RESEARCH ARTICLE

Mean deflection angle, anterior and posterior length of the cranial base in Pakistani population with different sagittal skeletal malocclusion

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Abstract

Objective: To compare the mean deflection angles as well as the anterior and posterior lengths of the cranial base in different sagittal skeletal patterns.

Method: The cross-sectional study was conducted at the Department of Orthodontics, Sharif Medical and Dental College, Jati Umrah, Lahore, Pakistan, from December 2022 to May 2023, and comprised orthodontic patients of either gender aged 8-20 years. Pre-treatment lateral cephalograms of the patients were traced on lead acetate tracing sheet with 0.03mm mechanical pencil. Outcome variables for the cranial base nasion-sella-articulare, nasion-sella-basion, nasion-sella and sella-basion were recorded, and data was stratified for age and gender. Data was analysed using SPSS 23.

Results: Of the 93 patients, 60(64.5%) were females and 33(35.5%) were males. The overall mean age was 15.6±3.0 years, 38(40.9%) aged 8-14 years and 55(59.1%) aged 15-20 years. Mean values of cranial base flexion nasion-sella-articulare, nasion-sella-basion and posterior cranial base length sella-basion were significant in different sagittal patterns ($p<0.05$). Gender-based differences in mean values of anterior and posterior cranial base lengths were significant ($p<0.05$).

Conclusion: Cranial base flexion decreased significantly in skeletal class III. Cranial base lengths were higher for males than females, while age had no effect on cranial base morphology.

Key Words: Cranial base, Craniofacial, Growth and development, Malocclusion, Mandible, Maxilla, Prognathism and retrognathia.

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Introduction

An understanding of the growth and development of basicranium is of particular importance in orthodontics.[1] Recent studies in the field indicate that effective orthodontic treatment depends mainly on the growth of the face, which influences the growth of maxilla and mandible that eventually establishes antero-posterior relationship of the jaws. Earlier, orthodontists' attention was confined to dental arches in occlusion, whereas, gradually it was realised that the jaws to which dento-alveolar processes are affixed were in turn associated intimately to the cranial base.[1,2]

Cranial base has an integrative role in determining the facial prognathism and establishing the anteroposterior relation of maxilla and mandible.[1-4] Growth at the cranial base is usually in the downward-forward direction, and the main growth centres are spheno-ethmoidal, inter-sphenoidal and spheno-occipital synchondrosis, which directly impact the positioning of the maxilla and mandible.[3,5]

Cranial base centre sella turcica (S)forms the anterior limb, where the maxillary complex articulates with the anterior cranial fossa, measured from the sella turcica to the frontonasal suture (N), and the posterior limb. The posterior limb, where mandible articulates with the skull at temporo-mandibular joint, which lies beneath the middle cranial fossa, extends from the sella turcica to the anterior border of foramen magnum, defined as basion (Ba).[3-7]

Fusion along the spheno-occipital synchondrosis is responsible for the flexion of the cranial base. Both anterior nasion-sella (N-S) and posterior sella-basion (S-Ba) limbs flex at the sella turcica in the mid-sagittal plane, forming an angle between the nasion-sella-basion(N-S-Ba) points, called the cranial base angle or saddle angle, that is measured on lateral cephalogram.[8,9] Anterior and posterior limbs of the cranial base flex at 130˚-135˚ at sella. This angle is nearly 142°at birth and decreases to 130° at 5 years.[10]

Based on geometrical relationships, the cranial base is the most stable of all parts of the craniofacial skeleton which is less exposed to environmental factors. The growth of

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the cranial base is genetically controlled, hence, it would be reasonable to assume that any variation in the cranial base angle N-S-Ba, nasion-sella-articulare (N-S-Ar), anterior nasion-sella(N-S) and posterior sella-basion(S-Ba) to cranial base lengths may be a potential cause of imbalance in dentofacial growth, influencing sagittal skeletal pattern and occlusion.[8,11,12]Thus, the association between cranial base positioning and the development of various types of sagittal skeletal malocclusions is an important field of concern for orthodontists and structural anthropologists.[2,13,14]

A thorough knowledge of the facial changes, the site, direction and amount of the remaining growth of the cranial base, and the influence of genetic and environmental factors that aid in facial growth is important because of the impact of cranial base on skeletal malocclusion and aesthetics. The current study was planned to compare the mean deflection angles as well as the anterior and posterior lengths of the cranial base in different sagittal skeletal patterns.

