Official Dental Journal of Suez Canal University
DENTAL SCIENCE Updates
Print ISSN 2636-3836
Online ISSN 2636-3844
www.dsujournals.ekb.eg
DSU — Vol. 4, No. 1, March (2023) — PP. 195:203

CORRELATION BETWEEN CRANIAL BASE ANGLE AND VARIOUS TYPES OF SAGITTAL SKELETAL DISCREPANCIES

Ahmed Sayed Mohammed El Masry [1], Mohamed Adel Nadim [2], Ahmed Abd El Fattah Ramadan [3]

DOI: 10.21608/dsu.2023.154810.1137
Manuscript ID: DSU-2208-1137

KEYWORDS

Cranial base angle, Lateral Cephalometric radiographs, sagittal skeletal discrepancies.

- E-mail address: Aelmasry9292@gmail.com

1. Post graduate student at Orthodontics Department, Faculty of Dentistry, Suez Canal University, Ismailia, Egypt.
2. Professor of Orthodontics, Faculty of Dentistry, Suez Canal University, Ismailia, Egypt.
3. Professor of Orthodontics, Faculty of Dentistry, Suez Canal University, Ismailia, Egypt.

ABSTRACT

Introduction: The cranial base angle is of great importance in determining sagittal skeletal discrepancies and the lateral cephalometric radiograph is a valuable tool in measuring the saddle angle (cranial base angle) relationship with skeletal maxillary and mandibular positions. **Aim:** To identify the correlation between measurements of the cranial base angle and various types of sagittal skeletal discrepancies using lateral cephalometric radiographs. **Methods:** The selected study sample included a total number of 60 cephalometric radiographs of patients ranging in age from [15-25] years, the radiographs were traced for the examined linear and angular measurements. **Results:** Results of the present study showed no significant difference between the cranial base angle measurements in Class II malocclusion and skeletal Class I normal readings. In addition, the cranial base angle was significantly smaller than normal in individuals with skeletal class III, especially cases caused by mandibular protrusion. **Conclusion:** In conclusion there was a positive correlation between the cranial base angle and skeletal class III cases, especially those caused by mandibular protrusion. However, no correlation was found between the cranial base angle measurements in Class II malocclusion and skeletal Class I normal readings.

INTRODUCTION

It has been always of paramount interest of orthodontists to study the skull anatomy and try to predict the growth pattern early in life(1-3), hence, early treatment or growth modifications could be initiated before further complications occur. Different techniques and theories were introduced to help in doing so, such as anthropometric and radiographic techniques. In spite of the various methods introduced, no technique was considered conclusively accurate. Radiographic assessment of the saddle angle (cranial base angle) parameters was one of these trials, due to its early completion during growth before all other jaw relationships of sagittal, transverse and vertical planes settle. Therefore, by visualizing the cranial base angle and obtaining accurate measurements early enough, we can predict -to an extent- the jaws' sagittal relationship at an early stage (4-8).

Many studies have been performed on the relationship between the cranial base anatomy on different populations using different linear and angular parameters, each resulted in different findings and results. The origin of this suggested relation rises from the ultimate direct contact between the cranial base angle, mainly by its anterior leg with the maxillary complex, in addition to the direct relation and contact of its most posterior part with the mandibular condyles. Based on that, it is hypothesized that any change in the cranial base measurements would in turn affect the maxillary and the mandibular positions, especially in the antero-posterior plane [4-7]. Therefore, the present study was conducted to determine the correlation between measurements of the cranial base angle and various types of antero-posterior skeletal discrepancies using lateral cephalometric radiographs in a sample of Egyptian population.

MATERIALS AND METHODS

The present study was carried out on 60 Lateral Cephalometric radiographs of Egyptian patients ranging in age from [15-25] years. The selected radiographs were chosen after the examination of an initial number of 120 radiographs obtained from the archives of the Oral Radiology Department, Faculty of Dentistry, Suez Canal University. The present study was conducted after the approval of the Research Ethics Committee (REC) of the Faculty of Dentistry, Suez Canal University with approval number (113/2018).

Sample size calculation

According to the sample size calculation [9], a minimum number of forty-eight radiographs was required in the present study, however the sample size was increased to 60 radiographs for more accurate and reliable results.

