Subject Category: Dentistry

A Computer Assisted Comparison of Cephalometric Norms between Caucasians and North Indian Population: An Analytical Study

Garima Singh[1,] Ashish Agrawal[2*], TP Chaturvedi[3], Kumar PG Naveen[4]
[1]Junior Resident III (MDS), Unit of Orthodontics, Faculty of Dental Sciences, Institute of Medical Sciences, Banaras Hindu University, Banaras Hindu University Campus, Varanasi, Uttar Pradesh 221005, India
[2]Professor of Orthodontics, Faculty of Dental Sciences, Institute of Medical Sciences, Banaras Hindu University, Banaras Hindu University Campus, Varanasi, Uttar Pradesh 221005, India
[3]Professor of Orthodontics, Faculty of Dental Sciences, Institute of Medical Sciences, Banaras Hindu University, Banaras Hindu University Campus, Varanasi, Uttar Pradesh 221005, India
[4]Professor of Community Dentistry, Faculty of Dental Sciences, Institute of Medical Sciences, Banaras Hindu University, Banaras Hindu University Campus, Varanasi, Uttar Pradesh 221005, India

Abstract

Aim and Objectives: The aim of this study was to determine the cephalometric skeletal and dental norm for orthognathic surgery for North Indian population using Burstone's analysis and to test the hypothesis that there are racial and ethnic differences in cephalometric measurements between North Indian and Caucasians. *Materials and Methods:* A total of 120 young adults which consists of 66 males and 54 females, 18-26 years with well-balanced facial profile and minimum arch length discrepancies were chosen for the study. Lateral cephalograms with teeth in maximum intercuspation were recorded and analyzed with AutoCeph software. The mean values of cephalometric skeletal and dental variables of COGS (Cephalometrics for Orthognathic surgery analysis) analysis for North Indian males and females were compared with those Caucasians. $P < 0.05$ was considered to be statistically significant. *Statistical Analysis:* The statistical difference in the values of parameters between males and females of North Indian population was analyzed using unpair 't' test whereas the difference between the study population and Caucasians was analyzed using one sample t test. *Results:* All the cephalometric parameters were found significantly less except convexity angle, maxillary and mandibular dental proclinations, occlusal plane angle. Maxilla and mandible was found prognathic and greater chin prominence in North Indian population compared to Caucasians. *Conclusion:* Significant difference in the cephalometric characteristics were found between Caucasians and North Indian population. Gender and racial/ethnic differences should be considered for diagnosis and treatment planning for orthognathic surgery for North Indian population.
Keywords: Cephalometric norms, Caucasians, North Indian, Burstone's analysis, COGS.

INTRODUCTION

The field of orthodontic was revolutionized by introduction of Radiographic cephalometry (Hofrath in Germany, Broadbent BH [1] in the United States) in 1931. Ever since it has been used extensively to study skeletal, dental, soft tissue forms, develop norms for orthodontic diagnosis and treatment planning, predict the craniofacial growth and assess the treatment progress. Subsequently Downs [2], Tweeds [3], Steiners [4] and Burstone's [5] analysis became popular for orthodontic treatment planning. These Cephalometric analysis were widely accepted throughout the world. However, these cephalometric norms were specific to one ethnic group - white subjects of European-American ancestry which might not apply to other ethnic groups [6-9]. Studies done on Japanese [10-12], Chinese [13], Black Americans [14], African-Americans [15-17], Saudis [18] lays stress on population based cephalometric norms. Alcalde *et al.*, [10] reported shorter maxilla and larger anterior facial height in Japanese compared to Caucasians. Y Gu *et al.*, [13] reported shorter midface and mandible in Chinese compared to Caucasians.

A specialized Cephalometric appraisal system known as Cephalometrics for Orthognathic surgery analysis (COGS) was developed at the University of Connecticut by Burstone *et al.*, [5] This analysis uses rectilinear measurements and has been used widely for research [19, 20] and for planning of orthognathic surgery. The reading can be directly incorporated in performing mock surgeries and is useful in prediction tracing.

India is a conglomerate of different topographical region with numerous racial subgroups, cephalometric studies done on various parts of India such as North Indians [21-25], South Indians [26-28], East India [29], Central India [30] has established the datum for the need of regional cephalometric norms. Nanda *et al.*, [21] in 1969 studied cephalometric norms of Lucknow Hindus and found protrusive skeletal and dental pattern compared to white Americans. Singh *et al.*, [22] established the cephalometric norms for North Indians and determined increased facial convexity, mandibular incisor proclination and retruded maxilla and mandible compared to Caucasians. Most of the studies on North Indian population has been done manually on cephalograms which can increase inter examiner error. There are no studies comprehending cephalometric norms for North Indian population using cephalometric softwares. Therefore a study was designed to determine cephalometric norms (COGS) for North Indian population using Autoceph softwares to increase inter examiner reliability and to test the hypothesis of existence of differences in cephalometric parameters between North Indian population and Caucasians.

