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Cranial Base Morphology Determining Sagittal and Vertical Facial Relation: A Cross Sectional Study

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1. Introduction

The diagnostic process in orthodontics and maxillofacial surgery requires identification of the underlying skeletal problems that contribute to dentofacial deformities and malocclusion. The clinical diagnosis significantly influences the treatment plan and can dictate the orthodontic mechanics used in a patient's treatment. Therefore it is important to be able to establish the elements contributing to the etiology of the skeletal discrepancy. One of the key diagnostic skeletal relationships in the fields of orthodontics and maxillofacial surgery is the anteroposterior relationship of the maxilla to the mandible and their respective dentition. This relationship is affected by several factors one of which has been hypothesized to the morphology of the base of the cranium[1].Any changes in flexion due to variations in shape and size of this region would alter the sagittal skeletal relationship of the jaws since the cranial base consists of two segments articulating with the maxilla and mandible[2-4].In a series of publications Bjork[5-7] also drew attention towards the role played by size and shape of the cranial base in determining maxillary and mandibular prognathism. Therefore, the cranial base area has long been of interest to orthodontists[3].

The cranial base, which supports the brain and provides adaptation between the developing neurocranium and viscerocranium during growth, is made up of bones mainly developed in cartilage. The midline cranial base extends from foramen magnum to foramen caecum and includes the basioccipital, the body of the Sphenoid, and the cranial or ethmoid bones whereas anterior craniumis formed by extension to nasion which includes part of the frontal bone. Located on a junction point between the cranium, midface and glenoid fossa, the cranial base may affect the development of both the face and the cranium.

Cranial base features for different ethnic and racial groups have been established previously in many studies. Most researchers have concluded that there are significant differences among these groups and many cranial base standards have been developed for the different groups[8,9].These studies indicate that normal measurements for each group should not be considered normal for every other race or ethnic group. Therefore, it is important to develop individual standards for each population. Different racial groups must be treated according to their own characteristics[10]. This study, therefore, aims at assessing the contribution of the linear and angular measurements of cranial base on skeletal malocclusions in sagittal and vertical plains in Indian population localized to Goa region.

2. Materials and Methods

The sample consisted of lateral cephalometric radiographs collected from patients treated at the Department. Subjects within the age range of 18 to 35 years were selected for the study. Cervical vertebrae maturation was re-evaluated to confirm the completion of growth.

Inclusion criteria was set for sample selection was: 1) Representative of local population, 2) Age between 18 and 35 years, 3) Cervical vertebrae maturation stage six, 4) No partial and low-resolution imagesand 5) No previous history of orthodontic treatment.

Of the total 356 records examined 183 (79 male and 111 females) met the inclusion criteria and were selected for the study. Selected patients were further divided into 3 groups, each containing 61 patients (Skeletal Class I, Class II and Class III groups). Each group was then subdivided into low and high angle cases.

Parameter for dividing in groups was:

1) Skeletal Class I group (29 males & 32 females): ANB 2°-4°, normal overjet and overbite (2-4 mm).
2) Skeletal Class II group (22 males & 39 females): ANB > 4° and overjet ≥ 4 mm.
3) Class III group (21 males & 40 females): ANB < 2° and overjet< 2 mm.

Lateral cephalograms of each subject were traced and analysed by the first author. Cranial base flexure measurements, anterior and posterior cranial base inclinations, and linear measurements for the assessment of cranial base dimensions were recorded and subjected to statistical analysis.

The following skeletal base measurements were done:

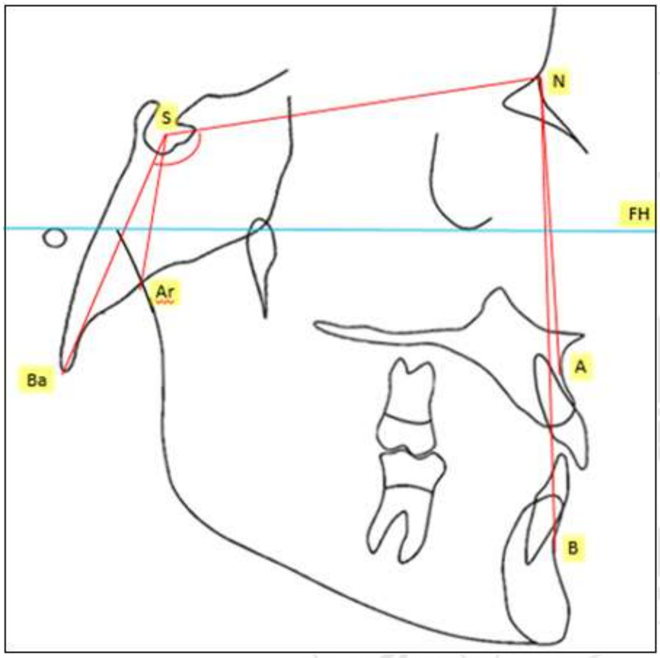
Angular measurements

1. SNA: Antero-posterior position of the maxilla in relation to the anterior cranial base.
2. SNB: Antero-posterior position of the mandible in relation to the anterior cranial base.
3. ANB: Antero-posterior relation of the maxilla and mandible to each other.
4. SN-MP: Divergence pattern of face

The following cranial base measurements were done (Figure 1):

Angular measurements
1) N-S-Ar: Saddle angle
2) N-S-Ba: The angle between the anterior and the posterior cranial base.
3) SN-FH: The inclination of the anterior cranial base to Frankfort horizontal plane.
4) SBa-FH: The inclination of the posterior cranial base to Frankfort horizontal plane.

