Original article

An investigation into the relationship between the cranial base angle and malocclusion in gujarati population.

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Abstract

Introduction: Malocclusions with skeletal discrepancies can be caused by abnormal forms, sizes and positions of the cranial base, maxilla and mandible. Aim of the present study was to assess the influence of cranial base angle on maxilla, mandible, maxillomandibular relationship and to compare and correlate the cranial base angle with size and position of maxilla and mandible; to evaluate the norms for cranial base angle in Gujarati population.

Material and Methods: The present study was conducted at the Department of Orthodontics,Government Dental College and Hospital,Ahmedabad. 160 Lateral Cephalograms were obtained with age between 15 -20 years.The sample was divided into 4 groups.Each group (Class I, Class II Div 1, Class II Div 2 and Class III) contained 40 subjects, 20 males and 20 females.

Results Whencomparing CRANIAL BASE ANGLE(NSAr, NSBa)in Class I control group with Class II Div 1and Class II Div 2 shows that the CRANIAL BASE ANGLE significantly increased in Class II Div 1 and Class II Div 2.Cranial base angleissignificantly decreased in Class III compared to that found in Class I group.

Conclusion: The jaw relation tends to change from class III to class II, with progressive flattening of the cranial base and vice –versa. Angle SNA has a significant negative correlation with cranial base angle. The mandibular position is influenced to a greater extent by the cranial base angle rather than maxillary position. Statistically significant difference was observed in Cd-ANS, Ar-ANS, Ar-Pog, Cd-Pog depicting that maxillary and mandibular length is greater in gujarati males as compared to females.

Introduction

The relationship between cranial base configuration and malocclusion has been of interest particularly to Anthropologists and Orthodontists, in relation to racial variation and aesthetics. Huxley[1] and Bjork[2]have carried out studies on dried skulls, cephalometrics respectively to discrepancy between cranial base , maxilla and mandible can cause malocclusion.

Malocclusions with skeletal discrepancies can be caused by abnormal forms, sizes and positions of the cranial base, maxilla and mandible. Facial patterns are expressed by the interrelation of variable factors such as heredity, function and environment. Such variable factors have an effect on the growth and development of maxillofacial bones [3]. In addition, it is important to recognize that growth at the cranial base can strongly influence facial growth[4],especially mandibular positioning[5].

The cranial base which forms the floor of the cranial vault and extends from the foramen caecum anteriorly to the basioccipital bone posteriorly. It is essentially a midline structure comprising parts of the nasal, orbital, ethmoid, sphenoid, and occipital bones. Sella turcica lies near the center of the cranial base and divides it into anterior (sella to nasion) and posterior (sella to basion) limbs forming cranial base angle, or saddle angle. This is radiographically measured between the Basion-Sella-Nasion points. The Articulare and/or Basion points have also been used to describe the posterior limit of the cranial base.[6]

The saddle angle (Na-S-Ar) at birth is approximately 142^{O}, but then reduces to 130^{0} at 5 years of age. From 5 to 15 years the cranial base angle is relatively stable[6].. Melsen has shown that this relative stability results from a dynamic process whereby Flexion at the spheno-occipital synchondrosis is counteracted by resorption of bone at the endocranial surface and deposition on the pharyngeal surface.[7]Flexion 130^{o}-135^{o} formed at Nasion-Sella-Articulare leads to maxilla and mandible articulate with different limbs of cranial base. The maxilla appears to be attached to the anterior limb and the mandible to the posterior limb.A number of authors have suggested that there is a relationship between the degree of cranial base flexion and type of malocclusion, with the angle becoming increasingly obtuse from class III through class I to class II subjects.[6]

The orthodontic literature contains many studies involving cephalometric standards of European-American, African-American, Japanese, and Chinese populations but little for other and gujaratis in specific.[8]

Thus in view of above facts, a cephalometric study was conducted with following purpose to determine the relationship between cranial base angle and various type of malocclusion in Gujarati population.

The aims and objectives of this study are:

- To assess the influence of cranial base angle on maxilla-mandibular relationship.
- To assess the influence of cranial base angle on maxilla.
- To assess the influence of cranial base angle on mandible.
- To compare and correlate the cranial base angle with size and position of maxilla and mandible
- To evaluate the norms for cranial base angle in Gujarati population.
- To compare various skeletal and dental parameter for gujarati males and females.

Material and methods

The present study was conducted at the Department of Orthodontics, Government Dental College and Hospital , Ahmedabad .For the present study, 160 cephalogram were obtained from the Department of Orthodontics , Government Dental College And Hospital, Ahmedabad, Gujarat after examining the patient. Their age ranged between 15 -20 years. The sample was divided into of 4 groups, each group contains 40 patients, 20 males and 20 females.

Group 1: Patients with Class I skeletal jaw relationship and class Idental occlusion.

Group 2: Patients with Class II skeletal jaw relationship and Class IIDiv.1 malocclusion.

Group 3: Patients with Class II skeletal jaw relationship and Class IIDiv.2 malocclusion.

Group 4: Patients with Class III skeletal jaw relationships and Class III malocclusion.

Sample criteria:

1-All of the patients were Gujarati in origin (Four grandparents were Gujarati).

2-Any cases with systemic diseases that affect the growth and development or craniofacial Syndromes, patient with trauma, previous orthodontic treatment and orthognathic surgery were excluded.

3-The age range of the subject was between 15-20 years.

4- All teeth were present and free of crown restorations.

5- Group 1 (Class I or normal occlusion)

- Well aligned upper and lower arches with no crowding or spacing.
- Bilateral Class I molar and canine relationship,
- The overjet ranged between 2-4 mm and over bite between 1-3 mm,
- ANB angle was 2^0-4^0

6- For group 2 (Class II Div.1 malocclusion)

- Bilateral half unit Class II or greater molar and canine relationship,
- Overjet was >5mm,
- ANB angle was >4^0.

7- For group 3 (Class II Div.2 malocclusion)

- Bilateral half unit class II or greater molar and canine relationship,
- Retroclination of the maxillary anterior teeth, at least of the two central incisors and a deep bite, complete vertical coverage by a maxillary central incisor of the crown of the corresponding mandibular incisor,
- ANB angle was >4^0

8- For group 4 (Class III malocclusion)

- Bilateral half Class III or greater molar and canine relationship,
- Edge to edge or reversed overjet
- ANB angle was < 2°.

Lateral cephalometric radiographs were under strict standardized conditions. They were printed and the point identification and measurements were done directly on the radiographs using a lead 6H pencil, protractor and metric ruler and they were traced twice to minimize the error. In case of discrepancy the mean shadow of bilateral structure were traced. All the linear measurements were made closest to 0.5 mm and angular measurements nearest to 0.5 degree.Further following cephalomatric points were plotted, lines and angles were drawn and necessary angular and linear parameters were recorded for carrying statistical analysis.

I. POINTS (Figure 1)

Nasion (N), Sella Turcica (S), Basion (Ba), Articulare (Ar),Orbitale (Or),Porion (Po), Anterior nasal spine,Posterior nasal spine (PNS),Point A (Subspinale), Gonion (Go), Menton (Me), Point B (Supramentale).