MATERIAL AND METHOD
Sample Selection
A cross sectional study was conducted in the Orthodontic division from July 2017 to May 2018. Preliminary research consisted of total 300 young adolescents in the age range of 18-26 years, selected from the outpatient department of Faculty of dental sciences whose two generations belonged to North India region. Selection of subjects in the study should

have dentoalveolar class l, with no history of orthodontic treatment, orthognathic or plastic surgery, no history of trauma, no facial asymmetry or absence of dental and skeletal discrepancies. Consent was taken from each subjects for the study. Frontal and profile extra oral photographs were taken in the standardize manner in the photographic setup of Orthodontic unit. A panel of 4 members were made constituting of orthodontist, oral and maxillofacial surgeon, plastic surgeon and a laymen. Since facial esthetic cannot be standardize as it is subjective criteria, a score of 0-10 was given (0=least esthetic, 10=most esthetic). Both the photographs of each subject were shown to all panel members for 15 seconds and they asked to record their esthetic record from 0-10. The mean reading from all the four panel members were taken of each subject and those fulfilling mean score of more than 7 was taken into consideration. 180 subjects scored more than 7 and were further subjected to various study parameters. Lateral cephalometric radiographs were taken in natural head position. Wits appraisal and beta angle was measured for selecting skeletal class 1 pattern. 120 subjects (66 males and 54 females) were found to be skeletal class l. Therefore these 120 subjects were finally considered as our study sample.

Cephalometric Analysis and Digitalization
120 cephalograms were exported in the AutoCeph software (version 1.0.2 for Windows 7) with detail patient registration and COGS analysis results obtained (Fig 1 and 2) for the three angular and 12 linear measurements for the skeletal parameters and three Angular, five Linear measurements for the dental parameters as shown in (Fig 3-7).
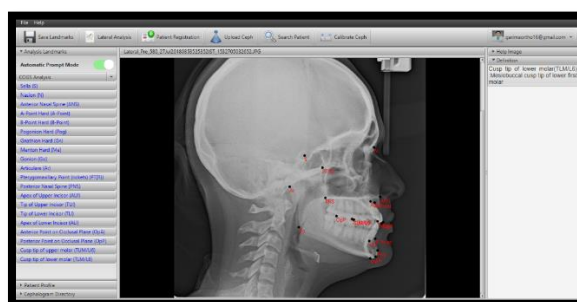

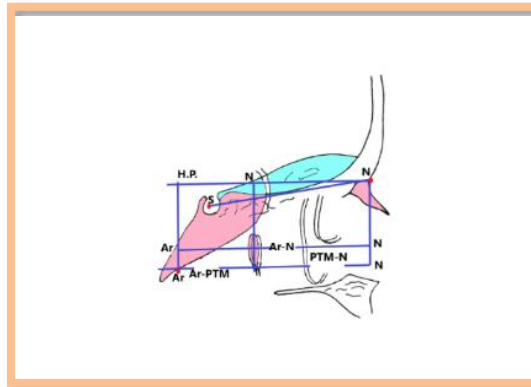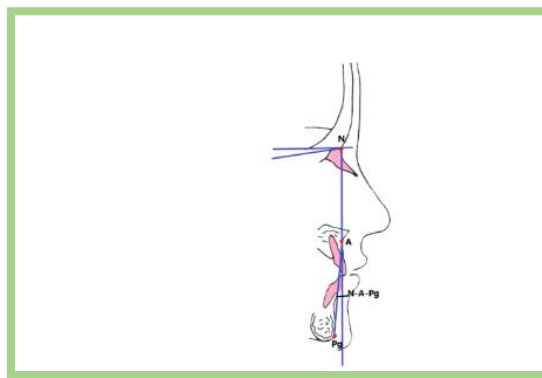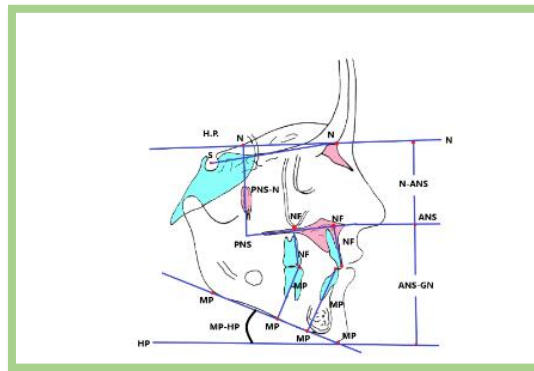**Fig-1: Subject's lateral cephalogram uploaded on the autoceph software**

