of both jaws in relation to each other or the cranial base, thus affecting the skeletal pattern and malocclusion type.[1,7] Other unknown factors can also relate the cranial base to anteroposterior growth. The cranial base angle (saddle angle) is usually measured as Ba-S-N. Some studies prefer the articular (Ar) or the Bolton (Bo) point instead of basion (Ba).[8,9] This angle is about 142° at the time of birth but decreases to 135° in 5 years. The angle remains constant from the 5th to the 15th year.[10] Numerous studies have evaluated the relationship between cranial base flexion and mandibular prognathism, some reported no relation,[7,11] while others found cranial base flexion as an important factor.[12-14]

Determining if patient's growth will progress to a complete skeletal Class III position or not is a complicating matter in the treatment of patients with tendency to skeletal Class III before puberty. The patient's treatment plan can be affected: dental camouflage or waiting until growth is completed and performing orthognathic surgery. Regarding the controversial results of previous studies and the fact that the cranial base cephalometric indicators are stabilized in the first 5 years,[10] if a significant relationship between the anteroposterior growth pattern and cephalometric indicators exists, a prediction can be made about the patient's anteroposterior growth before puberty. The aim of this study was to determine a possible relationship between the anteroposterior facial cephalometric values and cranial base cephalometric values in an Iranian population.

MATERIALS AND METHODS

In this historical cohort, 100 Class I patient cephalograms (26 males, 74 females), 101 Class II patient cephalograms (17 males, 84 females), and 98 Class III patient cephalograms (43 males, 55 female) who had attended Isfahan Dental Faculty and three specialized orthodontic clinics from October 2015 to April 2016 were selected. The inclusion criteria are as follows:

1. All of the cases had normal faces
2. Cephalograms should be clear and readable
3. Patients should not have any congenital abnormalities or significant facial asymmetry
4. Patients should not have any orthodontic treatment before the cephalograms date
5. Class III patients who need mandibular setback
6. Class II patients who need mandibular advancement or were matched with the study cases
7. Class I patients with dental problems who need cephalograms
8. Patients older than 18 years or ones who have passed CS6.

The cephalograms were traced manually by two orthodontists. The measurements were carried out using a protractor (Dentaurum, Germany) by a calibrated dental student with an accuracy of 0.5 mm and 1°. The measurements were confirmed by an orthodontist. The cranial base indicators measured were Ba-S-N, S-N-FH, and Ar-S-N angles and Ba-S, S-N, and Ba-N lines. The anteroposterior facial indicators measured were ANB, SNA, SNB, facial angle, and facial plane to AB plane angles, while the linear indicators measured were the Witts appraisal, mandibular effective length (Ar-Pog), maxillary effective length (Ar-ANS), mandibular effective length to S-N ratio, and maxillary effective length to S-N ratio.

The samples were divided into three groups according to the anteroposterior cephalometric indicators:[15]

Group 1: class I patients had ANB between 0 and 3 and AB plan to Facial plan between -4 and +2

Group 2: class I patients had ANB more than 3 and AB plan to Facial plan less than -4

Group 3: class I patients had ANB less than 0 3 and AB plan to Facial plan more than +2

The radiographic magnification was calculated according to the ruler placed on the right side of the cephalograms. Data were analyzed by the SPSS software (IBM SPSS Statistic Version 22, Windows7, 64Bit). The Mann–Whitney test compared the cephalometric indicators between the groups. Pearson's correlation test (significance set at 0.05) was used to assess the correlation between the cranial base indicators and anteroposterior facial indicators. If the correlation was 0.6 or higher, linear regression was calculated.

RESULTS

The Mann–Whitney test compared the cranial base indicators according to the patient's sex [Table 1].

Table 2 shows the mean and standard deviation for cranial base cephalometric indicators. Only the anterior cranial base length showed significant difference between Class I and Class II patients ($P = 0.03$). The indicators which were significantly different between Class II and Class III patients were Ba-S-N ($P = 0.04$), Ar-S-N ($P = 0.02$), and S-N-FH ($P = 0.04$) angles.

