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Cranial base morphology in different sagittal skeletal patterns in Chhattisgarh population.

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Abstract

In Orthodontics Cephalometric Radiography has become one of the most important diagnostic tool for recognizing the Craniofacial anatomical relationship. It has been utilized extensively to quantify the dental skeletal and soft tissue relationship of Craniofacial complex prior to the beginning of Orthodontic treatment throughout Growth[1].

Cranial base is a pivotal structure forming the floor of the cranial cavity. It extends anteriorly from foramen caecum and posteriorly extends to the Basi - occipital bone. For the purpose of Cephalometrics Sella point(S) divides the cranial base into anterior cranial base extending to the frontonasal suture(N), and posterior cranial base extending to the anterior border of foramen magnum defined as Basion (Ba)[1]. The anterior segment articulates with maxilla and posterior segments articulate with mandible[2]. Any change in the morphology of cranial base would alter the position of maxilla and mandible relative to the cranial base and each other[1].There is no information regarding the Cranial Base Morphology in different skeletal patterns in Chhattisgarh population in earlier studies. So, the purpose of the study is to compare the morphology of Cranial Base Morphology in Different Sagittal Skeletal Patterns and different genders in Chhattisgarh population.

Materials and Methods

A Cross Sectional Study was conducted to compare the Position of Hyoid Bone in Different Sagittal Skeletal

Patterns. 180 lateral cephalograms of patient reporting to Outpatient Department at the Department of Orthodontics and Dentofacial Orthopaedics, Government Dental College, Raipur are distributed according to skeletal pattern and gender. 60 Class I, 60 Class II and 60 Class III radiographs were collected with an equal distribution between males and females.

Classification of skeletal type into class I, Class II and Class III was based on ANB angle.

1. Angle 0-4˚ – Class I
2. Angle >4˚ – Class II
3. Angle <0˚ – Class III

Inclusion criteria

1. No History of previous Orthodontic treatment.
2. Patients having Class I, Class II and Class III Skeletal Patterns.
3. Patients who are willing to participate in the study after giving written informed consent.

Exclusion criteria

1. Patient underwent previous orthodontic treat Ment.
2. Patient underwent previous orthognathic surgery.
3. Patients with major illness or medical conditions.
4. History of head and neck trauma, vertebral column and craniofacial anomaly or syndrome.

Armamentarium

- Radiographic machine
- Digital lateral cephalogram (Planmeca, Proline XC Dimax 3 Ceph)
- Trimax printer.
- Digital Lateral cephalogram.
- Acetate tracing paper of 0.003-inch matte finish.
- 0.3mm HB lead pencil.
- Geometry box – (scale, protractor, eraser, sharpener.)
- Illuminator, cello tape.

Cephalometric analysis

The Lateral Cephalogram of the patients were obtained by positioning the patients head in cephalostat with teeth in maximum intercuspation with relaxed lip in order to maintain standardization of radiograph with the Frankfort horizontal plane parallel to the floor and ensured that (NHP) natural head position is obtained by positioning the ear rods and forehead, Positioning the knobs distance from the tube to patients was standardized at 5 feet.

The radiographs were hand traced in lead acetate paper (8” x 10” dimension and 0.003inch thickness) and measured by the same investigator to reduce intra operator errors.

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The following landmarks were used for cephalon metric analysis: (Fig: 1)

Linear measurements

1. S-N (anterior cranial base): Sella to Nasion.
2. S-Ba (posterior cranial base): Sella to Basion.
3. N-Ba (total cranial base): Nasion to Basion.

Angular measurements

1. N-S-Ar: Saddle Angle.
2. N-S-Ba: Cranial Base Angle.

Angular measurements for cranial base inclinations

1. SN-FH: Angle Between Anterior Cranial Base and Frankfurt’s Horizontal Plane.
2. SBa-FH: Angle Between Posterior Cranial Base and Frankfurt’s Horizontal Plane.