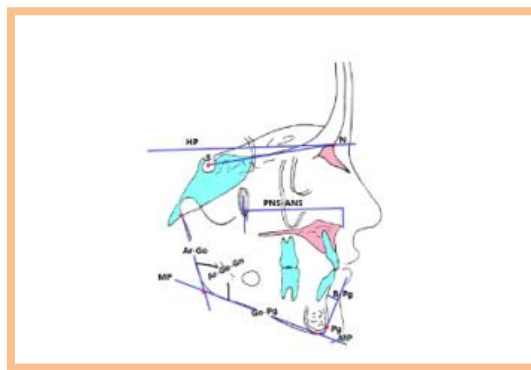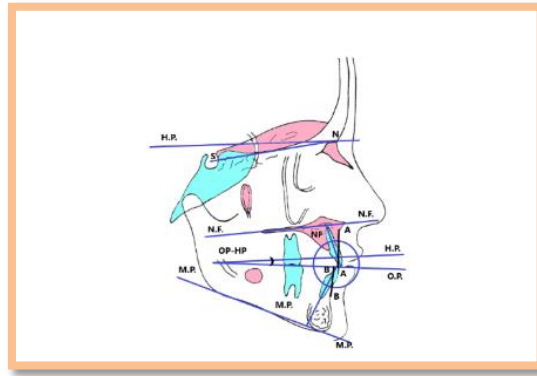**Fig-2: Landmarks for COGS analysis**

Fig-3: Cranial Base

Fig-4: Horizontal measurements

Fig-5: Vertical skeletal and dental measurements

Fig-6: Maxilla and mandible relationship
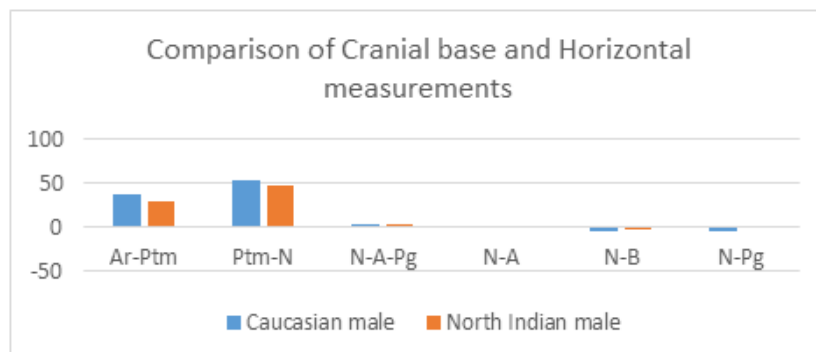
Fig-7: Dental measurements

Statistical Analysis

The data obtained for all the 120 subjects that is 66 males and 54 females were tabulated in the excel sheet and transferred to the SPSS software(Statistical package for the Social Sciences, Chicago Ill, USA) version 17.0 for windows 2007. Mean and standard deviation of each parameters were tabulated and the statistical difference between the study group and the Caucasian group was evaluated. A comparative data between various parameters of males and females (study subjects) was subjected to unpair 't' test. The difference in the mean of males and females for North Indian population and Caucasians was analyzed using one sample t test. The probability value $P < 0.05$ was considered statistically significant.

RESULTS

The mean, standard deviation, and standard error of the various COGS measurements for the males and females of the North Indian population is given in Table-1. The comparative results of COGS parameters for North Indian males with Caucasian males and North Indian females with Caucasian females are presented in Table 2 and 3; and in Figure 8-13 respectively.

