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Bjork-Jarabak Analysis in Different Anteroposterior Skeletal Relationship: A Comparative Study

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ABSTRACT

Aims: *This study aimed to evaluate cranial base measurements in individuals with different skeletal relationships (class I, II, and III) using Bjork-Jarabak analysis and compare them with existing research.*

Material and Method: *Lateral cephalograms of 103 Sudanese participants (aged 18-22) were assessed, grouped by ANB angle.*

Results: *Showed no significant differences between class I and II, or class I and III skeletal relationships. However, class II and III relationships exhibited significant differences in Articulare angle, Gonial angle, ramal height, and mandibular length (P<0.0001). Discrepancies in craniofacial morphology were observed between Sudanese and Bjork-Jarabak norms for Caucasian.*

Conclusion: *Saddle angle, Bjork sum of angles, and cranial case showed no significant differences among skeletal classes, but significant differences in several measurements existed between class II and III relationships.*

Keywords

Cephalometric, Bjork polygon, Cranial base, Sudanese.

Introduction and Review of Literature

Effective orthodontic therapy requires a solid understanding of craniofacial growth and development, which is a complex process involving differential growth in various dimensions. It is essential for clinicians to recognize the significance of craniofacial growth and conduct a thorough assessment to identify potential skeletal and dental discrepancies early. This understanding is critical for planning orthodontic treatment, as it can impact treatment outcomes. The present study aimed to contribute to this understanding by examining the relationship between cranial base variables in Sudanese patients seeking orthodontic treatment [1].

The controversy over cranial base landmarks, specifically Basion (Ba) versus Articulare (Ar), is discussed. The use of the Articulare point is recommended due to its ease of localization on skull radiographs. Craniofacial growth patterns vary widely, making it important to monitor individual growth closely as changes can impact the maxilla and mandible. The cranial base is crucial to the position and growth of these structures in the anteroposterior dimension and is composed of anterior and posterior components that play an important role in facial form and occlusion. The Bjork-Jarabak analysis is a valuable tool for examining the relationship between facial form, occlusion, and jaw growth variations [2].

Varjanne and Koski have suggested using Basion (Ba) as a cranial base landmark, despite its difficulty in identification, and discouraged the use of Articulare due to its distance from the cranial base [3]. The position of the fossa, which is determined by growth adjustments in the cranial base region, can have an impact on the facial profile. A short saddle angle indicates an anterior position of the fossa, while a big saddle angle indicates a posterior position. If the length of the ascending ramus cannot compensate for the deviation in the position of the fossa, the facial profile may become retrognathic or prognathic [4].

In 2012, Alam et al. utilized the Bjork-Jaraback analysis to establish cephalometric norms for adult individuals from Bangladesh. They discovered notable angular and linear dissimilarities in craniofacial structure when comparing Bangladeshi adults to the norms proposed by Bjork and Jarabak, as well as between males and females within the Bangladeshi population. Their conclusion emphasized the necessity of acknowledging ethnic and genetic variations when investigating craniofacial growth and development. Norms and benchmarks formulated for one population might not be applicable to another due to genetic, environmental, and cultural distinctions. Thus, establishing norms tailored to specific populations is crucial for precise diagnosis and treatment of craniofacial irregularities [5].

Rodriguez-Cardenas et al. employed CBCT-generated lateral cephalograms to assess the effectiveness of the Björk and Jarabak cephalometric analysis in distinguishing sagittal skeletal patterns. Their study revealed a robust differentiation of skeletal Class III malocclusion from other sagittal classes, particularly in the mandible, utilizing the Björk and Jarabak analysis [6]. The Bjork angles, encompassing the saddle angle, Articulare angle, and Gonial angle, serve as tools to assess vertical intermaxillary relationships and foresee sagittal skeletal malocclusions. By summing up these angles, the mandible's rotation is ascertained; readings exceeding 400 degrees suggest a backward rotation, while those below 392 degrees indicate a forward rotation. This data holds significance for diagnosing and strategizing treatment for both orthodontic and orthognathic cases [7].