Linear measurements
1) S-N: The anterior cranial base length.
2) S-Ba: The posterior cranial base length.
3) S-Ar: The posterior (lateral) cranial base length.



3. Statistical Analysis

To estimate the intra-operator error, 10 patients' records were selected at random and the above mentioned measurements were carried out. These measurements on the same radigraphs were repeated after 14 days. The two sets of measurements were evaluated using intra-class correlation coefficient test for any significant difference between the two intra-operator readings at p<0.05 level. The result of the test showed no significant difference between the two values. Excel 2007 and SPSS software version 20.0 for windows were used for the statistical analysis of the data.

Kruskal Wallis test and Mann-Whitney U test was used to check for statistical significance between different parameters of measurements (p<0.05).

4. Results

Table 1 shows the ages, SNA angle, SNB angle, ANB angle, Wits value, and SN-MP angle of all the subjects in all the three groups. These values were used to classify and arrange the subjects in each sagittal skeletal malocclusion group and then further subdivide each into three growth patterns. ANB angle and Wits value showed a significant statistical difference between the three groups (p<0.05). The age and SN-MP angle did not show any statistically significant difference between the Class I, II and III groups.

Among the linear measurements the S-N length signifying anterior cranial base length showed a highly statistically significant value (p<0.01) with a gradual increase in mean length from skeletal class III to class I followed by class II. S-Ba and S-Ar lengths (posterior cranial base length) was found to be maximum in class III group and least in Class II group which was statistically significant on comparing the class II group to the class III group.

Highly statistically significant difference was observed in anterior cranial base inclination (SN-FH) among the three groups with the greatest inclination in class II group (8.75±2.18mm) and lowest in the class III group (3.95±2.85mm).

Cranial base angulation (N-S-Ba and N-S-Ar) was least in the class III group and maximum in the class II group which was found to be statistically significant for class II-class III comparison (p<0.01).

Comparison among the growth patterns (Table 2) showed a statistically significant difference in N-S-Ba angle between the horizontal and the vertical growth patterns of the class I and the Class II groups with lesser angle in horizontal growth pattern. N-S-Ar angle also showed similar difference as N-S-Ba angle which was statistically significant in the Class I group between horizontal and vertical growth patterns.

5. Discussion

This study was designed to assess the contribution of the linear and angular measurements of cranial base on skeletal malocclusions in sagittal and vertical plains. Subjects within the age range of 18 to 35 years were selected for the study and cervical vertebrae maturational status was checked for completion of growth. 183 patients (79 male and 111 females) met the inclusion criteria and were selected for the study.

The length of the anterior cranial base (S-N) was found to be highly statistically significant (p<0.01) among the three with shortest in the skeletal class III group and longest in the skeletal class II group. Posterior cranial base length showed a gradual decrease in length from skeletal class III through class I to Class II groups which presented with a statistically significant difference on comparing the class II group to the class III group.These findings of the present study were in agreement with the studies by Hopkin et al[3] and Dibbets[11].On the other hand studies by Polat et al.[12], Ildwein et al.[13], Kasai et al.[14],Wilhelm et al.[15]Kamak et al.[16]showed no statistically significant differences between the anterior and posterior cranial base lengths to the sagittal malocclusions.

Studies by Polat et al.[12] found that the anterior andthe posterior cranial base inclinations were significantly increased in the Class III group than the Class I and the Class II groups. Whereas, among the three sagittal malocclusion groups Kamak et al.[16] found a marked increase in anterior cranial base inclination (SN-FH) in class II group which was found to be in accordance with the present study which showed greatest anterior cranial base inclination in class II group (8.75±2.18mm) and lowest in the class III group (3.95±2.85mm).Present study found no statistically significant difference in posterior cranial base inclination (SBa-FH).

Hopkin[3], Anderson et al.[17]and Järvinen[18] in their study found similar results to the present study which showed an increase in cranial base angle (N-S-Ba and N-S-Ar)from Class III through Class I and to Class II malocclusions. Conversely, Kasai et al.[14], Wilhelm et al.[15], Dhopatkar et al.[19], Hildwein et al.[20] and Polat et al.[12] could not demonstrate any differences in cranial base angulation and sagittal malocclusions.

Thus, the cranial factors associated with a prognathic mandible and/or a retrognathic maxilla in Goan population are associated with small anterior cranial base length, larger posterior cranial base length, reduced anterior cranial base inclination and reduced cranial base angulation. Conversely, larger anterior cranial base length, reduced posterior cranial base length, increased anterior cranial base inclination and increased cranial base angulation are associated with skeletal class II malocclusion.