Table 3 shows the result of the Pearson's correlation test between cranial base features and anterior-posterior features.

The linear formula of anterior cranial base and maxillary effective length is: maxillary effective length: 19.71 + 0.99 (anterior cranial base length).

The linear regression formula of total cranial base and maxillary effective length is: maxillary effective length: 11.91 + 0.74 (total cranial base length).

Table 1: Cranial base indicators based on gender in study group

Study group	Cranial base cephalometric features					
	Ba SN (°)	Ar SN (°)	SN-FH (°)	BaS (mm)	SN (mm)	NBa (mm)
Male						
Mean	128.65	123.17	7.69	45.83	68.70	103.72
Class I						
SD	4.96	4.96	3.49	3.30	4.11	5.55
Mean	127.76	122.41	6.82	45.37	70.38	104.76
Class II						
SD	3.64	3.12	2.77	3.27	3.81	5.39
Mean	128.65	123.17	7.69	45.83	68.70	103.72
Class III						
SD	4.96	4.96	3.49	3.30	4.11	5.55
Female						
Mean	130.64	124.42	9.07	42.55	65.58	98.57
Class I						
SD	4.77	4.88	2.86	3.00	4.71	3.22
Mean	131.72	125.43	8.56	42.63	66.76	100.28
Class II						
SD	5.04	5.62	2.99	2.66	3.38	4.61
Mean	130.29	122.56	9.9	41.59	65.55	97.46
Class III						
SD	5.07	5.20	2.79	2.37	2.57	3.57
Comparative *P* value based on gender						
Class I	0.087	0.335	0.210	<0.001**	0.001**	<0.001**
Class II	0.001**	0.011*	0.030*	0.001**	0.001**	0.002**
Class II	0.172	0.210	0.028*	<0.001**	<0.001**	<0.001**

*Significant ($P<0.05$), **Significant ($P\leq0.001$). SD: Standard deviation

DISCUSSION

Mandibular growth importance has become more than obvious, especially in Class II treatment.[16] Mandible acts more independently in comparison of the maxilla because of its remoteness from the cranial base.[17]

Most studies have only compared one or two malocclusion classes with control groups,[7,11,12,18] but this study compares all three malocclusion classes. S-N is regarded as the anterior cranial base; however, when measuring the posterior cranial base, there is controversy in using the basion or articular points. Bjork preferred the articular point because he believed that finding it was easier.[19] Kerr and Adams chose the basion point for measuring the cranial base angle.[20] Bhatia and Leighton used both Ba-S-N and Ar-S-N angles and both Ba-S and Ar-S and reported that the growth patterns described using the basion or articular points were very similar.[21] In our study, we used both points for measuring the cranial base angle and the basion point for measuring the posterior cranial base length, similar to the study of Kerr and Adams.[20]

Our results showed that the anterior cranial base length was significantly increased in Class II patients

Table 2: Cranial base cephalometric indicators in the study group

Cranial base cephalometric features	Study groups					
	Mean (SD)			Comparative *P* value between		
	Class I	Class II	Class III	Class I and Class II	Class I and Class III	Class II and Class III
BaSN (°)	130.13 (4.88)	131.05 (5.04)	129.74 (5.17)	0.2	0.3	0.04*
Ar SN (°)	124.10 (4.84)	124.93 (5.38)	123.09 (5.35)	0.2	0.9	0.2*
SN-FH (°)	8.71 (3.08)	8.27 (3.01)	9.14 (3.40)	0.2	0.2	0.04*
Bas (mm)	43.40 (3.39)	43.09 (2.94)	43.62 (3.74)	0.8	0.8	0.7
SN (mm)	66.39 (3.72)	67.37 (3.69)	67.02 (3.73)	0.03*	0.2	6.3
NBa (mm)	99.91 (5.41)	101.31 (5.01)	100.31 (5.55)	0.06	0.7	0.1