The saddle angle is a key measurement within the Bjork-Jarabak analysis, representing the extent of tilt in the posterior cranial base. An obtuse saddle angle, exceeding the typical 130-degree average, signifies a posterior mandibular position, associated with a Class II malocclusion. Conversely, a more acute saddle angle, below 130 degrees, suggests an anterior mandibular position, linked with a Class III malocclusion [8].

The Articular angle holds significance as a cephalometric measurement, reflecting the location of the glenoid fossa in relation to the cranial base. A greater Articular angle points to a posterior fossa position, typically linked to a Class II facial pattern. Conversely, a smaller Articular angle suggests an anterior fossa position, often associated with a Class III facial pattern. The mean Articulare angle, approximately 123° ± 5°, was reported by Björk [9]. In a recent investigation conducted by Ahmed and Abuaffan, substantial connections were uncovered between the cranial base and jaw base among a cohort of Sudanese individuals undergoing orthodontic treatment. The study unveiled that the Class II group exhibited an extended maxilla, whereas the Class III group displayed a lengthier mandible. Furthermore, a positive correlation emerged between cranial base length and both maxillary and mandibular dimensions. These findings offer valuable understanding into the interplay between craniofacial growth and skeletal malocclusions within this specific population [10].

Aims

The objective of this current study was to explore the interrelation of cranial base factors within a group of Sudanese individuals undergoing orthodontic treatment. The primary focus was to ascertain whether noteworthy distinctions existed in cranial base variables among varying skeletal classes (Class I, Class II, and Class III), classified according to the ANB angle system. Furthermore, the study aimed to juxtapose the outcomes derived from the Sudanese patient group against the established norms of Bjork and Jarabak, as well as against findings previously documented in existing literature.

Materials and Methods

This research encompassed a participant pool of 103 Sudanese patients aged 18 to 25. Exclusions encompassed individuals with prior orthodontic or orthognathic treatment, craniofacial anomalies, facial trauma, or identified asymmetries. For analysis, pretreatment lateral cephalometric X-rays were captured and digitally traced using the Web Ceph software. The measurements extracted from these radiographs underwent assessment. Subsequently, the participants were categorized into three skeletal classes, defined by the ANB angle.

The three skeletal classes were as follows:

Class I: ANB angle was between 2–4 degrees
Class II: ANB angle was greater than 4 degrees
Class III: ANB angle was less than 2 degrees

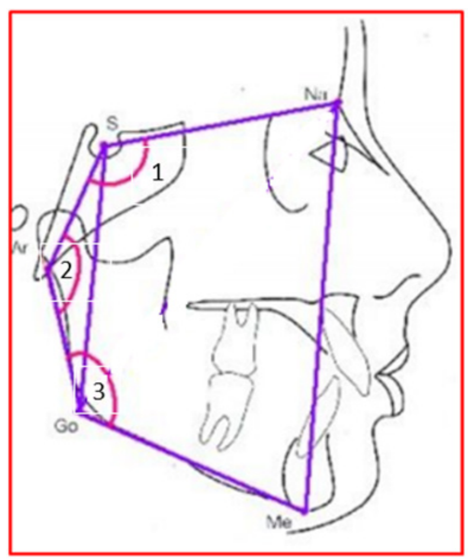

Figure 1: The angular measurements variables.

Cephalometric Landmarks

The angular measurements include the following:

1) Saddle angle (N-S-Ar) is the angle formed between Nasion-Sella-Articulare.
2) Articular angle (S-Ar-Go): formed between Sella-Articulare-Gonion.
3) Gonial angle (Ar-Go-Gn): formed between Articulare-Gonion-Gnathion.
4) Sum of Bjork polygon angles: formed by the Sum of saddle, articular and gonial angles. (Figure 1).

The linear measurements include the following:

1) Sella-Nasion (S-N) is the distance between point Nasion and point Sella forming the anterior cranial base length.
2) Sella-Articulare (S-Ar) is the distance between point Sella and point Articulare forming the posterior cranial base length,
3) Articulare-Gonion (Ar-Go) is the distance between point Articulare and point Gonion representing the ramal height,
4) Gonion-Gnathion (Go-Gn) is the distance between point Gonion and point Gnathion representing the body of mandibular length. (Figure 2).