Fig-8: Comparison of Cranial base and horizontal measurements between Caucasian and North Indian males
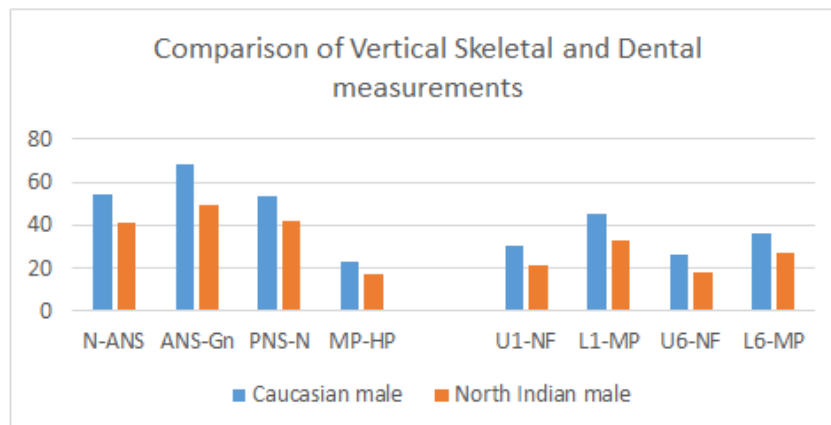
Fig-9: Comparison of Vertical skeletal and Dental measurements between Caucasian and North Indian males
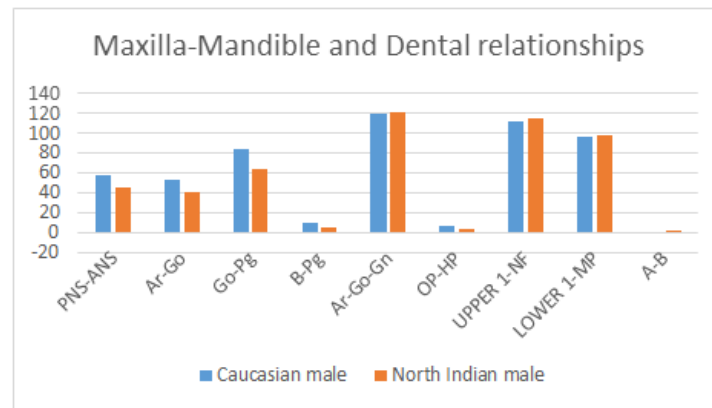
Fig-10: Comparison of maxilla-mandible and Dental relationships between Caucasian and North Indian males.

Fig-11: Comparison of Cranial base and horizontal measurements between Caucasian and North Indian females

Fig-12: Comparison of Vertical skeletal and Dental measurements between Caucasian and North Indian females

Fig-13: Comparison of maxilla-mandible and Dental relationships between Caucasian and North Indian females