II. ANGLES AND MEASUREMENTS (Figure 2)

The above measurements were selected S-N, S-Ar, S-Ba, Maxillary base length, Mandibular base length, N-S-Ar, N-S-Ba, SNA, SNB, ANB, Upper Central Incisortomaxillary plane angle (Imx), Lower Central Incisorto mandibular plane angle (Imn), Interincisal angle (I/I) :primarily to investigate the role played by the cranial base flexure in influencing the saggital and vertical position of the jaws.After identification and tracing the cephalogram, the results were tabulated and subjected to statistical analysis.

Results

Statistical analysis

The statistical methods that were employed in the present study are:Mean, Standard Deviation, Standard Error, Anova Test, Independent samples T test, P-value.

Tables and graphs:

The results are presented in Tables 1–14. Tables 1 to 4 shows comparison of various skeletal parameters between males and females of gujarati population using independent *t*-tests to show whether there exists significant difference between them.It was necessary to demonstrate that the data for each variable showed significant variance in the four malocclusion groups so as not to invalidate comparisons between individual malocclusion groups. This was done using a one-way ANOVA of relevant groups (Table 5).

Table 6 shows comparison between N-S-Ba and N-S-Ar of gujarati population using independent *t*-tests to show whether there exists significant difference between them. Tables 7, 8 and 9 show values for all skeletal and dental variables and also between-group comparisons of variables according to independent *t*-tests.

Table 10 shows the salient and significant inter variable correlations compiled using pooled data from all four malocclusions. Tables 11–14 show inter variable correlations for each malocclusion group.

Discussion

The role played by the cranial base, in influencing the positioning of the jaw is known since long.Research done by workers [9,10,11,1213,15,17,23]have shown that, there exists a relationship between the dentoalveolar,skeletal pattern and the cranial base morphology.The most rapid rate of growth of the cranial base occurs in the first and second year of life [49(13)]. The studies on the postnatal growth of the cranium and dentofacial skeletal structure reveal that the cranial base angle becomes established at a much younger age (5-7 years after birth)and subsequent changes in the value of this angle is very minimal [13,14,15,16,17].Class I sample shows good agreement with published cephalometric norms for both dental and skeletal base relationships.[18] Interestingly these figures also agree very closely with those recently published by Hamdan and Rock[19]who calculated the mean of means for major cephalometric variables using data from 14 prominent studies. The sample, therefore, represents a valid reference group for the purpose of this study. In all the skeletal and dental angular measurements viz. (NSAr, NSBa, SNA, SNB, ANB) and dental (Imx, Imn and I/I), respectively small difference existed between males and females of various malocclusion groups- but were not statistically significant (P>0.01,Table1-4). However statistically significant difference was observed in Cd-ANS, Ar-ANS (maxillary length), Ar-Pog, Cd-Pog (mandibular length) (P<0.01Table 1-4) depicting that maxillary and mandibular length is greater in gujarati males as compared to females. These finding agree with *Khoshy S. Fatehulla* studies which in gender comparisons confirmed that males possess significant greater maxillary and mandibular body linear dimensions than females [9].

It was necessary to demonstrate that the data for each variable show significant variance in the four malocclusion groups so as not to invalidate comparisons between individual malocclusion groups. This was done using a one-way ANOVA test of relevant groups (Table 5). This is justified in Table 5 which shows highly significant variation in various angular measurements like N-S-Ba, N-S-Ar, SNB,ANB and linear measurement like N-S, Cd-Pog,ANS-PNS, Go-Me (P<0.0001).

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Table 6 shows small difference existed between N-S-Ba and N-S-Ar of various malocclusion groups- Class I, Class II Div 1, Class II Div 2 and Class III groups and that they were not statistically significant (P>0.01,Table 6). In the present study, both Ar and Ba points have been used as the posterior cranial base limit. Our study is in concurrence with Bhatia and Leighton[20]who have published figures for N–S–Ba and N–S–Arangles as well as the S– Ba and S–Ar distances.

Whencomparing CRANIAL BASE ANGLE(NSAr, NSBa) in Class I control group with Class II Div 1and Class II Div 2, Table 7,8 shows that the CRANIAL BASE ANGLE significantly increased in Class II Div 1 and Class II Div 2 (*P*<.005). Cranial base angleissignificantly decreased in Class III compared to that found in Class I group (*P*<.005 ; Table 9). This was true for both males and females..These findings are in agreement with Ishii N, Chang HP, Namankani EA, Salehi P, Proff P, Patricia A [21-26].

The anterior cranial base length (S-N) shows significantly decrease in Class III group when compared to Class I group (p=0.004; Table 9). This finding was similar to Chang HP, Namankani EA, AlnamankaniEA studies [22,23,27] but it was in contrast to Proff P [25]who stated that S-N length in Class III malocclusion shows minimal non-significant shortening. The posterior cranial base length (S-Ba) is highly significantly increased in Class II division 1group(P=0.001; Table 7) and highly significantly decreased S-Ba distance in Class III groups (P=0.002; Table 9).The posterior cranial base appeared to play a more important role in Class II and Class III morphogenesis by virtue of its proximity to the mandibular complex. Variousce-phalometric studies have reported elongation of the posterior cranial base for Class II patients and shortening of posterior cranial base in Class III patients as compared to class I patients [22,24,28,29].

In present study Cd-ANS and Ar-ANS distance shows non significant result when comparing Class I control group with Class II Div1 (p<0.991,0.994: Table 3), Class II Div 2(p<0.997,0.698: table 4)and Class III (p<0.999, 0.626: Table 5) groups. The position of upper jaw in Class II and Class III malocclusion, as related to the cranial base, was relatively close to Class I. According to Dhopatkar A *,Khoshy S. Fatehulla studies* this may be due to the fact that the maxilla appears to be attached to anterior cranial base and there are only small variations in the anterior cranial base area in different classes of malocclusion as compared to Class I. [6,9]

In present study mandibular length measurement Cd-Pog and Ar- Pog distance shows significant decrease when comparing Class I control group with Class II Div1 (p= 0.003,0.002: Table 7), Class II Div2(p=0.010,0.011; Table 8) respectively and significant increase when comparing Class 1 control group with Class III(p=0.030,0.004 ; Table 9) groups. This finding agree with studies of Dhopatkar A,Mouakeh M *,Khoshy S. Fatehulla* [8,9,29].This again stresses the importance of posterior cranial base flexure, leading to Class II and Class III type of malocclusions.

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Maxillary length measured from the ANS point to PNS was highly significant shorter in the Class III group as compared with the control Class 1 group(P=0.000; TABLE 9) which indicated a smaller size of maxilla in Class III malocclusion. This result was close to those in other studies[27,30,31]who reported similar results in class III malocclusion. On the other side, the maxillary lengths in Class II Div1 (P=0.996; TABLE 7) and Class II Div2 (P=0.999; TABLE 8) did not show significant increase. According to the present study, the probable explanation for these findings is that in Class III malocclusions the shorter anterior cranial base length was responsible for the shorter maxillary length while in Class II Div1 and Class II Div 2 the anterior cranial base length was similar to that of Class I, therefore the maxillary length showed no significant variation.