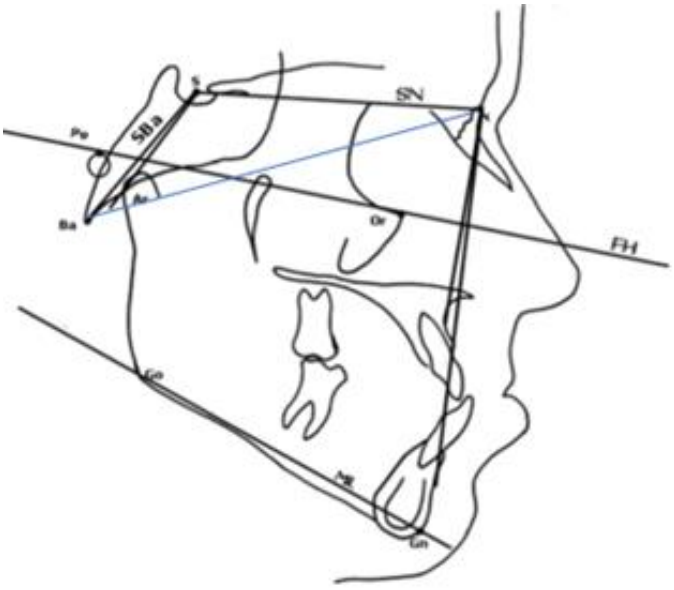

Figure 1: Cranial Base Dimensions.

Statistical analysis

Data were analysed using the statistical package for social sciences version 18.0 for windows (SPSS Inc., Chicago, Illinois, USA). Analysis of variance test was per formed to study the relationship between different skeletal patterns and Cranial Base dimensions. Multiple comparison test was used to further distinguish which skeletal pattern showed the most significant difference. Analysis of variance test was performed to study the relationship between different skeletal patterns and Cranial Base dimensions in both male and female subjects. A student's t-test was used to calculate the mean difference in Cranial Base dimensions between male and female subjects.

Table 1: Descriptives of cranial base grouped into class I, class II and class III skeletal patterns.

		N	Mean	Std. Deviation
S-N	Class I	60	68.26167	4.05718
	Class II	60	67.51667	4.247598
	Class III	60	67.54167	4.130592
	Total	180	67.77333	4.137168
S-BA	Class I	60	43.975	3.929921
	Class II	60	44.24483	3.919226
	Class III	60	44.125	3.890041
	Total	180	44.11494	3.892751
N-BA	Class I	60	100.6167	5.652633
	Class II	60	101.2517	5.511329
	Class III	60	100.2083	5.144762
	Total	180	100.6922	5.427073
N-S-AR	Class I	60	120.7833	6.442291
	Class II	60	122.1083	4.9865
	Class III	60	115.9167	6.696297
	Total	180	119.6028	6.616742

Table 2: ANOVA testing the effects of skeletal Patterns on Cranial Base linear and Angular dimensions

		Sum of Squares	df	Mean Square	F	Sig.
S-N	Between Groups	21.481	2	10.741	.625	.537
	Within Groups	3042.311	177	17.188		
	Total	3063.792	179			
S-BA	Between Groups	2.193	2	1.097	.072	.931
	Within Groups	2710.284	177	15.312		
	Total	2712.478	179			
N-BA	Between Groups	33.170	2	16.585	.560	.572
	Within Groups	5238.939	177	29.599		
	Total	5272.109	179			
N-S-AR	Between Groups	1275.536	2	637.768	17.205	.001*
	Within Groups	6561.312	177	37.070		
	Total	7836.849	179			
N-S-BA	Between Groups	296.736	2	148.368	4.581	.011*
	Within Groups	5732.812	177	32.389		
	Total	6029.549	179			
SN-FH	Between Groups	102.320	2	51.160	3.785	.025*
	Within Groups	2392.310	177	13.516		
	Total	2494.630	179			
SBA-FH	Between Groups	312.210	2	156.105	4.437	.013*
	Within Groups	6227.119	177	35.181		
	Total	6539.329	179			

Table 3: Gender Comparision within the Class I skeletal pattern (Cranial Base)

		Gender	N	Mean	Std. Deviation	P value
Class I	S-N	Male	30	69.8500	3.87109	0.002*
		Female	30	66.6733	3.64473	
	S-BA	Male	30	45.0167	3.65184	0.039*
		Female	30	42.9333	3.97998	
	N-BA	Male	30	1.0325E2	5.79945	0.001*
		Female	30	97.9833	4.12621	
	N-S-AR	Male	30	1.2168E2	6.99074	0.283
		Female	30	1.1988E2	5.82161	
	N-S-BA	Male	30	1.2747E2	7.14135	0.510