Inclusion Criteria:

The lateral cephalometric radiographs included in the study were chosen to fulfil the following eligibility criteria:

- No gender predilection.
- No apparent trauma (as revealed radiographically).
- Good quality radiographs with no distortion.
- No orthodontic appliances seen radiographically.

Sample Grouping:

According to the ANB cephalometric angle, the sample was divided into three equal groups, each representing one of the skeletal classes, each group included 20 radiographs: [3]:

Group 1: Class I – ANB angle between 2–4°

Group 2: Class II – ANB angle is larger than 4°

Group 3: Class III – ANB angle is smaller than 2°

ANB cephalometric angle: Is the angle which measures the relative position of the maxilla to mandible.

The assignment of radiographs into the study groups was confirmed using WITS linear measurement, defined as the linear dimension which measures the relative position of the maxilla to mandible.

Cephalometric analysis:

The selected anatomical reference landmarks used for obtaining the required linear and angular measurements used in cephalometric analysis are included in table (1).

Table (1) *The anatomical landmarks used for linear and angular measurements in cephalometric analysis*

Points	
A point (A)	*Condylion*
Articulare (Ar)	*Anterior Nasal Spine (ANS)*
B point (B)	*Posterior Nasal Spine (PNS)*
Sella (S)	*Gonion (Go)*
basion (Ba)	*Gnathion (Gn)*
Nasion (N)	*Menton (Me)*
Orbitale (Or)	*Pogonion (Pog)*
Porion (Po)	

While table (2) represents the angles and linear measurements used for radiographic analysis.

The additional linear and angular parameters included in the table, were assessed to verify results and exclude any errors that may have arised from misinterpretation.

Table (2) *The angles and linear measurements used for cephalometric analysis*

Angles/Linear measurements	
• ***Cranial base angles, (N-S-Ba, N-S-Art).***	• ***Cranial base length (N-S, S-Ba).***
• ***Maxillary and mandibular positional angles, (SNA, SNB angles).***	• ***Maxillary and mandibular lengths, (Cd-SNA, Cd-Pog, Art-SNA, Art-Pog, ANS-PNS, Me-Go, Cd-Go).***
• ***Dento-alveolar patterns, (ANB angle , Maxillary Mandibular plane angle).***	

Digital analysis of the cephalometric image: -

Cephalometric analysis was carried out for each radiograph using Dolphin Imaging Software/32 (Version 11.5, build 36), then, Webceph online tracing was done for verification of the radiographic readings to obtain accurate readings of the cranial base angle **(N-S-Ba)** as well as the additional maxillary and mandibular parameters used for analysis.

- The cephalometric radiograph was adjusted and aligned in the vertical and horizontal planes to prepare the image for marking the selected cephalometric landmarks.
- The analysis was customized by selection of the analysis measurements and landmarks. (Fig 1)
- The selected landmarks of the chosen analysis was plotted by opening the window of the needed subject to retrieve the stored digital image from the archive. The radiographic landmarks were identified with the click of the mouse arrow on the monitor screen over the selected landmark, following the program instructions that appear after each mouse click in a successive cascade manner.
- At the end of this process, the program spontaneously gives rise to the assessed lines and angles of the customized analysis.
- Then, the radiographs were divided into the three skeletal groups based on the value of ANB angle.
- Finally, the obtained readings and measurements were compared between the three skeletal sagittal groups.

Statistical analysis of the data:

Data from linear and angular measurements was fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Quantitative data was described using range (minimum and maximum), mean, standard deviation and median. Significance of the obtained results was judged at the 5% level.