Materials and Methods

The cross-sectional study was conducted at the Department of Orthodontics, Sharif Medical and Dental College, Jati Umrah, Lahore, Pakistan, from December 2022 to May 2023. After approval from the institutional ethics Review committee, the sample size was calculated using the World Health Organisation (WHO) calculator[15] with 95% confidence level, absolute precision 10% and anticipated population proportion of skeletal Class II 40.2%.[16]The sample was raised using non-probability consecutive sampling technique. Those included were orthodontic patients of Pakistani origin aged 8-20 years regardless of gender. Patients having clear cephalometric radiographs taken in their natural head position with lips relaxed were included. Patients with oligodontia/anodontia, presence of prostheses in edentulous areas, those having previous orthognathic treatment, temporomandibular joints (TMJ) problems, cleft lip and palate or associated syndromes, or any acquired skeletal deformities of the cranial base were excluded.

After taking written informed consent from all the patients, the cephalometric radiograph of each patient was traced using 0.3mm mechanical pencil on standard 0.003 inch acetate tracing paper. The mean cranial angles as well as anterior and posterior lengths of the cranial base in different skeletal patterns were measured. All the data was collected by a single researcher. To eliminate error due to fatigue, the number of cephalometric radiographs traced was kept to a maximum of 5 per day.

Sagittal skeletal patterns were evaluated with the following angular measurements on lateral cephalogram analysis: angle involving sella, nasion and subspinale point A (SNA), angle involving sella, nasion and supramentale point B (SNB), and angle involving subspinale point A, nasion and supramentale point B (ANB). Patients were classified as skeletal Class I ANB 0-4°, Class II ANB >4°, and Class III ANB <0°.[2]

Anterior cranial base length meant linear measurement from nasion to sella (N-S), posterior cranial base length meant linear measurement from sella to basion (S-Ba), cranial base angle was the inner angle formed between the S-N plane and articulare (N-S-Ar), and the inner angle formed between the S-N plane and basion (N-S-Ba).

Data was analysed using SPSS 23. Data normality was tested using Shapiro-Wilk and Q-Q Plot. Data was presented as frequencies and percentages, or as mean ± standard deviation, as appropriate. Outcome variables for cranial base(N-S-Ar, N-S-Ba, N-S, S-Ba) were recorded and compared with respect to the skeletal class. Data was stratified for age and gender. Independent t-test was used for comparing the mean values. P≤0.05 was considered significant.

Results

Of the 93 patients, 60(64.5%) were females and 33(35.5%) were males. The overall mean age was 15.6±3.0 years, 38(40.9%) aged 8-14 years and 55(59.1%) aged 15-20 years). Of the total, 32(34.4%) patients were of skeletal Class I, 53(57%) Class II, and 8(8.6%) Class III. The difference of the mean values of N-S-Ar, N-S-Ba and S-Ba were significant (p<0.05), while the difference in mean values of N-S was not significantly different (Table 1).

Table-1: Comparison of mean N-S-Ar, N-S-Ba, N-S and S-Ba values in different skeletal classes.

Variables	Skeletal Class	Mean	Std. Deviation	p-value
N-S-Ar degrees	Skeletal Class I	126.187	3.622	0.011*
	Skeletal Class II	126.000	6.229	
	Skeletal Class III	119.125	4.454	
N-S-Ba degrees	Skeletal Class I	130.875	3.580	0.028*
	Skeletal Class II	131.301	5.268	
	Skeletal Class III	124.500	2.828	
N-S mm	Skeletal Class I	66.312	3.146	0.687
	Skeletal Class II	67.886	4.241	
	Skeletal Class III	67.500	4.105	
S-Ba mm	Skeletal Class I	44.062	2.299	0.019*
	Skeletal Class II	45.415	3.393	
	Skeletal Class III	40.375	3.502	

Statistically significant difference p<0.05.
N-S-Ar: Nasion-sella-articulare, N-S-Ba: Nasion-sella-basion, N-S: Nasion-sella, S-Ba: Sella-basion.

Table-2: Stratification of N-S-Ar, N-S-Ba, N-S and S-Ba with respect to age.

Variables	Age Distribution	Mean	Std. Deviation	p-value
N-S-Ar(degrees)	Early Adolescent 8-14 years	125.526	5.875	0.393
	Late Adolescent 15-20 years	125.436	5.510	
N-S-Ba (degrees)	Early Adolescent 8-14 years	130.736	5.228	0.672
	Late Adolescent 15-20 years	130.454	4.732	
N-S (mm)	Early Adolescent 8-14 years	66.842	3.365	0.578
	Late Adolescent 15-20 years	67.636	4.252	
S-Ba (mm)	Early Adolescent 8-14 years	44.342	3.060	0.083
	Late Adolescent 15-20 years	44.636	3.566	

N-S-Ar: Nasion-sella-articulare, N-S-Ba: Nasion-sella-basion, N-S: Nasion-sella, S-Ba: Sella-basion.
p >0.05 shows non-significant difference.

Table-2: Stratification of N-S-Ar, N-S-Ba, N-S and S-Ba with respect to gender.