		Female	30	1.2637E2	5.62772	
	SN-FH	Male	30	7.7500	3.11213	0.843
		Female	30	7.9500	4.54925	
	SBA-FH	Male	30	59.8533	5.00143	0.899
		Female	30	59.6833	5.32639	
Class II	S-N	Male	30	68.6500	4.18155	0.038*
		Female	30	66.3833	4.06983	
	S-BA	Male	30	45.9563	3.66502	0.001*
		Female	30	42.5333	3.42892	
	N-BA	Male	30	1.0395E2	5.08546	0.001*
		Female	30	98.5500	4.56439	
	N-S-AR	Male	30	1.2275E2	5.09183	0.323
		Female	30	1.2147E2	4.87947	
	N-S-BA	Male	30	1.2897E2	4.87593	0.489
		Female	30	1.2995E2	5.99763	
	SN-FH	Male	30	8.5133	3.19458	0.092
		Female	30	10.3167	4.80388	
	SBA-FH	Male	30	56.2500	9.86176	0.293
		Female	30	58.3833	4.89138	
Class III	S-N	Male	30	68.9500	4.11128	0.007*
		Female	30	66.1333	3.70213	
	S-BA	Male	30	44.7500	4.64192	0.216
		Female	30	43.5000	2.90362	
	N-BA	Male	30	1.0222E2	5.64875	0.002*
		Female	30	98.2000	3.68735	
	N-S-AR	Male	30	1.1537E2	6.53232	0.529
		Female	30	1.1647E2	6.92314	
	N-S-BA	Male	30	1.2637E2	5.67045	0.748
		Female	30	1.2680E2	4.67864	
	SN-FH	Male	30	7.4500	3.45999	0.378
		Female	30	8.1167	2.21936	
	SBA-FH	Male	30	59.5667	4.75020	0.157
		Female	30	61.1500	3.73278	

Male		N	Mean	Std. Deviation	Std. Error	95% confidence interval for mean		Minimum	Maximum
						Lower Bound	Upper Bound		
S-N	Class I	30	69.8500	3.87109	.70676	68.4045	71.2955	64.00	76.00
	Class II	30	68.6500	4.18155	.76344	67.0886	70.2114	63.00	79.00
	Class III	30	68.9500	4.11128	.75061	67.4148	70.4852	62.00	77.00
	Total	90	69.1500	4.04362	.42623	68.3031	69.9969	62.00	79.00
S-BA	Class I	30	45.0167	3.65184	.66673	43.6530	46.3803	36.00	52.50
	Class II	30	45.9563	3.66502	.66914	44.5878	47.3249	41.00	54.00
	Class III	30	44.7500	4.64192	.84749	43.0167	46.4833	30.00	53.50
	Total	90	45.2410	4.00175	.42182	44.4028	46.0792	30.00	54.00
N-BA	Class I	30	1.0325E2	5.79945	1.05883	101.0844	105.4156	92.00	118.00
	Class II	30	1.0395E2	5.08546	.92847	102.0544	105.8523	94.00	114.00
	Class III	30	1.0222E2	5.64875	1.03132	100.1074	104.3259	91.00	112.00
	Total	90	1.0314E2	5.50434	.58021	101.9871	104.2929	91.00	118.00
N-S-AR	Class I	30	1.2168E2	6.99074	1.27633	119.0729	124.2937	108.00	134.50
	Class II	30	1.2275E2	5.09183	.92964	120.8487	124.6513	111.00	131.00
	Class III	30	1.1537E2	6.53232	1.19263	112.9275	117.8059	104.00	129.00
	Total	90	1.1993E2	7.00088	.73796	118.4670	121.3996	104.00	134.50
N-S-BA	Class I	30	1.2747E2	7.14135	1.30383	124.8000	130.1333	111.50	141.00
	Class II	30	1.2897E2	4.87593	.89022	127.1460	130.7874	119.00	138.00
	Class III	30	1.2637E2	5.67045	1.03528	124.2493	128.4840	113.00	137.00
	Total	90	1.2760E2	5.99916	.63237	126.3435	128.8565	111.50	141.00
SN-FH	Class I	30	7.7500	3.11213	.56819	6.5879	8.9121	2.00	15.00
	Class II	30	8.5133	3.19458	.58325	7.3205	9.7062	3.00	14.00
	Class III	30	7.4500	3.45999	.63171	6.1580	8.7420	2.00	19.00
	Total	90	7.9044	3.25341	.34294	7.2230	8.5859	2.00	19.00
SBA-FH	Class I	30	59.8533	5.00143	.91313	57.9858	61.7209	52.00	69.50
	Class II	30	56.2500	9.86176	1.80050	52.5676	59.9324	6.50	63.00