The mean values of mandibular body length (Go-Me) in the sample of the present study were significantly lower in Class II Div 1 (p=0.000: Table 7) and Class II Div 2(p=0.000: Table 8) as compared to normal class I while they were non significantly higher in Class III group. The low values of mandibular body length in class II malocclusion and higher value in class III malocclusion were possibly due to hereditary factors, as supported by Michell et al where it was stated that the size of the jaws is mainly genetically determined [32].

The Class II Div 1 was characterized by proclined upper and lower central incisors that resulted in decreasing interincisal angle as compared to Class I group, however the difference was not significant. This was similar to studies by Miethke RR,Antanas Sidlauskas, Lapter M [33,34,35] who reported the same findings. In present study it was found that Class II Div 2 malocclusion had a significantly pronounced retroclination of upper central incisors in relation to the maxillary plane(p=0.000;Table 8) with tendency of the lower incisors to be retroclined(p=0.000;Table 8), thus resulting in an obvious increase of the interincisal angle(p=0.000;Table 8). This was in accordance with the previous studies Dhopatkar A, Lapter M [6,35]. Class III malocclusion was characterized by a more proclined upper centrals(p=0.000;Table 8) and retroclined lower incisors (p=0.000;Table 8) with a non significant tendency of interincisal angle to be decreased(p=0.697;Table 8). These variations in incisor inclination in different malocclusions reflect the dento-alveolar compensations to the underlying skeletal discrepancies. This was in accordance with the previous studies Dhopatkar A, Miethke RR[6,33].

CRANIAL BASE ANGLE (N-S-Ar) when correlated with angle SNA and SNB in pooled group, shows inverse relation which is highly significant(-0.301, -0.744; Table 10) respectively. Even individual group Class I (-0.535, -0.560; Table 11) Class II Div 1(-0.448,-0.448 ;Table 12) Class II Div 2 (-0.540,-0.565; Table 13) and Class III (-0.542,-0.411; Table 14) showed inversely significant correlation between cranial base angle and angle SNA, SNB. These finding where inagreement with Bjork[2]and Kasai et al[5]who demonstrated a relationship between the cranial base angle and facial prognathism. The correlation analysis also suggests a relationship between mandibular

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position and the magnitude of cranial base flexure. The smaller the cranial base angle, the more forward the mandibular position, as indicated by angle SNB. Table 7, 8 and 9 shows the comparison between Class I and each of Class II Div 1, Class II Div 2 and Class III group, the SNB angle was significantly decreased in Class II Div 1 and Class II Div2(P=0.000 ; Table 7,8) and increased in Class III malocclusion groups(P=-0.000 ; Table 9). The mean values found in the present study groups reflected the retrognathic mandible in the Class II divisions and the prognathic mandible in Class III malocclusion.These findings are in agreement with Giuntini V, Bacetti T[36,37,38]Correlation was evident between angle ANB and cranial base parameters (N-S-Ar, N-S-Ba) when looking at pooled or individual group data (0.628, 0.404;Tables 9). This suggests that there is direct significant relationship between the cranial base and various class of malocclusion.

The present correlation analysis of the test and control groups yielded a significant association between cranial base angle and the anteroposterior relation of the jaw bases. The correlation analysis also suggested a relationship between mandibular position and the magnitude of cranial base flexure. The positive and significant correlations between N- S (anterior cranial base length)and N-Ba(posterior cranial base length) distances with maxillary and mandibular lengths also suggested a link between jaw length and facial prognathism. This study agrees with studies by various authors who carried out study in various populations; however larger sample size would be helpful to establish norms for gujarati populations.

Various other factors like heredity, function and environment need to be considered to correlate between cranial base angle and anterioposterior relationship of jaw bases.

Conclusion

It has been known for a long time that cranial base angle influences the craniofacial morphology. There have been numerous reports by many author on this aspect; some author have supported the above hypothesis while others have not. The influence of the cranial base on the position of the mandible has been investigated and proved by many workers.

The conclusions made were as follows:

I. **The influence of cranial base angle on maxilla-mandibular relationship**:

A significant positive correlation exists between indicators of saggital jaw discrepancy (ANB) and cranial base angle. The jaw relation tends to change from class III to class II,with progressive flattening of the cranial base and vice –versa .thus taking the cranial base angle at an early age can help the clinician to predict the future skeletal pattern of the child.

II. **The influence of cranial base angle on maxilla:**

Angle SNA has a significant negative correlation with cranial base angle (N-S-Ar, N-S-Ba) for overall sample similar trend is found between groups. Cranial base has definite influence on the maxilla.

III. **The influence of cranial base angle on mandible :**

The mandibular position is influenced to a greater extent by the cranial base angle

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rather than maxillary position, as revealed by a stronger negative correlation between angles (N-S-Ar, N-S-Ba) and SNB .It is thus concluded that cranial base angle has a determinant role in influencing the mandibular position.

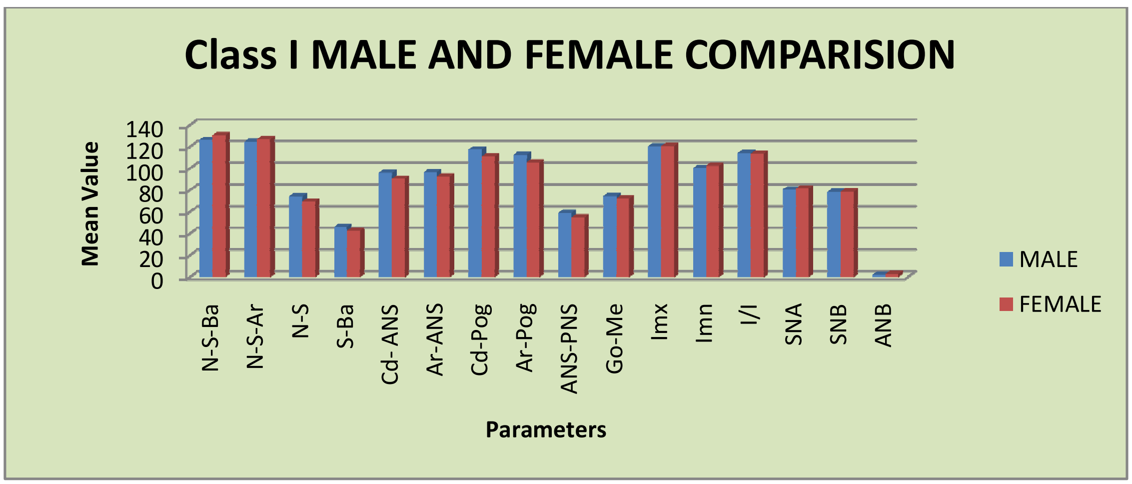
IV. Skeletal and dental parameter for gujarati males and females.

In all the skeletal and dental angular measurements viz. (**NSAr, NSBa, SNA, SNB, ANB**) and dental **(Imx, Imn and I/I)**, respectively non significant small difference existed between males and females of various malocclusion groups- Class I, Class II Div 1, Class II Div 2 and Class III groups, however statistically significant difference was observed in Cd-ANS, Ar-ANS (maxillary length), Ar-Pog, Cd-Pog (mandibular length) for gujarati male and female.