Table-1: Burstone's COGS Analysis for North Indian males and females

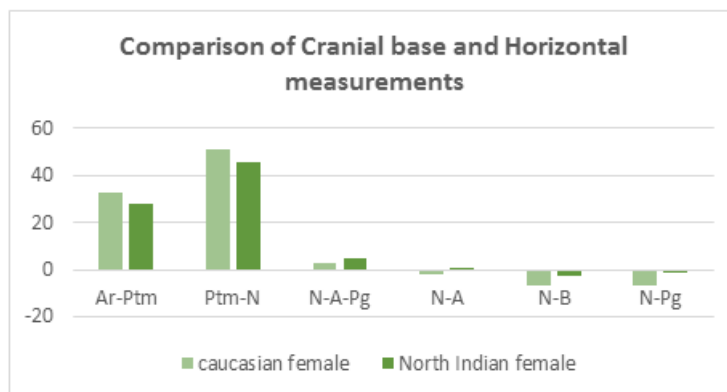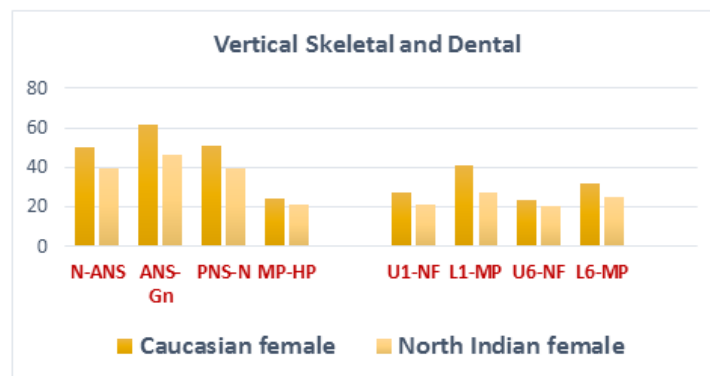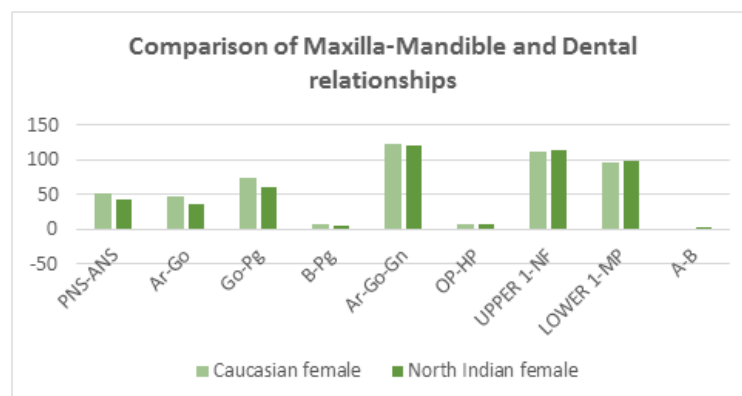| Parameters	Abbreviations	North Indian males Mean ±SD	North Indian Females Mean ±SD
Cranial base			
Posterior cranial base	Ar-PTM	29.45±1.88	28.2±2.21
Anterior cranial base	PTM-N	48.18±1.84	45.5±1.95
Skeletal horizontal			
Facial convexity	N-A-Pg	3.83±4.31	4.63±4.73
Maxillary protrusion	N-A	1.85±2.91	0.38±2.71
Mandibular protrusion	N-B	-0.93±5.24	-2.52±4.70
Chin protrusion	N-Pg	0.86±5.75	-1.33 ±5.65
Skeletal vertical			
Upper anterior facial height	N-ANS	40.78±2.95	39.11±2.36
Lower anterior facial height	ANS-Gn	49.60±4.00	45.95±3.71
Upper posterior facial height	PNS-N	41.75±2.24	39.51±2.32
Mandibular plane angle	MP-HP	17.05±5.80	20.66±6.06
Dental vertical			
Upper anterior dental height	U1-NF(PNF)	21.43±2.18	21.0±2.17
Lower anterior dental height	L1-MP(PMP)	33.23±2.67	27.13±6.23
Upper posterior dental height	U6-NF(PNF)	18.23±1.69	20.5±6.02
Lower posterior dental height	L6-MP(PMP)	27.06±2.59	24.6±1.89
Maxilla mandible			
Maxillary length	PNS-ANS	44.71±2.56	42.7±1.95
Mandibular ramus length	Ar-Go(linear)	40.78±3.98	36.4±3.31
Mandibular body length	Go-Pg(linear)	62.81±2.56	60.4±3.60
Chin depth	B-Pg	5.00±1.16	4.5±1.14
Gonial angle	Ar-Go-Me(angle)	120.43±6.8	121.7±6.2
Dental			
Occlusal plane	OP-HP(angle)	3.53±3.90	6.3±4.5
Upper incisor inclination	U1-NF(angle)	114.95±5.77	114.4±6.9
Lower incisor inclination	L1-MP(angle)	98.23±7.08	99.0±6.8
Wits analysis	A-B(OP)	0.86±1.62	0.36±1.35

Table-2: Comparison of Cephalometric norms between Caucasian and North Indian males

Parameters	Abbreviations	Caucasian male Mean± SD	North Indian Male Mean± SD	t- value	p value
Cranial base					
Posterior cranial base	Ar-PTM	37.1±2.8	29.45±1.88	-31.495	0.000
Anterior cranial base	PTM-N	52.8±4.1	48.18±1.84	-48.753	0.120
Horizontal skeletal relation					
Facial convexity	N-A-Pg	3.9±6.4	3.83±4.31	-0.120	
Maxillary protrusion	N-A	0±3.7	1.85±2.91	4.924	0.000
Mandibular protrusion	N-B	-5.3±6.7	0.93±5.24	6.448	0.000
Chin protrusion	N-Pg	-4.3±8.5	0.86±5.75	6.953	0.000
Vertical skeletal and dental relation					
Upper anterior facial height	N-ANS	54.7±3.2	40.78±2.95	-36.445	0.000
Lower anterior facial height	ANS-Me	68.6±3.8	49.60±4.0	-36.78	0.000
Upper posterior facial height	PNS-N	53.9±1.7	41.75±2.24	-41.92	0.000
Mandibular plane angle	MP-HP	23±5.9	17.05±5.80	-7.934	0.000
Upper anterior dental height	U1-NF	30.5±2.1	21.43±2.18	-32.082	0.000
Lower anterior dental height	L1-MP	45±2.1	33.23±2.67	-34.131	0.000
Upper posterior dental height	U6-NF	26.2±2.1	18.23±1.69	-36.49	0.000
Lower posterior dental height	L6-MP	35.8±2.6	27.06±2.59	-26.055	0.000
Maxilla and Mandible					
Maxillary length	PNS-ANS	57.5±2.5	44.71±2.56	-39.208	0.000
Mandibular ramus length	Ar-Go(linear)	52±4.2	40.78±3.98	-21.811	0.000
Mandibular body length	Go-Pg	83.7±4.6	62.81±2.56	-63.162	0.000