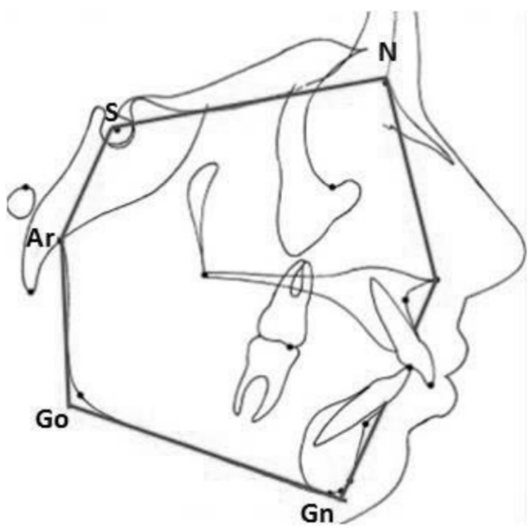

Figure 2: The linear measurements variables.

Bjork polygon measurements were recorded, and comparison was made between the three skeletal classes.

Statistical Analysis

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 22.0. The dataset underwent examination through two statistical approaches: analysis of variance (ANOVA) and unpaired t-test. The threshold for significance was established at $P<0.05$.

Results

Table 1 displays the average values and standard deviations of cranial base measurements in Sudanese participants with various anteroposterior (AP) skeletal relationships (Class I, II, and III). Additionally, the disparities in mean values across each skeletal class are provided. The Saddle angle, Bjork sum of angles, and both anterior and posterior cranial base measurements exhibited no noteworthy discrepancies among Class I, II, and III skeletal relationships. These findings suggest that these particular measurements remain consistent regardless of the skeletal relationship. Nevertheless, significant distinctions emerged between Class II and Class III skeletal relationships concerning the Articulare angle, Gonial angle, ramal height, and body of mandibular length. Specifically, the Articulare angle was notably greater in Class II compared to Class III, while the Gonial angle, ramal height, and body of mandibular length exhibited significant enlargement in Class III relative to Class II. Hence, this outcome indicates that specific cranial base measurements diverge significantly between Class II and Class III skeletal relationships, while other measurements do not display significant variation.

Table 2 illustrates the comparison between the Sudanese sample and the Bjork and Jarabak Norms, spotlighting a distinct variation in craniofacial structure between these two groups. Specifically, the Sudanese sample exhibited a considerably elongated posterior cranial base length in comparison to the Bjork standard population ($t=-5.82$, $p<0.001$). However, no significant distinction emerged in terms of anterior cranial base length ($t=-0.06$, p=NS.). Moreover, the Sudanese sample displayed a notably extended mandibular body length compared to the Bjork standard value ($t=-2.66$, $p=0.012$). The remaining variables, however, exhibited no significant disparities between the two groups.

Discussion

Cephalometric analysis plays a crucial role in detecting deviations in dental and facial structures and serves purposes such as diagnosis, treatment strategy formulation, evaluating treatment effectiveness, and forecasting growth patterns. Consequently, it holds indispensable significance in orthodontic practice. An adaptation of Jarabak and Bjork's analysis involves employing the N-S-Ar-Go-Me polygon. This polygon aids in assessing the correlation between anterior and posterior facial height and predicting the direction of facial growth [11]. Significant and clear differences were identified between the Sudanese population and the norms established by Bjork and Jarabak for a Caucasian sample. As a result of this marked ethnic disparity, it is scientifically unsound to employ cephalometric norms intended for a particular racial group when dealing with a different population.

The present study's findings indicated significant dissimilarities in facial growth patterns between Class III and Class II patients. This distinction was evident in variables such as the articular angle, Gonial angle, ramal height, and body of mandibular length. However, no significant variations were observed in terms of linear and angular measurements between Class I and Class II, or between Class I and Class III. While certain researchers contend that the cranial base doesn't exhibit morphological differences in skeletal Class III individuals compared to those with a normal

Table 1: Means and standard deviations (SDs) of cranial base (Bjork Polygon) measurements in different AP skeletal relationships of Sudanese (n =103).