Significant ($P<6.03$), *Significant ($P<0.05$). SD: Standard deviation

Table 3: Correlation between cranial base features and anterior-posterior features

Anterior-posterior features	Cranial base features					
	Ba SN (°)	Ar SN (°)	SN-FH (°)	BaS (mm)	SN (mm)	NBa (mm)
R ANB (°)	0.126*	0.126*	−0.063	−0.104	−0.037	−0.005
R SNA (°)	0.053	−0.058	0.429**	−0.223**	−0.284**	−0.285**
R SNB (°)	−0.054	−0.145*	0.404**	−0.105	−0.206**	−0.232**
R Facial angle (°)	−0.056	−0.124*	0.427**	−0.087	−0.171**	−0.195**
R AB to facial plan (°)	−0.113	−0.127*	0.080	0.086	−0.011	−0.028
R Ar-ANS (mm)	0.154**	0.298**	−0.218**	0.417**	0.691**	0.736**
R Witts appraisal (mm)	0.172**	0.204**	−0.091	−0.096	0.103	0.096

*Significant (P<0.05), **Significant ($P \leq 0.001$)

compared to Class I patients, but the difference was not significant between Class I and Class III and also between Class II and Class III. Posterior cranial base and total cranial base lengths had no significant difference between the three classes. Salehi and Danaei[22] studied an Iranian population and reported that only anterior cranial base length had a significant difference between Class I and Class II patients, which was similar to our results. Dhopatkar *et al*.[1] reached the same results; the only difference was that their study also showed the posterior cranial base (Ba-S) length being significantly increased in Class II patients compared to Class I. This difference could be due to the different populations investigated. Sanggarnjanavanich *et al*.[23] found no significant difference between Class I and Class III patients regarding anterior (S-N) and posterior (Ba-S) cranial base lengths. Sayin and Türkkahraman[24] studied patients with Class II Division 1 malocclusion and Class I occlusion and proved that anterior and posterior cranial base length is significantly shorter in Class II patients, which does not agree with our findings. Proff *et al*.[13] stated that Class III patients showed a significant decrease in the total cranial base length (Ba-Ca, Ar-Ca) (Ca = foramen cecum) compared to Class I controls, which is in contrast with our study. Hopkin *et al*.[25] showed a progressive increase in the cranial base length from Class III to Class I to Class II, while our study also showed an increased length in Class II patients compared to Class I. Mouakeh[12] reported that both anterior and posterior cranial base length was significantly smaller in Class III patients. Sanborn[11] also stated that the anterior cranial base length is significantly smaller in Class III patients. Our results are in contrast with these studies.

Some cephalometric studies have reported that Class III patients have a shorter anterior and posterior cranial base length compared to Class I and Class II patients.[12,25-28] It appears that the posterior cranial base has a more important role in Class III anomalies due to its proximity to the mandibular complex. The glenoid fossa is located in the posterior cranial base, and any increase in the posterior cranial base length pushes the glenoid fossa and subsequently the mandible backward.[13] Our results do not confirm this geometrical theory because the posterior cranial base length had no significant difference between the study groups. Some researchers believe that the cranial base is a contributing factor in the development of the maxilla and mid-face complex; therefore, it seems that anterior cranial base changes can be a cause for Class III anomalies with maxillary deficiency.[20,26] Our study confirmed that the anterior cranial base was shorter in Class III patients compared to Class II patients, but the difference was not significant. The most significant proved cranial base anomaly in Class III patients is the decrease in the angle between anterior and posterior cranial bases.[14,25] Our study showed that the Ba-S-N and Ar-S-N angles increased from Class III to Class I an then to Class II. But the difference was only significant between Class II and Class III patients. Our results are similar to those of Sanborn[11] who stated that the cranial base angle (Ar-S-N) had no significant difference between Class III and normal occlusion groups. Sanggarnjanavanich *et al*.[23] also reported that the S-N/FH angle had no significant difference between