	Class III	30	59.5667	4.75020	.86726	57.7929	61.3404	51.00	67.00
	Total	90	58.5567	7.06377	.74459	57.0772	60.0361	6.50	69.50

Table 4: Comparison of parameters in males between Class I, Class II & Class III skeletal patterns (Cranial Base)

Table 5: ANOVA testing the effects of skeletal Patterns on Cranial Base linear and Angular dimensions in males

		Sum of Squares	Df	Mean Square	F	Sig.
S-N	Between Groups	23.400	2	11.700	.711	.494
	Within Groups	1431.825	87	16.458		
	Total	1455.225	89			
S-BA	Between Groups	24.093	2	12.047	.748	.476
	Within Groups	1401.156	87	16.105		
	Total	1425.249	89			
N-BA	Between Groups	45.785	2	22.892	.751	.475
	Within Groups	2650.711	87	30.468		
	Total	2696.496	89			
N-S-AR	Between Groups	955.517	2	477.758	12.201	.000*
	Within Groups	3406.583	87	39.156		
	Total	4362.100	89			
N-S-BA	Between Groups	102.200	2	51.100	1.434	.244
	Within Groups	3100.900	87	35.643		
	Total	3203.100	89			
SN-FH	Between Groups	18.034	2	9.017	.849	.431
	Within Groups	924.005	87	10.621		
	Total	942.038	89			
SBA-FH	Between Groups	240.665	2	120.332	2.493	.089
	Within Groups	4200.156	87	48.278		
	Total	4440.821	89			

Table 6: Comparison of parameters in females between Class I, Class II & Class III skeletal patterns (Cranial Base)

Female		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
S-N	Class I	30	66.6733	3.64473	.66543	65.3124	68.0343	59.00	77.00
	Class II	30	66.3833	4.06983	.74305	64.8636	67.9030	58.00	81.00
	Class III	30	66.1333	3.70213	.67591	64.7509	67.5157	61.00	78.00
	Total	90	66.3967	3.77370	.39778	65.6063	67.1871	58.00	81.00

S-BA	Class I	30	42.9333	3.97998	.72664	41.4472	44.4195	38.00	52.00
	Class II	30	42.5333	3.42892	.62603	41.2530	43.8137	36.50	55.00
	Class III	30	43.5000	2.90362	.53013	42.4158	44.5842	40.00	52.00
	Total	90	42.9889	3.44946	.36360	42.2664	43.7114	36.50	55.00
N-BA	Class I	30	97.9833	4.12621	.75334	96.4426	99.5241	92.00	105.00
	Class II	30	98.5500	4.56439	.83334	96.8456	100.2544	87.00	112.00
	Class III	30	98.2000	3.68735	.67321	96.8231	99.5769	91.00	108.00
	Total	90	98.2444	4.10141	.43233	97.3854	99.1035	87.00	112.00
N-S-AR	Class I	30	1.1988E2	5.82161	1.06287	117.7095	122.0572	108.00	131.00
	Class II	30	1.2147E2	4.87947	.89086	119.6446	123.2887	113.00	130.50
	Class III	30	1.1647E2	6.92314	1.26399	113.8815	119.0518	104.00	125.00
	Total	90	1.1927E2	6.23066	.65677	117.9672	120.5772	104.00	131.00
N-S-BA	Class I	30	1.2637E2	5.62772	1.02748	124.2652	128.4681	112.50	140.00
	Class II	30	1.2995E2	5.99763	1.09501	127.7104	132.1896	121.00	151.50
	Class III	30	1.2680E2	4.67864	.85420	125.0530	128.5470	111.00	134.00
	Total	90	1.2771E2	5.63491	.59397	126.5253	128.8858	111.00	151.50
SN-FH	Class I	30	7.9500	4.54925	.83058	6.2513	9.6487	1.00	23.00
	Class II	30	10.3167	4.80388	.87707	8.5229	12.1105	4.00	30.00
	Class III	30	8.1167	2.21936	.40520	7.2879	8.9454	3.00	12.00
	Total	90	8.7944	4.12848	.43518	7.9298	9.6591	1.00	30.00
SBA-FH	Class I	30	59.6833	5.32639	.97246	57.6944	61.6722	48.00	69.00
	Class II	30	58.3833	4.89138	.89304	56.5569	60.2098	50.00	70.00
	Class III	30	61.1500	3.73278	.68151	59.7562	62.5438	56.00	71.00
	Total	90	59.7389	4.78247	.50412	58.7372	60.7406	48.00	71.00