TABLE 1 (CLASS I) : SHOWING THE MEAN (x), STANDARD DEVIATION, STANDARD ERROR, MEAN DIFFERENCE AND P VALUE OF ALL PARAMETERS IN MALE AND FEMALE.

Parameters	MALE			FEMALE			Mean Difference	P value
	Mean	Std. Deviation	Std. Error	Mean	Std. Deviation	Std. Error		
N-S-Ba	126. 20	26. 233	5.886	130.40	2.780	.622	-7. 200	. 230
N-S-Ar	124.30	4. 219	.943	126.85	2.700	.604	-1.550	.054
N-S	74.30	5.334	1.170	69.40	4.571	1.089	4.900	.051
S-Ba	46.10	4.304	.963	42.50	3.830	.857	3.600	.063
Cd- ANS	95.80	7.804	1.745	90.50	5. 216	1.166	5.300	.016
Ar-ANS	96.30	5.782	1.695	92.50	6.314	1.411	3.800	.093
Cd-Pog	117.30	8.637	1.939	111.10	5.831	1.304	6. 200	.011
Ar-Pog	112.50	8.383	1.853	105. 20	5.791	1. 295	7.300	.003
ANS-PNS	58.90	4.117	.943	55.05	4.718	1.055	3.850	.638
Go-Me	74.55	6.597	1.475	72. 25	5.418	1. 212	2.300	. 236
Imx	120.30	7.310	1.637	120.55	7. 294	1.631	-.250	.914

Imn	100.30	8.939	1.999	102.30	5.931	1.334	-2.00	.409
I/I	113.95	10.050	2. 247	113.45	11. 269	2.520	.500	.883
SNA	80.50	5. 277	1.180	81.30	3.585	.802	-.802	.578
SNB	78.35	4.705	1.052	78.50	3.887	.869	-.150	.913
ANB	2.15	1.137	. 251	2.80	.894	. 200	-.650	.052



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Parameters	MALE			FEMALE			Mean Difference	P value
	Mean	Std. Deviation	Std. Error	Mean	Std. Deviation	Std. Error		
N-S-Ba	131.30	2.736	.612	134.00	5.786	1.294	-2.700	.067
N-S-Ar	126.25	4.128	.923	128.80	5.970	1.335	-2.550	.124
N-S	71.65	8.022	1.794	68.20	4.287	.959	3.450	.098
N-Ba	45.25	5.739	1.283	44.75	6.851	1.532	.500	.804
Cd- ANS	95.95	7.964	1.781	89.35	6.218	1.390	6.600	.006
Ar-ANS	96.55	8.654	1.935	90.30	6.814	1.524	6.250	.015
Cd-Pog	108.40	6.557	1.466	105.95	10.231	2.288	2.450	.373
Ar-Pog	103.15	6.846	1.531	100.05	9.720	2.173	3.100	.015
ANS-PNS	59.55	6.100	1.364	54.95	5.296	1.184	4.600	. .251
Go-Me	68.90	6.766	1.513	64.50	7.681	1.718	4.400	.062
Imx	116.30	6.899	1.543	119.65	7.590	1.697	-3.350	.152
Imn	105.25	6.086	1.361	101.10	4.633	1.036	4.150	.120
I/I	111.70	7.270	1.626	113.15	9.719	2.173	-1.450	.596
SNA	83.95	4.334	.969	82.55	3.649	.816	1.400	.276
SNB	76.40	3.733	.835	76.55	4.058	.907	-.150	.904
ANB	7.55	1.572	.352	6.00	1.338	.299	1.550	.112

Table 2 Class II div I

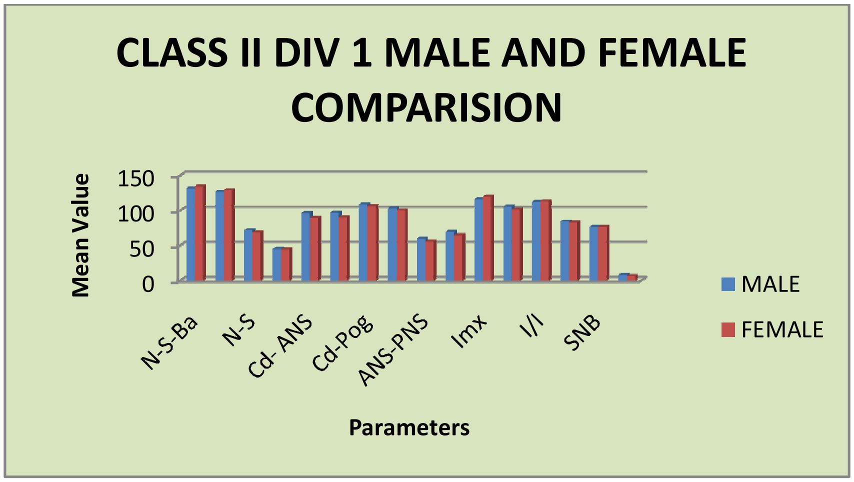

TABLE 3 (CLASS II DIV 2) : SHOWING THE MEAN (x), STANDARD DEVIATION, STANDARD ERROR , MEAN DIFFERENCE AND P VALUE OF ALL PARAMETERS IN MALE AND FEMALE.

Parameters	MALE			FEMALE			Mean Difference	P value
	Mean	Std. Deviation	Std. Error	Mean	Std. Deviation	Std. Error		
N-S-Ba	135.65	3.897	.871	134.60	5.443	1.217	1.050	.487
N-S-Ar	130.75	4.447	.994	129.75	5.159	1.154	1.000	.515
N-S	72.05	3.252	.727	70.10	4.278	.957	1.950	.113
N-Ba	44.40	6.038	1.350	42.35	3.964	.886	2.050	.212
Cd- ANS	94.10	4.291	.959	90.70	5.948	1.330	3.400	.045
Ar-ANS	93.85	4.955	1.108	91.15	5.669	1.268	2.700	.010
Cd-Pog	110.55	5.558	1.243	105.35	5.869	1.312	5.200	.007
Ar-Pog	105.55	6.074	1.358	99.70	6.208	1.388	5.850	.005
ANS-PNS	57.20	5.033	1.125	56.45	4.594	1.027	.750	.625
Go-Me	69.50	5.624	1.258	65.55	3.252	.727	3.950	.117
Imx	88.95	6.039	1.350	91.60	13.975	3.125	-2.650	.441
Imn	93.10	9.431	2.109	92.45	8.630	1.930	.650	.821

I/I	160.75	8.491	1.899	155.35	15.055	3.366	5.400	.170
SNA	79.75	5.609	1.254	80.95	4.707	1.053	-1.200	.468
SNB	73.45	5.530	1.236	74.80	4.396	.983	-1.350	.398
ANB	6.30	.979	.219	6.15	1.461	.327	.150	.705