Chin depth	B-Pg	8.9±1.7	5.0±1.16	-26.025	0.000
Gonial angle	Ar-Go-Me	119.1±6.5	120.43±6.8	1.518	.134
Dental relationships					
Occlusal plane angle	OP-HP(angle)	6.2±5.1	3.53±3.90	-5.292	0.000
Upper incisor inclination	U1-NF(angle)	111±4.7	114.95±5.77	5.291	0.000
Lower incisor inclination	L1-MP(angle)	95.9±5.7	98.23±7.08	2.551	0.013
Wits analysis	A-B II (OP)	-1.1±2.0	0.86±1.62	9.401	0.000

Table-3: Comparison of Cephalometric norms between Caucasian and North Indian females

Parameters	Abbreviations	Caucasian female Mean± SD	North Indian female Mean± SD	t- value	P value
Cranial base					
Posterior cranial base	Ar-PTM	32.8±1.8	28.2±2.21	-16.083	0.000
Anterior cranial base	PTM-N	50.9±3	45.5±1.95	-45.2	0.09
Horizontal skeletal relation					
Facial convexity	N-A-Pg	2.6±5.1	4.63±4.73	3.326	0.002
Maxillary protrusion	N-A	-2±3.7	0.38±2.71	6.801	0.000
Mandibular protrusion	N-B	-6.9±4.3	-2.52±4.70	7.198	0.000
Chin protrusion	N-Pg	-6.5±5.1	-1.33 ±5.65	7.080	0.000
Vertical skeletal and dental relation					
Upper anterior facial height	N-ANS	50±2.4	39.11±2.36	-35.636	0.000
Lower anterior facial height	ANS-Me	61.3±3.3	45.95±3.71	-31.994	0.000
Upper posterior facial height	PNS-N	50.6±2.2	39.51±2.32	-36.922	0.000
Mandibular plane angle	MP-HP	24.2±5	20.66±6.06	-4.509	0.000
Upper anterior dental height	U1-NF	27.5±1.7	21.0±2.17	-22.996	0.000
Lower anterior dental height	L1-MP	40.8±1.8	27.13±6.23	-16.974	0.000
Upper posterior dental height	U6-NF	23±1.3	20.5±6.02	-3.108	0.003
Lower posterior dental height	L6-MP	32.1±1.9	24.6±1.89	-30.23	0.000
Maxilla and Mandible					
Maxillary length	PNS-ANS	52.6±3.5	42.7±1.95	-39.1	0.000
Mandibular ramus length	Ar-Go(linear)	46.8±2.5	36.4±3.31	-24.296	0.000
Mandibular body length	Go-Pg	74.3±5.8	60.4±3.60	-29.683	0.000
Chin depth	B-Pg	7.2±1.9	4.5±1.14	-17.8	0.000
Gonial angle	Ar-Go-Me	122±6.9	121.7±6.2	-0.371	-0.300
Dental relationships					
Occlusal plane angle	OP-HP(angle)	7.1±2.5	6.3±4.5	-1.327	0.190
Upper incisor inclination	U1-NF(angle)	112±5.3	114.4±6.9	2.127	0.038
Lower incisor inclination	L1-MP(angle)	95.9±5.7	99.0±6.8	3.614	0.001
Wits analysis	A-B II (OP)	-0.4±2.5	0.36±1.35	4.391	0.000

DISCUSSION

Cephalometry is an essential tool in hands of clinicians to ascertain skeletal abnormalities which may be camouflaged by the soft tissue drape. Since facial esthetics plays a critical role in deciding a definitive orthodontic and orthognathic treatment planning it is important to use population based cephalometric norms. Numerous studies have shown differences between racial group which is cearly evident. In our study we found similar evidences of determining cephalometric norms for the given region. The sample size of 120 adult males and females were taken as most of the orthognathic surgery are performed on non-growing individual. Further sexual dimorphism was considered as it is significant in various parameters.