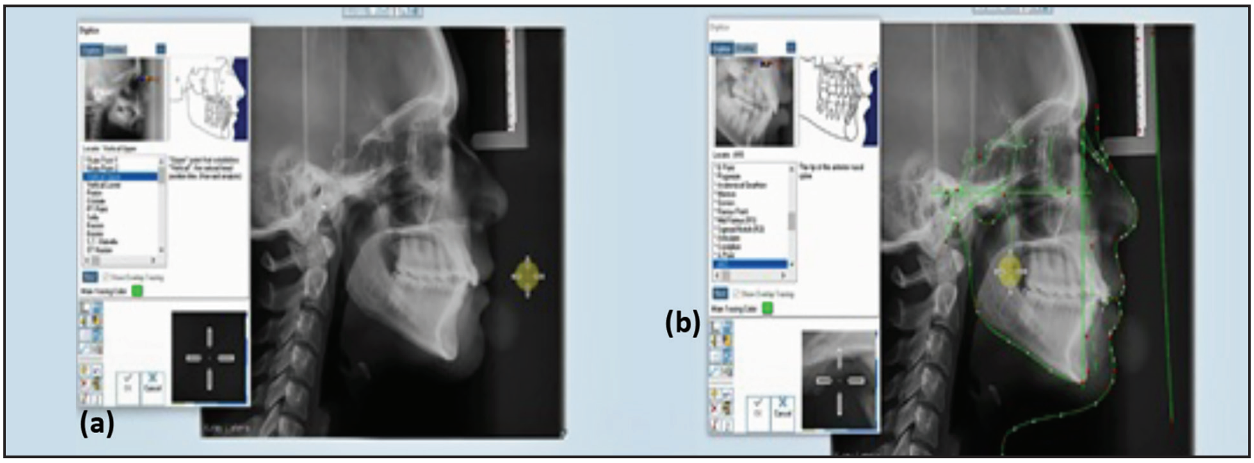

Fig. (1) (a) selection of the analysis measurements and landmarks, (b): refining the lines and angles between the traced points.

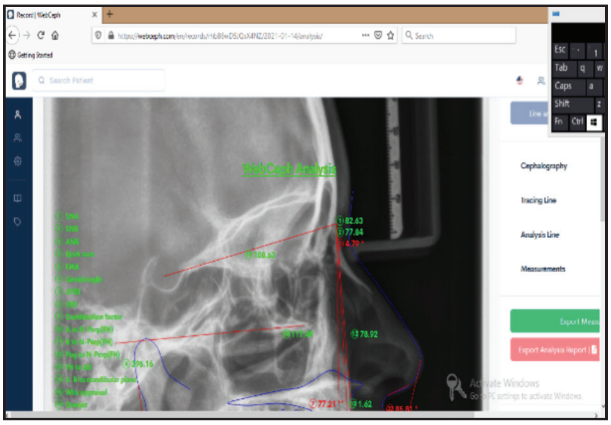

Fig. (2) Webceph tracing

RESULTS

Table (3) presents results of the comparison between the three study groups regarding the different study parameters

It was found that there was no significant difference in the cranial base angle measures (N-S-Ba) between ***Group 2*** (Class II malocclusion) and ***Group 1*** (skeletal Class I) normal cases and readings. In addition, the cranial base angle was significantly smaller than normal in the population with skeletal class III (group III), especially those caused by mandibular protrusion. Regarding the other parameters evaluated in the present study, the NSBa and SNA angles showed non-significant difference between groups with p-value (p=0.271) and (p=0.087) respectively. However, the value of SNB angle showed a statistically significant difference (p=0.001) between the study groups as well as ArGoMe and GoPg which showed significant difference with (p=0.001). (p=0.001) respectively.

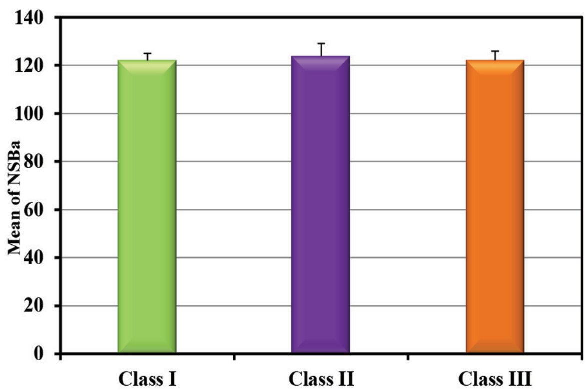

Fig. (3) Comparison between the three studied groups according to N-S-Ba

Table (3) *Comparison between the three studied groups regarding the cranial base angle and the different study parameters*