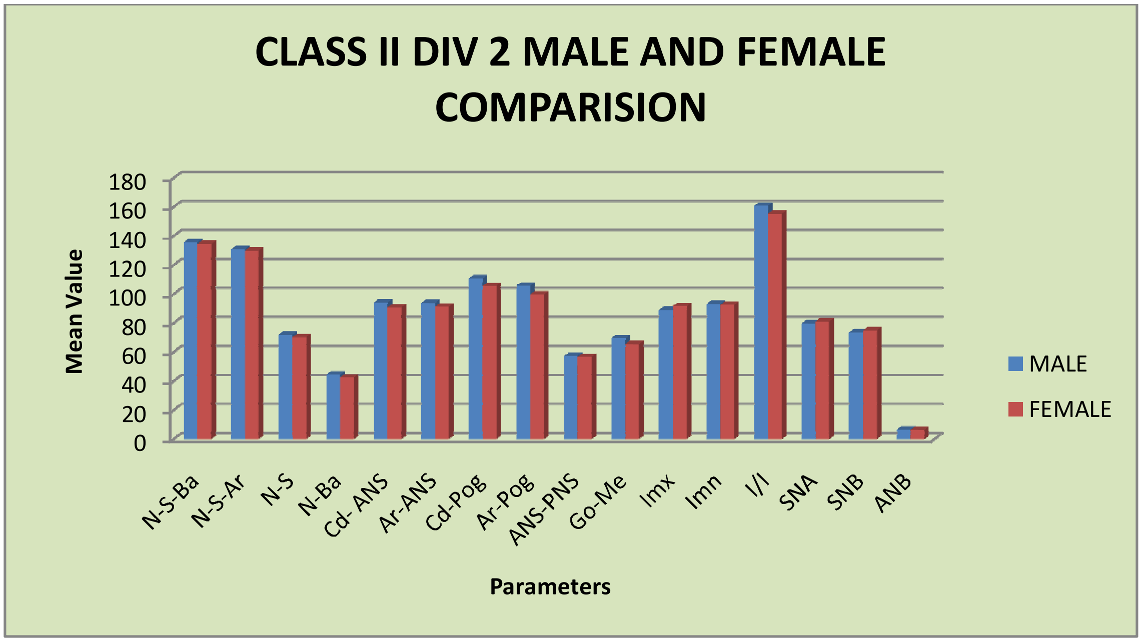

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TABLE 4 (CLASS III) : SHOWING THE MEAN (x), STANDARD DEVIATION, STANDARD ERROR, MEAN DIFFERENCE AND P VALUE OF ALL PARAMETERS IN MALE AND FEMALE.

Parameters	MALE			FEMALE			Mean Difference	P value
	Mean	Std. Deviation	Std. Error	Mean	Std. Deviation	Std. Error		
N-S-Ba	121.00	3.728	.834	122.60	3.050	.682	-1.600	.146
N-S-Ar	117.40	2.644	.591	117.50	4.818	1.077	-.100	.936
N-S	73.30	6.570	1.469	67.50	5.680	1.270	5.800	.115
N-Ba	41.70	6.744	1.508	41.40	5.548	1.241	.300	.879
Cd- ANS	89.60	10.585	2.367	86.80	7.647	1.710	2.800	.005
Ar-ANS	90.60	11.436	2.557	84.30	6.506	1.455	6.300	.039
Cd-Pog	116.30	12.053	2.695	112.70	11.211	2.507	3.600	.030
Ar-Pog	113.20	12.129	2.712	109.30	11.342	2.536	3.900	.300
ANS-PNS	51.50	7.359	1.646	52.60	3.016	.674	-1.100	.540
Go-Me	76.00	7.341	1.642	75.20	5.288	1.182	.800	.695
mx	115.90	10.617	2.374	120.60	8.768	1.961	-4.700	.135
Imn	90.30	12.880	2.880	88.60	9.703	2.170	1.700	.640
I/I	123.10	11.986	2.680	125.20	11.597	2.593	-2.100	.577
SNA	80.70	5.469	1.223	80.80	4.124	.922	-.100	.948
SNB	83.70	4.281	.957	85.50	3.532	.790	-1.800	.155
ANB	-3.00	2.294	.513	-4.70	2.386	.534	1.700	.127

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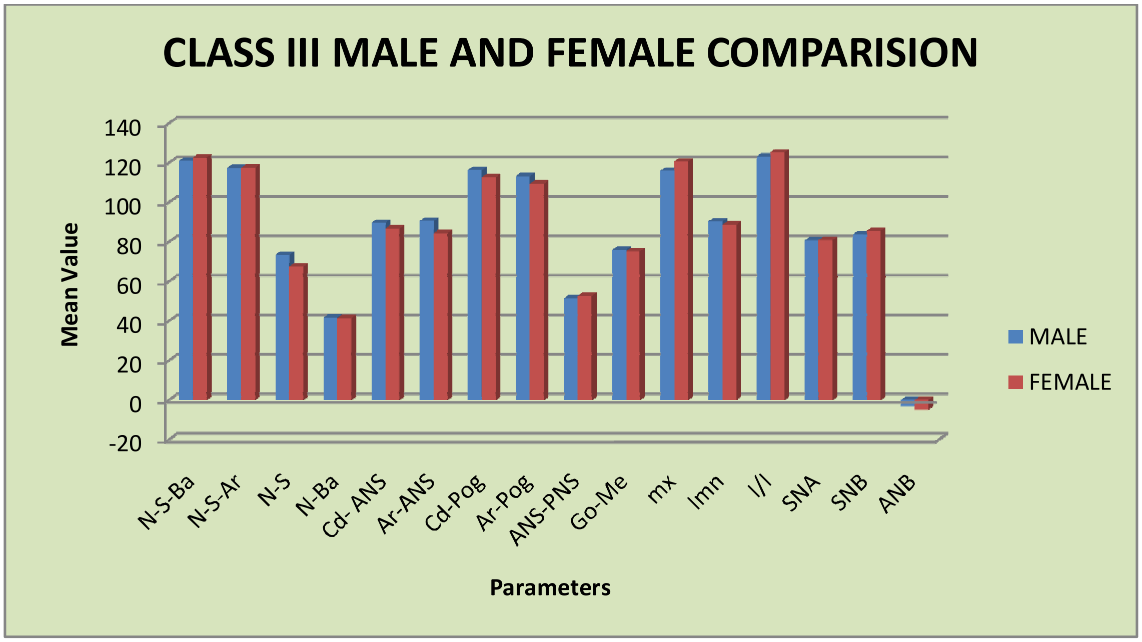

TABLE 5 SHOWING THE RESULTS OF ONE-WAY ANOVA OF RELEVANT GROUPS.