The anterior cranial base length of North Indian population is comparable to the Caucasians, no significant difference is found between them whereas the posterior cranial base length is smaller in North Indian population in comparison to the Caucasians. Singh *et al*., [22], Gulati *et al*., [23] and Tikku *et al*., [24] in North Indians and Trivedi *et al*., [31] in Rajasthani males found non-significant difference in the anterior cranial base length. In contrast posterior cranial length was found larger by Gulati *et al*., [23], Singh *et al*., [22] in North Indian females and non-significant in males and significantly smaller in North Indians by Tikku *et al*., [24] when compared with Caucasians. Arunkumar [26] and Nachiappan [27] found significantly greater total cranial base length in South Indians than the Caucasians. Alcalde R. A *et al*., [10] showed similar cranial base length in Japanese females but the longer posterior and shorter anterior cranial base compared to Caucasian females. Chan *et al*., [32] found shorter anterior cranial base in Chinese (Cantonese) and

significantly larger posterior cranial base in black American adults [14] in comparison to Caucasians.

The angle of convexity was found significantly greater in North Indian females compared to Caucasian females whereas no significant difference was found between Caucasian and North Indian males, both have similar skeletal profile. Other research on North Indians [23, 24] and on Rajasthan population [31] showed non-significant difference. Singh *et al.*, [22] observed greater convexity in North Indians but the difference was not significant. Nanda *et al.*, [21] showed larger angle of convexity in Negroes, Chinese and Japanese groups while North Indian Hindus approaching the straight profile similar to Caucasians. Chan *et al.*, [32] and Flynn *et al.*, [14] observed more convex profile in Chinese (Cantonese) and black American adults than Caucasians.

Maxillary apical base was placed significantly anterior in North Indian population compared to the Caucasians indicating prognathic maxilla. Similar findings suggestive of prognathic maxilla was observed by Gulati *et al.*, [23] and Tikku *et al.*, [24] respectively whereas Singh *et al.*, [22] found retrognathic and non-significant by Garg *et al.*, [25] in North Indians. Study by Flynn *et al.*, [14] on black American adults and Miyajima *et al.*, [33] on Japanese concluded maxillary prognathism compared to Caucasians.

Mandibular apical base is placed significantly less posteriorly to the perpendicular from nasion in North Indian population as compared to the Caucasians. Similar finding was observed in Eastern U. P population [23], Karnataka population [26] and North Indians [24, 25]. Whereas Singh *et al.*, [22] found more retruded mandible in North Indians compared to Caucasians.

Chin is placed more anteriorly in North Indian population compared to Caucasians suggestive of greater chin prominence in North Indian males and females. Similar results were observed in Eastern U. P [23], Karnataka population [26, 28] and in the Rajasthani females [31].

Middle third facial height of North Indian population is significantly decreased in both males and females compared to the Caucasians. Similar results was observed in North Indians [24]. Similarly, Eastern U. P [23], North Indian [22, 25], Rajasthan [31] and East India [29] population showed no significant difference in males and only marginal increase of middle third facial height in females. Lower third facial height of North Indian population was significantly reduced when compared to Caucasians norms. In contrast, no significant difference was found in the Eastern U. P [23] and Rajasthan [31] males and marginally increased in lower third facial height in females. H. loi *et al.*, [11] found significantly greater

facial height in Japanese females and little difference in males.

MP-HP angle is significantly lesser in North Indian males and females as compared to the Caucasians indicative of counterclockwise rotation and anterior divergence of mandible in North Indian population. The suggested decrease in the mandibular plane angle of the present study is in accordance with the study conducted by Gulati *et al.*, [23], Tikku *et al.*, [24], Valiathan [34], Arunkumar *et al.*, [26], S. Nachiappan [27] and N Sahoo [29]. Japanese subjects showed more vertical growth pattern as measured by lower anterior facial height and facial axis angle [11].

When compared to Caucasians the anterior maxillary dental height is significantly lesser in both males and females of North Indian population. The suggested decrease in the dental height is in accordance with the study by Tikku *et al.*, [24], N Sahoo [29], AV Arunkumar [26] whereas other studies on Tamil nadu [27], Central India [30] and North India [25] have shown insignificant difference compared to Caucasians. Middle third facial height is significantly decreased in both North Indian males and females compared to the Caucasians. Similarly, Eastern U. P [23], North Indian [22, 35], Rajasthan [31] and East India [29] population showed no significant difference in males and only marginal increase of middle third facial height in females. Lower third facial height of North Indian population was significantly reduced when compared to Caucasians norms. In contrast, no significant difference was found in the Eastern U. P [23] and Rajasthan [31] males and marginally increased in lower third facial height in females. Singh *et al.*, [22] revealed significantly decreased lower third facial height in North Indian males and non-significant in females compared to Caucasians.