	Class I (n = 20)	Class II (n = 20)	Class III (n = 20)	p
ANB				
Mean ± SD.	3.52 ± 0.64	6.53 ± 1.06	-0.23 ± 2.0	$<0.001^*$
Sig. bet. gps.	$p_1<0.001^*, p_2<0.001^*, p_3<0.001^*$			
WITS				
Mean ± SD.	-0.54 ± 1.41	4.01 ± 3.14	-5.78 ± 4.0	$<0.001^*$
Sig. bet. gps.	$p_1=0.001^*, p_2=0.001^*, p_3<0.001^*$			
NSBa				
Mean ± SD.	122.0 ± 3.02	123.87 ± 5.22	122.03 ± 3.91	0.271
SNA				
Mean ± SD.	82.70 ± 3.93	82.83 ± 2.15	80.56 ± 4.25	0.087
SNB				
Mean ± SD.	78.93 ± 3.39	76.37 ± 2.28	80.58 ± 4.26	0.001^*
Sig. bet. gps.	$p_1=0.054, p_2=0.283, p_3=0.001^*$			
ArGoMe				
Mean ± SD.	123.24 ± 5.11	123.07 ± 6.98	82.42 ± 9.83	$<0.001^*$
Sig. bet. gps.	$p_1=0.997, p_2<0.001^*, p_3<0.001^*$			
GoPg				
Mean ± SD.	75.55 ± 3.98	72.84 ± 3.76	80.76 ± 4.46	$<0.001^*$
Sig. bet. gps.	$p_1=0.099, p_2<0.001^*, p_3<0.001^*$			

p: p value for comparing between the studied groups
p_1: p value for comparing between **Class I** *and* **Class II**
p_2: p value for comparing between **Class I** *and* **Class III**
p_3: p value for comparing between **Class II** *and* **Class III**
**: Statistically significant at $p \le 0.05$*

DISCUSSION

It has been always of interest for clinicians [1-3] to achieve a method for growth prediction for many reasons, orthodontic treatment procedure is one of these reasons. Understanding the pattern of growth of the jaws in a younger age would help in preventing certain malocclusions or decrease the possibility of occurrence in the future as well as aid in treatment retention. This is done mostly by using anatomical landmarks that have completed their growth earlier in the childhood years to obtain certain linear and angular measurements and corelate them to other linear and angular measurements that affect growth and complete their development later in life. [4,6,7].

The cranial base angle is mostly stable and completes its growth at the age of five years old[4], therefore, finding a correlation between it and the antero-posterior (sagittal) position of the jaws, would help in prediction of the need of orthodontic treatment. Up to our knowledge, within the available literature, no study was conducted on the Egyptian population to determine if a correlation between the cranial base angle and the types of sagittal skeletal malocclusions exists, hence, the aim of the present study was chosen.

The present study was carried out on lateral cephalometric radiographs being the most commonly used radiograph used by orthodontists for skeletal analysis [3, 4]. The age group of the study sample was chosen to be in a window between 15 to 25 years old, since the cranial base angle is mostly stable after the puberty growth spurt in males and females. Although the cranial base angle and lengths are stable after the age of 5 years old, however, minor changes occur during the growth spurt for males around the age of 14, and females around the age of 12 [4], therefore ages older than 15 were chosen for the study.

There was no gender predilection in the chosen radiographs, because it is found that after a certain age, males and females show almost the same relationship between their cephalometric readings regarding the cranial base measures and other related readings [4].

No signs of trauma in the study sample was necessary, since trauma to the skull or facial region would directly affect the growth pattern, in addition trauma to the face would alter the maxillary and mandibular measures including mainly the sagittal measures [10].

In addition, the sample was free of any patient that showed orthodontic treatment, because any orthodontic treatment could alter the skeletal bases positions, which by turn changes the A point and B point positions, and change the skeletal sagittal occlusion, especially if the treatment included the use of functional appliances. Therefore, the cranial base angle correlation with any point in the maxilla or the mandible would not be real [11].

The ANB angle was the angle of choice in determining the antero-posterior position of the maxilla and the mandible because it compares points on the maxillary and the mandibular bases to a fixed point on the cranial base which is the Nasion. Alternatively, ANB is the subtraction value of SNA and SNB angles (SNA – SNB = ANB). The value of the ANB angle determines the skeletal relation type in Antero-posterior or the sagittal plane. ANB correction was not used, because all the sample radiographs were selected with normal Antero-posterior position of the Nasion point. Side by side to the ANB angle measuring, WITS analysis was done to assure the ANB angle readings and confirm it regarding the sagittal skeletal classes [12].