Parameters	Degrees of Freedom	Sum of Squares	Mean Square	Variance Ratio (F)	Probability (P)
N–S–Ba	3	4299.319	1433.106	14.043	<0.0001
N–S–Art	3	3644.450	1214.817	61.667	<0.0001
SNA	3	206.675	68.892	3.224	0.024
SNB	3	2416.869	805.623	43.794	<0.0001
ANB	3	2872.569	957.523	335.652	<0.0001
N-S	3	84.125	28.042	5.832	0.008
S-Ba	3	267.819	89.273	2.923	0.016
Cd-ANS	3	628.200	209.400	3.718	0.013
Cd-Pog	3	1856.619	618.873	7.980	<0.0001
ANS-PNS	3	743.750	247.917	8.667	<0.0001
Go-Me	3	2293.419	764.473	19.418	<0.0001

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TABLE 6 : SHOWING THE MEAN (x), STANDARD DEVIATION, STANDARD ERROR , MEAN DIFFERENCE AND P VALUE OF ALL PARAMETERS IN N-S-Ar AND N-S-Ba

	Parameters	Mean	N	Std. Deviation	Std. Error Mean	Mean Difference	p Value
Over ALL	N_S_Ba	128.84	160	11.277	0.892	2.140	0.389
	N_S_Ar	126.70	160	6.500	0.514		
CLASS I	N_S_Ba	126.80	40	18.770	2.968	1.225	0.683
	N_S_Ar	125.58	40	3.727	0.589		
CLASS 2 DIV 1	N_S_Ba	134.65	40	4.672	0.739	1.120	0.435
	N_S_Ar	133.53	40	5.228	0.827		
CLASS 2 DIV 2	N_S_Ba	135.13	40	4.702	0.744	4.880	0.135
	N_S_Ar	130.25	40	4.781	0.756		
CLASS III	N_S_Ba	118.80	40	3.458	0.547	1.350	0.634
	N_S_Ar	117.45	40	3.836	0.607		

COMPARISION BETWEEN N-S-Ba AND N-S-Ar

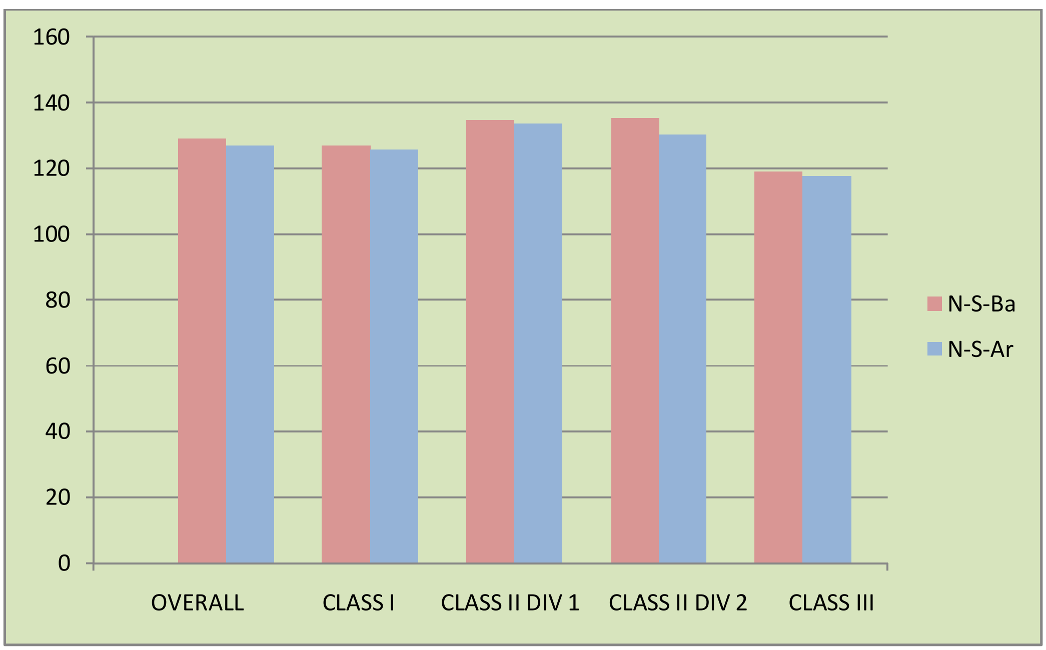

TABLE 7 SHOWING COMPARISON OF SKELETAL AND DENTAL VARIABLES BETWEEN THE CLASS I ANDCLASS II DIV 1 SAMPLE GROUPS

Parameters	CLASS I			CLASS II DIV 1			P value
	Mean	Std. Deviation	Std. Error	Mean	Std. Deviation	Std. Error	
N-S-Ba	126.80	18.770	2.968	134.65	4.672	.739	.004
N-S-Ar	125.58	3.727	.589	133.53	5.228	.827	.005
N-S	71.85	5.573	.881	74.93	6.584	1.041	.004
N-Ba	44.30	4.416	.698	47.00	6.243	.987	.001
Cd- ANS	93.15	7.080	1.119	92.65	7.804	1.234	.991
Ar-ANS	94.40	7.150	1.130	93.43	8.314	1.315	.944
Cd-Pog	114.20	7.914	1.251	107.18	8.572	1.355	.003
Ar-Pog	108.85	7.966	1.260	101.60	8.445	1.335	.002
ANS-PNS	56.98	4.828	.763	57.25	6.101	.965	.996
Go-Me	73.40	6.071	.960	66.70	7.484	1.183	.000
Imx	120.43	7.214	1.141	123.98	7.357	1.163	.211
Imn	101.30	7.552	1.194	103.18	5.737	.907	.765
I/I	113.70	10.542	1.667	112.43	8.503	1.344	.953
SNA	80.90	4.471	.707	83.25	4.018	.635	.109
SNB	78.43	4.260	.674	76.48	3.850	.609	.180
ANB	2.48	1.062	.168	6.78	1.641	.259	.000