Cranial Base Measurements	Class I Mean (SD)	Class II Mean (SD)	Class III Mean (SD	Difference Class I to Class II	Difference Class I to Class III	Difference Class II to Class III
Saddle angle,	123.7 (4.7)	123.4 (4.1)	124.0 (5.3)	0.3	-0.3	-.06
Articular angle,	147.0 (5.2)	149.4 (6.7)	143.2 (5.2)	-.2.4	3.8	6.2 ***
Gonial angle,	123.3 (6.2)	123.7 (7.0)	125.9 (7.4)	-0.4	-.2.6	-2.2 ***
Bjork sum angles	394.1 (7.5)	396.5 (7.9)	391.5 (8.3)	-2.4	2.6	5.0
S-Ar, mm	37.0 (3.8)	35.2 (4.0)	35.0 (3.2)	1.8	2.0	0.2
NS, mm	71.1 (1.4)	71.5 (1.5)	71.1 (1.1)	-0.4	0.0	0.4
Ar-Go, mm	48.2 (4.7)	46.9 (5.3)	50.2 (5.5)	1.3	- 2	-3.3 ***
Go-Gn, mm	77.6 (5.2)	75.4 (5.2)	80.3 (6.2)	2.2	-.2.7	-4.9 ***

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

Table 2: Comparison between Sudanese and Bjork and Jaraback norms.

Variable	Bjork	Sudanese	t-value	p-value
Saddle angle	123 ± 5	123.7 ± 4.7	-0.42	NS
Articular angle	143 ± 6	147.0 ± 5.2	-2.01	NS
Gonial angle	128 ± 7	123.3 ± 6.2	1.59	NS
Bjork Sum	394	394.1 ± 7.5	-0.04	NS
Anterior cranial base	71 ± 3	71.1 ± 1.4	-0.06	NS
Posterior cranial base	32 ± 3	37.0 ± 3.8	-5.82	<0.001***
Ramal height	44 ± 5	48.2 ± 4.7	-1.92	NS
Mandibular body length	71 ± 5	77.6 ± 5.2	-2.66	0.012*

* P< 0.05 *** P<0. 001.NS: Not Significant.

Class I profile, others propose that a lengthier posterior cranial base might exacerbate a Class II sagittal relationship, while a shorter base could elevate the likelihood of a Class III relationship [12-15]. Conversely, in contrast, Proff et al. [16] identified a significant reduction in the cranial base angle within class III subjects, with an average measurement of 17.7 ± 3.05 degrees. This finding prompted them to deduce that the interplay between the fundamental cranial and maxillary structures in cases of skeletal Class III malocclusion remains ambiguous.

Moreover, prior research has yielded comparable outcomes concerning the connection between the cranial base angle and skeletal classification. For instance, Guyer et al. [17] noted a marked cranial base angle among individuals with Class III malocclusion in contrast to those exhibiting Class I occlusions, within the period of growth up to 15 years of age. Similarly, Reyes et al. [18] identified a smaller Sella angle in Class III individuals compared to those with regular occlusion, encompassing both males and females. Nonetheless, Al Ma'aitah et al. [19] determined that males possess an extended cranial base length, mandibular ramal height, and body length in comparison to females. It's crucial to recognize that contrasting the findings of the present study with the aforementioned research is unfeasible due to the variations in gender distribution among the respective sample sets.

The current study yielded results that did not reveal any statistically significant distinctions in Sella angle and anterior/posterior cranial base linear measurements among the three skeletal classes ($P > 0.05$). This contrasts with the outcomes reported by AL-Ma'aitah et al. [19] in a Jordanian sample (Class II vs. Class III, $P < 0.05$). This divergence could potentially be attributed to differences in sample size or ethnic factors. However, noteworthy variations were observed in the Gonial angle, ramal height, and mandibular body length across the three skeletal classes ($P < 0.001$), aligning with the findings of this study.