The Dolphin software with the webceph online site were used for tracing of the lateral cephalometric radiographs. Those software methods give the same results as the old manual tracing methods, but with less time consumption, and sometimes more accuracy. The use of features of the computerized cephalometric tracing software such as zoom, changes in brightness density and contrast, were useful to achieve cephalometric tracing much better than a fixed radiographic film [13].

The Gonial angle and the mandibular body length were traced because they are in a direct relation with the outcomes of the sagittal position of the mandible and its relation with the maxilla. So, any readings that were abnormal regarding those measurements could camouflage the other results concerning the mandibular position as a whole [14].

Regarding class II relationship, results of the present study found no difference between the cranial base angle and the antero-posterior jaw relationships. This was in agreement with studies done by various researchers as Dhopatkar et al [15], Shah et al [16], Andria et al [17], Afrand et al [18], Tinano et al [19] and Wilhelm et al [20], those previous studies found no relation between the saddle angle and any of the sagittal skeletal relationships in general.

Additionally, studies done by Proff et al[21], Chang et al[22], Sanggarnjanavanich et al[23], Sichani et al [24] and Flores-Ysla et al [25], found no significance between skeletal class II and the saddle angle measurements.

On the other hand, other studies done by Cutovic et al [26] and Mestriner & Valente [27] found correlation between the saddle angle measurements in the antero-posterior maxillary and mandibular positions in skeletal class II as well as in Class III.

Similar to the previous results, the study done by Mehta et al [28] found positive correlation between the saddle angle and the mandibular positions, but only in retrusion and protrusion and not the maxillary positions. Regarding the findings regarding class II in the previous studies, they were not on line as the current study results.

Such discrepancy may be due to that the majority of the previous studies which found a positive correlation between the cranial base angle and the skeletal class II relation, were conducted on European populations, not on Egyptians.

Regarding skeletal class III relation, results of the current study revealed a significant correlation with the saddle angle, especially with the mandibular positions. Studies performed by Proff et al [21],Chang et al [22], Sanggarnjanavanich et al [23], Sichani et al [24] and Flores-Ysla et al [25], were on the same line with our study. Additionally, studies conducted by Mehta et al [28], Cutovic et al [26] and Mestriner & Valente [27], as mentioned previously, found positive correlation between the saddle angle and class III malocclusion.

On the other hand, results of the studies done by Dhopatkar et al [15], Shah et al [16], Andria et al[17], Afrand et al[18], Tinano et al[19] and Wilhelm et al[20], found no correlation between the saddle angle with the maxillary and mandibular positions in not only class III, but in any skeletal sagittal abnormal relation.

However, it should be mentioned that the studies that found no correlation between the saddle angle and the sagittal relation of 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 protrusion, were because those studies were not performed on a sample that included class III cases at all, or 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 Angle classification or British Standards Institute incisor classification.

CONCLUSIONS

Within the limitations of the current study, the following was concluded:

The cranial base angle measurements were comparable between class I and class II cases, however, class III cases showed smaller than normal cranial base angle, especially in the cases caused by mandibular protrusion.