Variables	Gender Distribution	Mean	Std. Deviation	p-value
N-S-Ar degrees	Females	125.6333	5.93743	0.842
	Males	125.1818	5.10180	
N-S-Ba degrees	Females	131.3667	4.97440	0.587
	Males	129.1212	4.52602	
N-S mm	Females	66.1000	3.18737	0.040*
	Males	69.5152	4.19167	
S-Ba mm	Females	44.0667	2.52356	0.026*
	Males	45.3333	4.42060	

N-S-Ar: Nasion-sella-articulare, N-S-Ba: Nasion-sella-basion, N-S: Nasion-sella, S-Ba: Sella-basion.
* Statistically significant difference p<0.05..

Figure: Cephalometric landmarks for the measurement of deflection angle, anterior and posterior length of the cranial base.

Age of the patient was not significantly associated with the discrepancy in the mean values of N-S-Ar, N-S-Ba, N-S and S-Ba (Table 2), while gender was significantly associated with the difference in the mean values of N-S and S-Ba (Table 3).

Discussion

The impact of the cranial base has to be recognised for the diagnosis and evaluation of orthodontic problems. It is not given enough emphasis while determining the aetiology of malocclusion. Constant evolution of orthodontics has validated a deeper investigation into the domain of craniofacial and maxillo-mandibular complex.[5]

The differences in mean cranial base flexion (N-S-Ar, N-S-Ba) in different skeletal malocclusion patterns were significant in the current study, which was in accordance with earlier studies that reported significant difference in the angular measurement of the cranial base angle (N-S-Ba) among three groups of sagittal skeletal malocclusion, and also found that the cranial base angle was reduced from skeletal Class II through Class I to Class III.[9,14,17]In contrast, other studies found no significant differences among skeletal patterns for N-S-Ba parameter.[2,5,18]However, one of these studies found significantly greater N-S-Ar parameter in Class II than Class I.[18]Two other studies also found no relationship between cranial base flexure and skeletal class.[6,19]

In the current study, the difference in mean anterior cranial base length (N-S) in different sagittal skeletal patterns was found to be non-significant, whereas the difference in mean posterior cranial base length (S-Ba) was significant. These results were in line with earlier findings of a significant difference in posterior cranial base lengths among different skeletal groups, and no difference with respect to anterior cranial base length.[2,5]Studies evaluated linear measurements of N-S and S-Ba, and found no significant differences with respect to skeletal class.[6,18-20]

In the current study, stratification of data was done for early adolescence age group and late adolescence age group. No significant difference was seen in cranial base mean values of N-S-Ar, N-S-Ba, N-S and S-Ba between the age groups. This reflects that cranial base is stable after 7-8 years. The stability of cranial base found in the current study matches with earlier findings that saddle angle modifies from birth to 5 years of age, and remains stable afterwards till 15 years.[14,21-23]The evidence demonstrates that cranial base serves as a reliable landmark in serial cephalometric radiographs. However, a longitudinal study[24]stated that N-S-Ba angle decreased up till 18 years of age, which is contrary to the current results.

Data stratification for gender showed that the difference in mean values of N-S and S-Ba in the current study was significantly higher in males than females. This was in line with earlier research.[2,9,20,25,26]

The anterior cranial base is the principal anatomical landmark for cephalometric analysis, since it is considered to be a steady reference plane to ascertain the three-dimensional(3D) positioning of maxilla relative to the skull. Locating the landmarks for posterior cranial base (S-Ba) on a lateral cephalogram has been debatable.[14]In the current study, the cranial base angle was measured using both Ba and Ar landmarks. However, investigating only a few parameters is not sufficient to establish the structural craniofacial configuration of orthodontic patients because several other hard and soft tissue features integrate to determine the particular facial pattern of an individual.[5]

The current study has limitations as the margin of error was kept at 10%. Besides, 3D imaging, such as cone beam computed tomography (CBCT), was more likely to locate the cranial base with higher precision compared to the 2D cephalometric radiograph used in the current study. The use of CBCT is recommended for more extensive research in the future.[2,27] However, unlike the lateral cephalogram, the CBCT is not indicated in every orthodontic patient, and would require additional radiation exposure.

Conclusion

Cranial base flexion was found decreased significantly in skeletal Class III relative to skeletal Class II. Anterior cranial base was slightly longer in skeletal Class II than Class I and Class III, but the difference was not significant. Posterior cranial base length was significantly larger in skeletal Class II than class III. The mean values for anterior and posterior cranial base lengths were significantly higher for males than females, and after 8 years, age had no effect on cranial base morphology.

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FR: Literature search, study design, concept, proforma design, data collection, analysis, interpretation, drafting and revision.
FM: Drafting, revision and final approval.