Table 7: ANOVA testing the effects of skeletal Patterns on Cranial Base linear and Angular dimensions in females

		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
S-N	Between Groups	4.382	2	2.191	.151	.860
	Within Groups	1263.047	87	14.518		
	Total	1267.429	89			
S-BA	Between Groups	14.156	2	7.078	.589	.557
	Within Groups	1044.833	87	12.010		
	Total	1058.989	89			
N-BA	Between Groups	4.906	2	2.453	.143	.867
	Within Groups	1492.217	87	17.152		
	Total	1497.122	89			

N-S-AR	Between Groups	391.806	2	195.903	5.564	.005*
	Within Groups	3063.275	87	35.210		
	Total	3455.081	89			
N-S-BA	Between Groups	229.506	2	114.753	3.845	.025*
	Within Groups	2596.442	87	29.844		
	Total	2825.947	89			
SN-FH	Between Groups	104.689	2	52.344	3.225	.045*
	Within Groups	1412.258	87	16.233		
	Total	1516.947	89			
SBA-FH	Between Groups	114.956	2	57.478	2.604	.080
	Within Groups	1920.658	87	22.077		
	Total	2035.614	89			

Result

The mean length of Anterior cranial base (S-N) is statistically not significant among different skeletal patterns (table 1,2; P= 0.537). [class II < class III < class < I]

The mean length of Posterior cranial base (S-Ba) is statistically not significant among different skeletal patterns (table 1,2; P= 0.931) [class I < class III < class II]

The mean length of Total Cranial base (N-Ba) is statistically not significant among different skeletal patterns (table 1,2; P=0.572) [class III < class I < class II]

The cranial base angle (N-S-Ba) and saddle angle (N-S-Ar) is significantly more in class II group than class I group and class III skeletal patterns (table 1,2; P=0.01and P=0.001 respectively) suggests that lesser cranial base angle leads to prognathic mandible whereas increased cranial base angle leads to retrognathic mandible.

The saddle angle (N-S-Ar) is significantly more in class II skeletal pattern than class I skeletal pattern and class III skeletal pattern in both males and Females (table 4,5,6,7; P=0.000 and P=0.005)

The cranial base angle (N-S-Ba) and saddle angle (N-S-Ar) is significantly more in class II skeletal pattern than class I and class III skeletal pattern in females (table 6,7; P=0.025 and 0.005 respectively)

The Anterior (SN-FH) cranial base inclination is in significantly more in the Class II skeletal pattern compared with Class I and Class III skeletal patterns (P=0.025) and Posterior (SBa-FH) cranial base inclination is significantly more in the Class III skeletal pattern compared with Class I and Class II skeletal patterns (table 1,2; P=0.013)

Anterior (S-N) and total cranial base dimensions (N-Ba) are significantly more in males compared to females in class I skeletal pattern (table 3; P=0.002 and 0.001 respectively)

Anterior (S-N) and total cranial base dimensions (N-Ba) are significantly more in males compared to females in class II skeletal pattern (table 3; P=0.038 and 0.001 respectively)

Anterior (S-N) and total cranial base dimensions (N-Ba) are significantly more in males compared to females in class III skeletal pattern (table 3; P=0.007 and 0.002 respectively)

Posterior cranial base dimension (S-Ba) is significantly more in males compared to females in class I skeletal pattern and class II skeletal pattern (table 3; P=0.039 and P=0.001 respectively)

The anterior (SN-FH) cranial base inclination is significantly more in the Class II skeletal pattern compared with Class I and Class III skeletal patterns in female subjects (table 6,7; P=0.045)

Discussion

The Cranial Base morphology was measured to determine various linear and angular dimensions in different sagittal skeletal patterns. The cranial base plays a key role in craniofacial growth, helping to integrate, spatially and functionally, different patterns of growth in various adjoining regions of the skull such as components of the brain, the nasal cavity, the oral cavity, and the pharynx. Depending on the fact that the maxilla relates to the anterior part of the cranial base and the rotation of the mandible is influenced by the maxilla, a relationship can be found between the cranial base variations and sagittal malpositions of the jaws. Information regarding the Cranial Base morphology in different skeletal patterns in Chhattisgarh population is not available in previous studies.