REFERENCES

1. Proffit W, Fields H, Sarver D. Contemporary orthodontics, 4th ed. St. Louis, Mo, Mosby Elsevier;; 2007.:495-496.
2. Mitchell L, Littlewood S, Nelson-Moon Z, Dyer F. An introduction to orthodontic., 4th ed. Oxford University Press; ; 2013.:73-84.
3. Ricketts R. A foundation for cephalometric communication. Am J Orthod 1960;64:330-357.
4. Moss M, Greenberg SN. Post-natal growth of the human skull base. Angle Orthod 1955;25:77-8
5. Singh A, Wessell A P, Anand V K, Schwartz T H. Surgical anatomy and physiology for the skull base surgeon. Oper Tech Otolaryngol Head Neck Surg 2011; 22:184-193. doi: 10.1016/j.otot.2011.08.014
6. Renfroe E. Study of facial pattern associated with class I, class II div I and class II div II malocclusions. Angle Orthod 1948;19:12-15.
7. Gkantidis N, Halazonetis D. Morphological integration between the cranial base and the face in children and adults. J Anat 2011; 218(4): 426-438.
8. Scott J. The cranial base. Am J Phys Anthropol 1958; 16(3),319-348.
9. Arkin H. Handbook of Sampling for Auditing and Accounting, 3rd ed, McGraw-Hill, 1984; 3:21.
10. National Library of Medicine, American Medical Association. Cumulated index medicus. Bethesda, Md:U.S. Depart of Health, Public Health service, National Institutes of Health; 1960.
11. Ricketts RM. The influence of orthodontic treatment on facial growth and development, 1960. Angle Orthod; 30:103-33.
12. Davies C. Textbook for orthodontic therapists. John Wiley & Sons; 2020:286-289.
13. Premkumar S. Textbook of orthodontics, 1st ed. E-Book, Elsevier India; 2015.;338-342.
14. Kim YH, Kang SJ, Sun H. cephalometric angular measurements of the mandible using three-dimensional computed tomography scans in Koreans. Arch Plast Surg 2016; 43(1):32–37.
15. Dhopatkar A, Bhatia S, Rock P. An investigation into the relationship between the cranial base angle and malocclusion. Angle Orthod 2002; 72:456–463.
16. Shah R, Mushtaq M, Mahmood A. The relationship between cranial base angle and various malocclusion types. Pak Orthod J 2015; 7(1):8-12.
17. Andria, Louis, Leite, Luis, Prevatte, Tracie, King, Lydia. Correlation of the cranial base angle and its components with other dental/skeletal variables and treatment time. Angle Orthod 2004; 74(3): 361-6.
18. Afrand M, Ling C, Khosrotehrani S, Flores-Mir C, Lagravère-Vich M. Anterior cranial-base time-related changes: A systematic review. Am J Orthod Dentofacial Orthop 2014;146(1):21-32.
19. Tinano M, Martins M, Bendo C, Mazzieiro E. Base of the skull morphology and Class III malocclusion in patients with unilateral cleft lip and palate. Dental Press J Orthod 2015;20(1):79-84.
20. Wilhelm B, Beck F, Lidral A, Vig K. A comparison of cranial base growth in Class I and Class II skeletal patterns. Am J Orthod Dentofac 2001;119(4):401-405.
21. Proff P, Will F, Bokan I, Fanghnel J, Gedrange T. Cranial Base Features in Skeletal Class III Patient. Angle Orthod 2008;78(3):433-439.

22. Chang H, Chou T, Hsieh S, Tseng Y. Cranial-Base Morphology in Children with Class III Malocclusion,. Kaohsiung J Med Sci 2005; 21(4):159-165.

23. Sanggarnjanavanich S, Sekiya T, Nomura Y, Nakayama T, Hanada N, Nakamura Y. Cranial-base morphology in adults with skeletal Class III malocclusion. Am J Orthod Dentofac 2014; 146(1):82-91.

24. Sichani A, Monirifard M, Sadeghian S, Afshari Z, Rafiei E. Relationship between cephalometric cranial base and anterior-posterior features in an Iranian population. J Dent Res 2020; 17(1):60.

25. Flores-Ysla A, Arriola-Guillén L, Rodriguez-Càrdenas Y, Ruiz-Mora G, Aliaga-Del Castillo A, Janson G. Skeletal open bite cranial base characteristics in young Latin-American individuals with class I, II and III malocclusions: An observational study. Inter Ortho2020; 18(2):237-245.

26. Cutovic T, Jovic N, Stojanovic L, Radojicic J, Mladenovic I, Matijevic S, Kozomara R. A cephalometric analysis of the cranial base and frontal part of the face in patients with mandibular prognathism. Vojnosani pregled 2014; 71(6):534-541.

27. Mestriner Junior W, Valente A. Facial prognathism and its relation to the cranial base in Brazilian children with Class I malocclusion. Rev Odontol Univ Sao Paulo 1989; 3:324-333.

28. Mehta N, Parekh H, Patel D, Trivedi R, Bhatia A, Bhattacharya A. Evaluation of relationship between cranial base angle and maxillofacial morphology in Indian population: A cephalometric study. J Orthod Sci 2014; 3(3):74.