Class I and Class III groups, which is similar to our results. Some studies have compared the cranial base angle between Class III and Class I malocclusions and reported that the angle is significantly decreased in Class III patients, which does not agree with our results.[12,29,30]

Our study showed no significant difference between Class I and Class II patients regarding the cranial base angle, which is similar to the results of Wilhelm *et al*.[18] and Varrela,[31] but does not agree with the results of Sayin and Türkkahraman[24] and Anderson and Popovich.[14] The geometrical reasoning proposed in some studies is that the more the cranial base angle is closed, the more it affects the condyle and pushes it forward, resulting in a prognathic mandible.[11,13,25] Our study also showed decreased cranial base angle in Class III patients. The lack of significant difference regarding cranial base angle between Class I and Class III and also between Class I and Class II groups in our study, which does not agree with the mentioned studies, could be due to race, sample size, and measurement differences.

Our study proved a direct and significant relationship between cranial base angle and the ANB angle, which is similar to the results of Sayin and Türkkahraman[24] and is in contrast with the results of Klock *et al*.[9]

This study found no significant relation between the cranial base angle (Ar-S-N, Ba-S-N) and the SNA angle. Only the Ar-S-N and SNB angles had a significant reverse relation. Järvinen[27] stated that SNA can be affected by the cranial base so that with the increase of the cranial base angle, SNA decreases and vice versa. This could be in part due to geometrical reasons. Klock *et al*.[9] reported that patients with increased cranial base angle, show decreased SNA and SNB angles. Our study also showed a reverse relation between Ar-S-N and SNB angles. Andria *et al*.[7] reached similar results with our study and showed that Ba-S-N had no significant relation with SNA, SNB, and Ar-Pog.

Our study showed a significant direct relation between the cranial base angles (Ar-S-N, Ba-S-N) and Witts appraisal, which is similar to the results of Proff *et al*.,[13] who showed a significant relation between the Witts appraisal and Ba-S-Ca and Ba-S-N angles.

The results of our study showed a significant direct relation between the posterior cranial base length (Ba-S) and the maxillary (Ar-ANS) and mandibular (Ar-Pog) effective lengths and a significant reverse relation with SNA. Andria *et al*.[7] showed that Ba-S has a significant reverse relation with facial angle and the B point. Our findings showed a significant reverse relation between S-N length and SNA and between SNB and facial angle and a direct relation with maxillary effective length and mandibular effective length.

Sayin and Türkkahraman[24] showed that anterior and posterior cranial base lengths have a reverse relation with ANB, while our study found no significant relation. Our results found no significant relation between the cranial base and anteroposterior skeletal conditions. Our findings showed a significant reverse relation between total cranial base length with SNA, SNB, and facial angle and significant direct relation with maxillary and mandibular effective lengths. The cranial base angle had a direct relation with the maxillary effective length, and the S-N/FH angle had a reverse relation with the maxillary effective length. Our study compared the cranial base dimensions between men and women and found that the dimensions are bigger in men. Wilhelm *et al*. [18]also stated that Class II men have a larger cranial base compared to women. Lewis *et al*.[32] stated that men show more cranial base length increase. The different results of our study compared to other studies could be due to racial, sample size, and measurement technique differences. Maxillary effective length had a direct relation with anterior cranial base length and total cranial base length (r = 0.6). This confirms the increased anterior cranial base length in Class II patients, which results in maxillary length increase. Our study found no significant relation between cranial base factors and the factors contributing to mandibular prognathism.

CONCLUSION

The cranial base dimensions are bigger in men compared to women. The cranial base angle is smaller in Class III malocclusion compared to Class II. The S-N/FH angle is greater in Class III malocclusion compared to Class II. Maxillary effective length has a direct relation with anterior, posterior, and total cranial base lengths and also the cranial base angle. It has a reverse relation with the S-N/FH angle. Mandibular effective length has a direct relation with anterior, posterior, and total cranial base lengths.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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