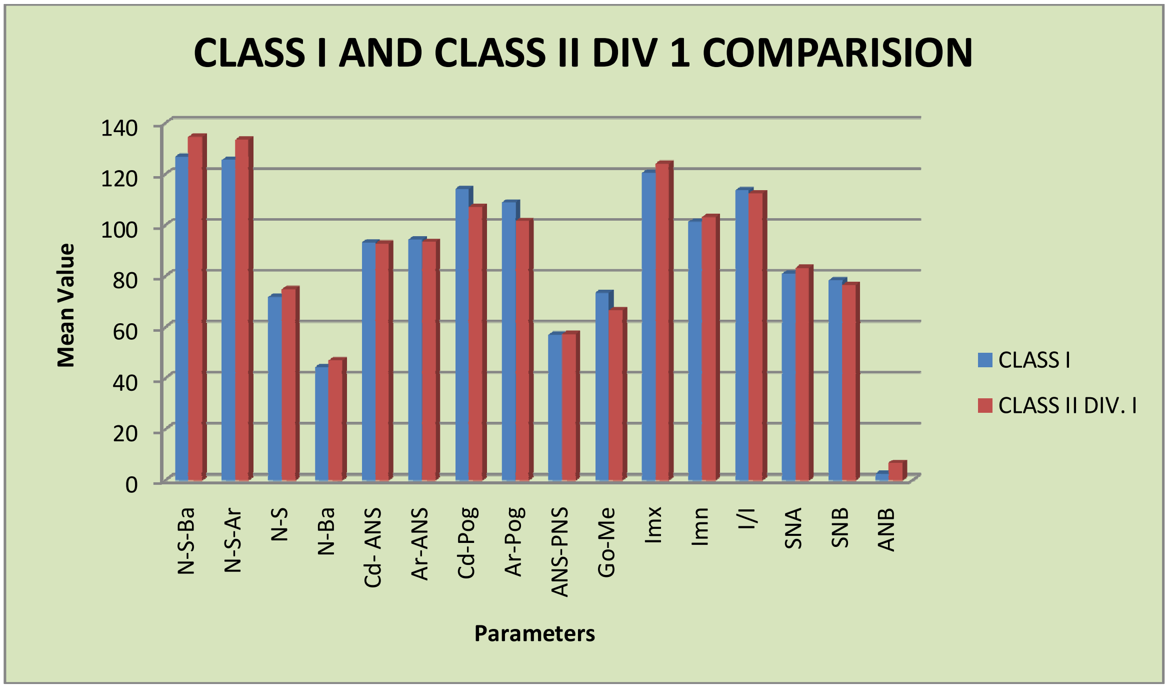

TABLE 8 SHOWING COMPARISON OF SKELETAL AND DENTAL VARIABLES BETWEEN THE CLASS I AND CLASS II DIV 2 SAMPLE GROUPS

Parameters	CLASS I			CLASS II DIV 2			P value
	Mean	Std. Deviation	Std. Error	Mean	Std. Deviation	Std. Error	
Na-S-Ba	126.80	18.770	2.968	135.13	4.702	.744	.002
Na-S-Ar	125.58	3.727	.589	130.25	4.781	.756	.000
N-S	71.85	5.573	.881	71.08	3.879	.613	.933
N-Ba	44.30	4.416	.698	43.38	5.148	.814	.877
Cd- ANS	93.15	7.080	1.119	92.40	5.401	.854	.970
Ar-ANS	94.40	7.150	1.130	92.50	5.430	.859	.698
Cd-Pog	114.20	7.914	1.251	107.95	6.226	.984	.010
Ar-Pog	108.85	7.966	1.260	102.63	6.747	1.067	.011
ANS-PNS	56.98	4.828	.763	56.83	4.771	.754	.999

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Go-Me	73.40	6.071	.960	67.53	4.956	.784	.000
Imx	120.43	7.214	1.141	90.28	10.711	1.693	.000
Imn	101.30	7.552	1.194	92.78	8.928	1.412	.000
I/I	113.70	10.542	1.667	158.05	12.370	1.956	.000
SNA	80.90	4.471	.707	80.35	5.147	.814	.951
SNB	78.43	4.260	.674	74.13	4.978	.787	.000
ANB	2.48	1.062	.168	6.23	1.230	.194	.000

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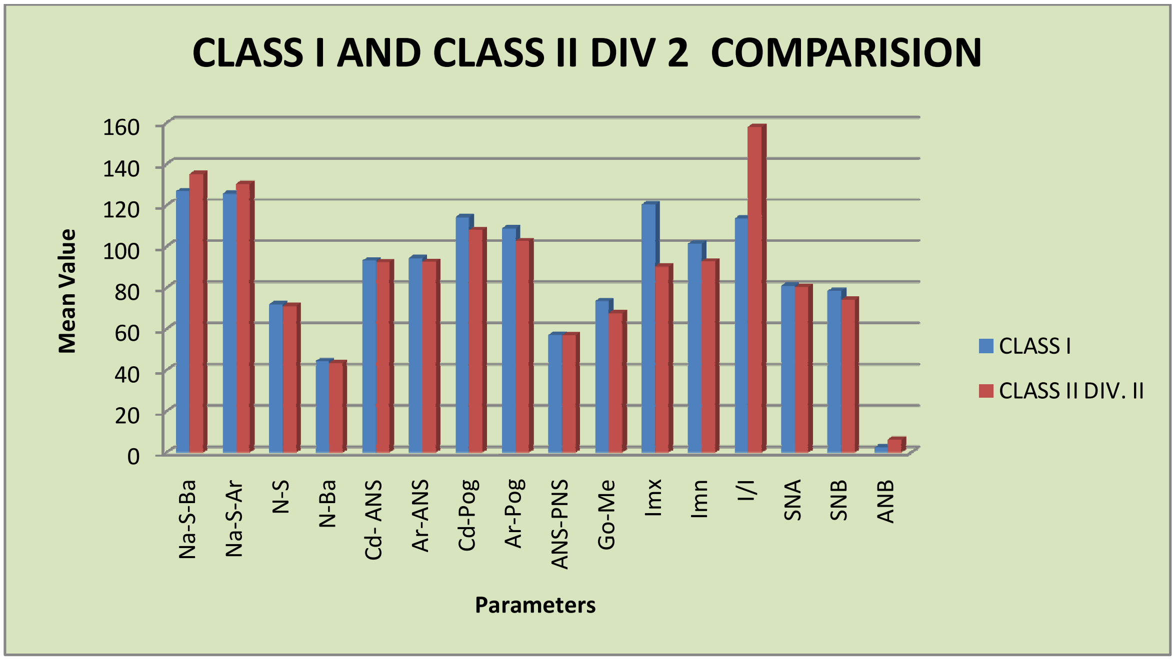

TABLE 9SHOWING COMPARISON OF SKELETAL AND DENTAL VARIABLES BETWEEN THE CLASS I AND CLASS III SAMPLE GROUPS

Parameters	CLASS I			CLASS III			P value
	Mean	Std. Deviation	Std. Error	Mean	Std. Deviation	Std. Error	
Na-S-Ba	126.80	18.770	2.968	118.80	3.458	.547	.004
Na-S-Ar	125.58	3.727	.589	117.45	3.836	.607	.000
N-S	71.85	5.573	.881	68.40	6.736	1.065	.004
N-Ba	44.30	4.416	.698	40.55	6.097	.964	.002
Cd- ANS	93.15	7.080	1.119	88.20	9.224	1.458	.119
Ar-ANS	94.40	7.150	1.130	87.45	9.722	1.537	.231
Cd-Pog	114.20	7.914	1.251	119.50	11.633	1.139	.030
Ar-Pog	108.85	7.966	1.260	113.25	11.758	1.159	.004
ANS-PNS	56.98	4.828	.763	52.05	5.579	.882	.000
Go-Me	73.40	6.071	.960	75.60	6.328	1.001	.400

Imx	120.43	7.214	1.141	128.25	9.901	1.566	**.000**
Imn	101.30	7.552	1.194	89.45	11.289	1.785	**.000**
I/I	113.70	10.542	1.667	124.15	11.689	1.848	**.697**
SNA	80.90	4.471	.707	80.75	4.781	.756	**.999**
SNB	78.43	4.260	.674	84.60	3.979	.629	**.000**
ANB	2.48	1.062	.168	-3.85	2.466	.390	**.000**