In contrast to the outcomes of the present study, the investigation carried out by Ahmed and Abu Affan [10] on a Sudanese sample indicated that the cranial base angle was most prominent in class II (134.78 ± 6.29), while it was less pronounced in class III (131.43 ± 8.11). However, the current study demonstrated a contrary trend, where class III exhibited the highest mean value (124.0 ± 5.3), and class II showcased the lowest (123.4 ± 4.1). Nevertheless, despite these disparities, no statistically significant distinctions were discerned among the three skeletal classes [10]. This variation in the cranial base angle might be attributed to differences in the methodology employed for cephalographs tracing. Our study utilized the Web Ceph program, unlike the manual tracing employed in their research.

The current study observed that ramal height was shorter in individuals with a Class II skeletal relationship, whereas mandibular body length was longer in those with a Class III skeletal relationship, in comparison to Class II. These results were in line with earlier investigations, such as those conducted by Dong et al. and Gasgoos et al. [20,21]. Furthermore, the present study noted that the mandible exhibited greater size within the Class III group, a finding consistent with previous research [21-23].

Moreover, Kuramae et al. [24] discovered that cephalometric measurements in black Brazilian patients resembled Jarabak's standards, and the polygon sum (Björk) exhibited no significant variations across the three sagittal skeletal classes. This discovery was in alignment with the outcomes of the current study. Yalil

[6] conducted a study utilizing CBCT-generated synthesized cephalograms from individuals aged 16 to 40 years. The study identified that within the Skeletal Class III, there was an increase in both the Gonial and superior Gonial angles. For the Class I category, the Sella angle demonstrated a decrease, the Articular angle show an increase, and the Gonial angle depicted a decrease. In Class III males, the Gonial angle experienced an increase. Nevertheless, no noteworthy disparities were observed in Björk's sum and Björk and Jarabak polygon sum. The outcomes of the present study demonstrated similarity to the findings of Yalil [6], even though distinct apparatus was employed (CBCT vs. CEPH). This suggests the practicality of the Bjork-Jarabak analysis in modern orthodontic assessment and intervention.

Nonetheless, the disparities between the findings of these cited studies and the results of the present study may potentially stem from variations in sample size, analytical methodologies, and contextual influences. Furthermore, Mills noted in 1982 that genetics wield a significant influence over the formation of an individual's facial and dental characteristics [25]. On the whole, the role of the cranial base remains a subject of ongoing discussion, and the amalgamation of the insights from Jarabak and Bjork's studies assists in comprehending the dynamics of the polygon in diverse sagittal skeletal interactions. Moreover, these findings imply that specific cephalometric measurements can vary across distinct skeletal classifications, and the comprehension of standard values for cranial base variables within diverse populations can aid clinicians in formulating well-suited treatment strategies for their patients. Moreover, through the analysis and juxtaposition of these measurements, clinicians can evaluate the degree of growth irregularities and deviations from established norms in their patients. This assessment informs treatment choices and facilitates the attainment of optimal results. Furthermore, familiarity with these benchmarks enables clinicians to identify potential hazards and complexities linked to treatment, particularly when notable deviations from the norm are evident.

In essence, an enhanced comprehension of cranial base variables empowers clinicians to make well-informed judgments, ultimately enhancing treatment effectiveness and outcomes for their patients.

Conclusions

In summary, the outcomes of the present study lead to the following conclusions:

No statistically significant distinctions were identified in the Sella angle, Bjork sum of angles, or the anterior and posterior cranial base measurements across Classes I, II, and III.

Noteworthy variations were observed in the Articular angle, Gonial angle, ramal height, and mandibular body length when contrasting individuals with Class II and Class III skeletal relationships.

These findings underscore the significance of incorporating these specific cephalometric measurements into the orthodontic assessment and formulation of treatment strategies for patients with varying skeletal relationships.

It is imperative to exercise caution when interpreting these findings, and to combine them with other clinical information for precise diagnosis and meticulous treatment planning.

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