The cranial base separates cranium to the midface and glenoid fossa. The cranial base may affect the development of cranium and the face. The cranial base linear and angular dimensions of previous studies were compared with the current study.

In the current study, the results shows that total cranial base length (N-Ba) is more in class II skeletal pattern when compared to class I and class III skeletal patterns.

G. B. Hopkin, et al (1968)[8], W. John S. Kerr and C. Philip Adams (1988)[10], Bhattacharya A, et al (2014)[13], Awad AM, et al (2018)[18] suggests that the dimensions of cranial base are major factor in determining the sagittal relationship of jaws.

The cranial base angle (N-S-Ba) and saddle angle (N-S-Ar) is significantly more in class II skeletal pattern compared to class I and class III skeletal pattern. Qadir M (2017)[17]it was concluded that cranial base angle does have a significant influence on jaw positioning and with a progressive increase in cranial base angle sagittal relation of jaws changes from Class III to Class II. These results agreed with the results of Hong-Po Chang, et al (2005)[11], Meghna Vandekar et al (2013)[1], Bhattacharya A, et al (2014)[13], Alice Chin, et al (2014)[12], Qadir M (2017)[17] suggests that lesser cranial base angle leads to prognathic mandible whereas increased cranial base angle leads to retrognathic mandible.

Kélei Cristina Mathias de Almeida, et al (2017)[16] concluded that a more obtuse angle at the skull base, in association or not with a greater anterior length of the cranial base, can contribute to the development of Class II malocclusions. On the other hand, a more acute angle at the skull base can contribute to a more anterior positioning of the mandible and to the development of Class III malocclusions.

The results obtained from the studies of Shah R, et al (2015)[14] and Lina cossio, et al (2016)[15] does not demonstrate any difference in cranial base angle between different sagittal skeletal patterns.

Awad AM, et al (2018)[18] conducted study on Lateral cephalometric radiographs of 180 adult patients of all three malocclusion groups, he concluded that cranial base angle has influence on antero-posterior position of the mandible.

The results of the present study show that the posterior cranial base angle (SBa-FH) is significantly more in class III skeletal pattern when compared to class I and class II skeletal pattern. Similar results found in results

of Polat OO and Kaya B (2007)[2], he conducted study on 75 patients with 25 patients in each group, concluded that Posterior cranial base inclination is increased significantly in the Class III group compared with Class I and Class II groups. It has been suggested that cranial base flexure influences mandibular prognathism by determining the anteroposterior position of the condyle relative to the facial profile.

The results of the present study show that the anterior cranial base angle (SN-FH) is significantly more in class II skeletal pattern when compared to class I and class III skeletal pattern. Dissimilar results found in results of Polat OO and Kaya B (2007)[2] show class III skeletal pattern is more when compared to class I and class II skeletal patterns.

In previous studies, there is no gender comparison of cranial base in different skeletal patterns. When effect of gender on cranial base dimensions were studied. Anterior cranial base (S-N), total cranial base (N-Ba) is significantly more in males compared to females in class I, class II and class III skeletal patterns. Posterior cranial base (N-Ba) is significantly more in males compared to females in class I, and class II skeletal patterns.

Since present study has been performed retrospectively on lateral cephalogram which is 2D image of 3D structures, future studies can be planned on recent CBCT and MRI modalities to make study more relevant in long term. Further study can be performed on larger scale in longitudinal pattern to provide more clinical data.

Conclusion

Lesser cranial base angle leads to prognathic mandible whereas increased cranial base angle leads to retrognathic mandible. In other words, a more acute angle at the skull base can contribute to a more anterior positioning of the mandible and to the development of Class III malocclusions. The posterior cranial base angle (SBa-FH) is significantly more in class III skeletal pattern when compared to class I and class II skeletal pattern. The anterior cranial base angle (SN-FH) is significantly more in class II skeletal pattern when compared to class I and class III skeletal pattern. Anterior cranial base (S-N), total cranial base (N-Ba) is significantly more in males compared to females in class I, class II and class III skeletal patterns. Posterior cranial base (N-Ba) is significantly more in males compared to females in class I, and class II skeletal patterns.

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