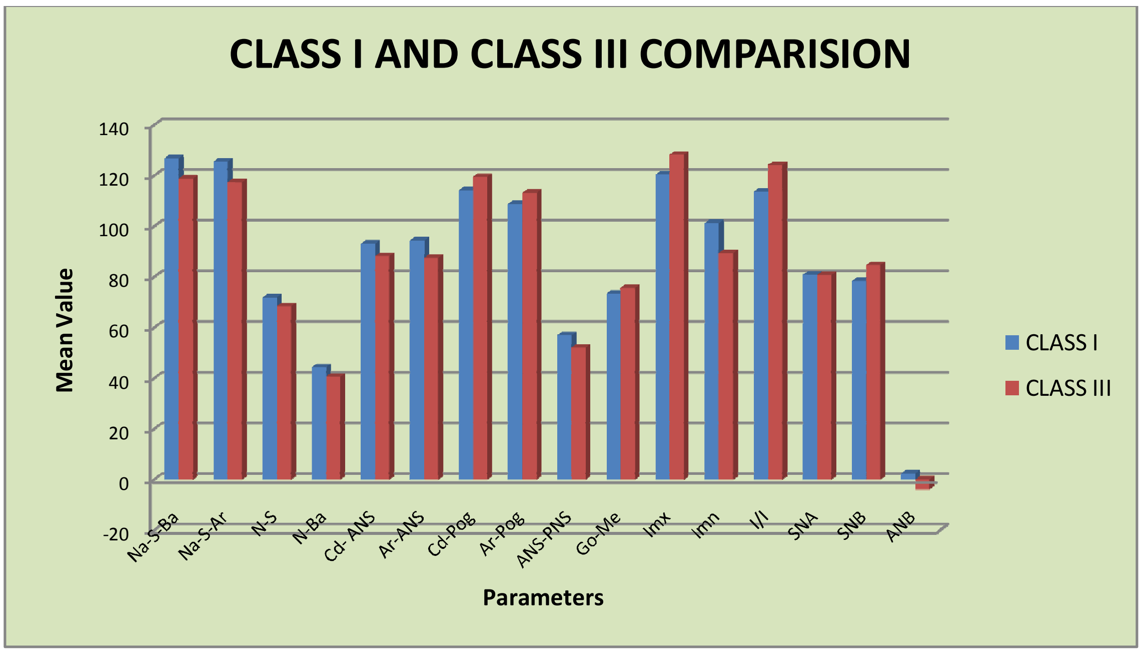

TABLE 10 CORRELTATING COEFFIENTS WITH POOLED GROUP DATA

PARAMETERS	N_S_Ar	N_S_Ba	S_Ba	N_S	SNA	SNB
SNA	-.301**	-.066	.201*	-.115	-	-
SNB	-.744**	-.374**	.009	-.130	-	-
ANB	.628**	.404**	.195*	.045	.229**	-.605**
ANS_PNS	.174*	.092	.416**	.507**	.230**	-.142
Go_Me	-.453**	-.221**	.307**	.437**	.218**	.503**
** Correlation is significant at the 0.01 level						
* Correlation is significant at the 0.05 level						

TABLE 11 CORRELTATING COEFFIENTS WITH POOLED CLASS I DATA

PARAMETERS	N_S_Ar	N_S_Ba	S_Ba	N_S	SNA	SNB
SNA	-.535**	.073	.251	-.004	1	.972**
SNB	-.560**	.052	.285	-.059	.972**	1
ANB	-.006	.098	-.086	.220	.313*	.079
ANS_PNS	-.155	.036	.284	.598**	.160	.092
Go_Me	-.314*	.218	.393*	.446**	.573**	.561**
**. Correlation is significant at the 0.01 level						
*. Correlation is significant at the 0.05 level						

TABLE 12 CORRELTATING COEFFIENTS WITH POOLED CLASS II DIV 1 DATA

PARAMETERS	N_S_Ar	N_S_Ba	S_Ba	N_S	SNA	SNB
SNA	-.448**	-.592**	.210	-.380*	1	.914**
SNB	-.448**	-.572**	.172	-.452**	.914**	1
ANB	-.046	-.108	.110	.129	.304	-.108
ANS_PNS	-.030	-.115	.307	.521**	-.027	-.150
Go_Me	-.177	-.219	.406**	.424**	.178	.119
**. Correlation is significant at the 0.01 level						
*. Correlation is significant at the 0.05 level						

TABLE 13 CORRELTATING COEFFIENTS WITH POOLED CLASS II DIV 2 DATA

PARAMETERS	N_S_Ar	N_S_Ba	S_Ba	N_S	SNA	SNB
SNA	-.540**	-.504**	-.101	-.434**	1	.971**
SNB	-.565**	-.541**	-.079	-.407**	.971**	1
ANB	.025	.079	-.103	-.170	.255	.016
ANS_PNS	-.152	-.074	.172	.286	.288	.255
Go_Me	-.124	-.092	.235	.309	.247	.277
**. Correlation is significant at the 0.01 level						
*. Correlation is significant at the 0.05 level						

TABLE 14 CORRELTATING COEFFIENTS WITH POOLED CLASS III DATA

PARAMETERS	N_S_Ar	N_S_Ba	S_Ba	N_S	SNA	SNB
SNA	-.542**	-.208	.353*	.255	1	.857**
SNB	-.411**	-.040	.354*	.188	.857**	1
ANB	-.387*	-.339*	.114	.191	.556**	.048
ANS_PNS	-.257	-.568**	.649**	.650**	.448**	.345*
Go_Me	-.267	-.538**	.757**	.698**	.398*	.332*
**. Correlation is significant at the 0.01 level						
*. Correlation is significant at the 0.05 level						

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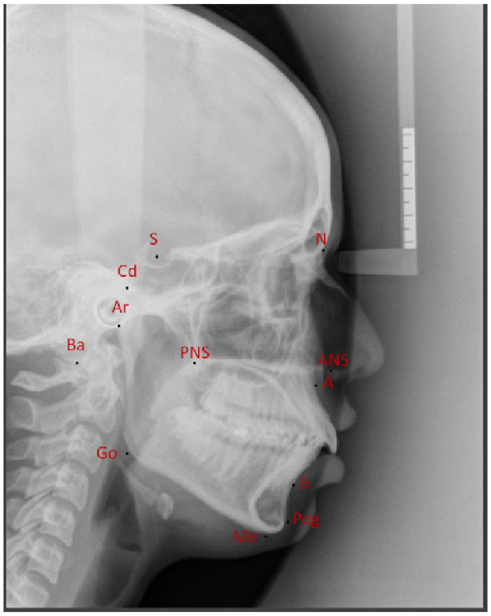

Figure 1: Cephalometric landmarks

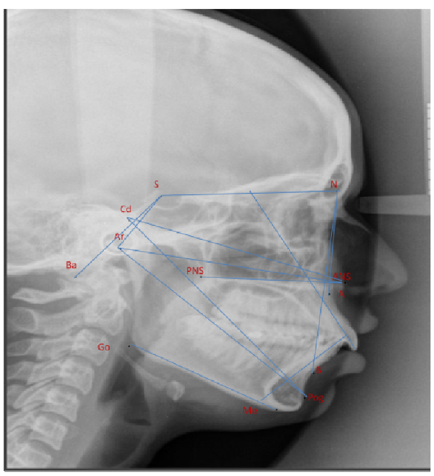

Figure 2: Cephalometric Measurements

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