Opening of the cranial base angle, the relative forward movement of components (the maxilla and the mandible) to the cranium, and the amount of surface deposition along the facial profile are the three factors which determine the skeletal component of malocclusion[21]. Role of genetic factors which play a major role in determining the craniofacial extension can never be ignored. It has been also hypothesized that soft tissues play a major role in inducing cranial extension and hence influencing craniofacial development[22]. Increased pressure from soft tissues due to impaired nasal airflow affect the craniofacial development as a consequence of inducing cranial base extension[22].

Differences in the previous studies and the present study could be due to the racial and ethnic differences of the subject representatives. The present study failed to assess the above mentioned parameters which influence sagittal and vertical malocclusions. However, influence of various cranial base lengths and angulations could be understood in this cross-sectional study. Before relating these variables to general population longitudinal studies with large population sample should be performed.

6. Conclusions

- A gradual increase in mean anterior cranial base length was observed from skeletal class III to class II through class I subjects which was highly statistically significant ($p<0.01$).
- Posterior cranial base length was minimum in class II and maximum in class III subjects.
- Anterior cranial base inclination (relative to Frankfort horizontal reference line) and cranial base angulation (anterior to posterior cranial base) were minimum in Class III subjects followed by class I subjects and maximum in Class II subjects.
- Cranial base angulation also had a lesser value in horizontal growth pattern in Class I and Class II subjects.

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Table 1: Comparison of mean cranial base linear and angular measurements for the Skeletal class I, II and III malocclusions.

Patient	Variable	Class I		Class II		Class III		P value (2-tailed)		
		Mean	SD	Mean	SD	Mean	SD	ClassI, ClassII	ClassII, ClassIII	ClassI, ClassIII
	AGE	22.8	4.34	23.7	4.21	23.0	5.72			
Maxillo-mandibular Measurements	SNA	79.15	4.210	84.10	2.488	83.30	3.721	.000	.549	.000
	SNB	76.64	4.159	76.13	9.496	86.97	5.122	.139	.000	.000
	ANB	2.52	1.105	6.90	1.841	-4.11	3.493	.000	.000	.000
	Wits	2.62	2.296	6.46	2.005	-8.87	6.886	.000	.000	.000
	SN-MP	34.74	4.757	35.31	7.049	32.20	5.176	.630	.061	.133
Anterior & Posterior Cranial Base Inclinations (DEGREE)	N-S-Ar	124.28	4.913	125.62	4.744	120.28	7.840	.349	.000	.000
	N-S-Ba	129.89	5.323	130.56	4.511	126.31	8.504	.801	.003	.002
	SN-FH	7.70	2.124	8.75	2.181	3.95	2.854	.007	.000	.000
	Sba-FH	59.08	3.328	59.10	5.932	60.98	4.972	.904	.145	.049
Linear Cranial Base Measurements (mm)	S-N	73.62	2.782	75.26	3.082	70.05	2.991	.006	.000	.000
	S-Ba	47.15	4.486	46.07	4.686	50.36	4.554	.244	.000	.000
	S-Ar	36.39	3.190	33.49	4.265	37.02	6.685	.000	.001	.260

Table 2: Comparison of mean cranial base linear and angular measurements for various facial divergences in skeletal class I, II and III malocclusions

			Maxillomandibular Measurements					Anterior & Posterior Cranial Base Inclinations(ANGLE)				Linear Cranial Base Measurements(mm)		
Patient	Age	n	SNA	SNB	ANB	Wits	SN-MP	N-S-Ar	N-S-Ba	SN-FH	Sba-FH	S-N	S-Ba	S-Ar
Class I Average	22.08	24	78.00	75.12	2.87	2.58	34.08	126.16	131.91	8.5	57.79	74.93	47.41	36.27
Class I Low angle	24.22	17	86.27	83.61	2.66	2.00	26.22	118.11	122.88	6.11	62.22	72.66	46.33	37.72
Class I High angle	23.03	20	77.83	75.69	2.14	2.85	38.01	124.64	130.39	7.53	59.17	72.76	47.14	36.035
Class II Average	23.13	15	84.53	72.5	7.7	6.43	32.8	127.40	131.46	7.40	55.20	76.00	46.83	36.00
Class II Low angle	24.75	16	86.06	79.81	6.25	6.56	26.25	122.87	127.50	9.28	64.68	74.09	47.71	32.62
Class II High angle	23.50	30	82.83	75.96	6.86	6.48	41.45	126.20	131.73	9.13	58.06	75.53	44.81	32.65
Class III Average	20.83	24	82.77	85.12	-2.85	-6.79	32.54	121.08	127.75	5.16	59.41	70.22	50.02	36.66
Class III Low angle	24.95	21	84.33	90.80	-6.47	-13.3	26.80	123.28	128.61	2.76	61.57	70.14	51.92	39.28
Class III High angle	23.87	16	82.75	84.75	-3.00	-6.12	38.75	115.12	121.12	3.59	62.56	69.84	49.25	35.31