Length of the maxilla and mandibular ramal and body length is significantly lesser in the North Indian population in comparison to the Caucasians. Similar findings observed in North Indians [24] by Tikku *et al.*, whereas one more study on North India by Singh *et al.*, [22] showed significantly reduced maxillary and mandibular ramus and body length in males and insignificant in females. Flynn *et al.*, [14] found significantly greater mandibular body length, whereas ramus length was similar and the maxillary length was somewhat longer but not significant in Black Americans compared to Caucasians. Japanese had shorter maxilla as reported by Alcalde *et al.*, [10] and sexual dimorphism was found, showed larger maxilla mandibular measurements in Japanese males.

Gonial angle in North Indian population is comparable to the Caucasians, it doesn't show any significant difference in comparison to Caucasians. Gulati *et al.*, [23] in their study on Eastern U.P population showed decreased gonial angle in males and

females but the difference was not significant. Similar results was observed in North Indians [24], East Indians males [29], Rajasthan [31] and Karnataka population [26]. Singh *et al.*, [22] in his study on North Indians found significantly increased gonial angle in males.

The occlusal plane angle in North Indian population is significantly less steep in comparison to Caucasians. Similar findings was observed in North Indians [23, 24, 35] whereas Singh *et al.*, [22] found increased occlusal plane angle in North Indian males and females.

Proclination of maxillary and mandibular central incisor are found significantly greater in North Indian population in comparison to the Caucasians. Various studies by different authors on North Indians [22, 25, 35] and Rajasthan population [31] showed similar results. Studies done on South Indian population [26, 27] has shown significantly increased inclination of incisors in Karnataka and Tamil population. The Japanese males displayed more proclined upper incisors than Caucasians as reported by Alcalde *et al.*, [10]. H loi *et al.*, [11] and Flynn *et al.*, [14] reported significantly more protruded and tipped forward lower incisors in Japanese and Black American respectively than those of Caucasians.

CONCLUSION

From this study we can conclude that the fundamental variations exist in the craniofacial structure (skeletal, dental) of the North Indian population when compared with Caucasians. The findings of this study support the premise that a single standard of facial esthetics is not appropriate for application to diverse racial and ethnic groups. The derived values for skeletal and dental can be considered as normal value for North Indian population and used for comparison of subjects with malocclusion, thereby aiding in proper diagnosis and treatment plan.

REFERENCES

1. Broadbent, B. H. (1981). A new X-ray technique and its application to orthodontia: the introduction of cephalometric radiography. *The Angle Orthodontist*, *51*(2), 93-114.
2. Downs, W. B. (1948). Variations in facial relationships: their significance in treatment and prognosis. *American journal of orthodontics*, *34*(10), 812-840.
3. Tweed, C. H. (1969). The diagnostic facial triangle in the control of treatment objectives. *American journal of orthodontics*, *55*(6), 651-667.
4. Steiner, C. C. (1953). Cephalometrics for you and me. *American journal of orthodontics and dentofacial orthopedics*, *39*(10), 729-755.
5. Burstone, C. J., James, R. B., Legan, H., Murphy, G. A., & Norton, L. A. (1978). Cephalometrics for orthognathic surgery. *Journal of oral surgery (American Dental Association: 1965)*, *36*(4), 269-277.
6. Cotton, W. N., Takano, W. S., & Wong, W. M. (1951). The Downs analysis applied to three other ethnic groups. *The Angle Orthodontist*, *21*(4), 213-220.
7. Haralabakis, H. (1954). Familial resemblances in cranio-facial osteology as revealed by cephalometric x-rays in Greek families. *Amer. J. Orthod.*, *40*, 233.
8. Altemus, L. A. (1960). A comparison of cephalofacial relationships. *The Angle Orthodontist*, *30*(4), 223-240.
9. Kotak, V. B. (1964). Cephalometric evaluation of Indian girls with neutral occlusion. *J Indian Dent Assoc*, *36*, 183-197.
10. Alcalde, R. E., Jinno, T., Pogrel, M. A., & Matsumura, T. (1998). Cephalometric norms in Japanese adults. *Journal of oral and maxillofacial surgery*, *56*(2), 129-134.
11. Ioi, H., Nakata, S., Nakasima, A., & Counts, A. L. (2007). Comparison of cephalometric norms between Japanese and Caucasian adults in antero-posterior and vertical dimension. *The European Journal of Orthodontics*, *29*(5), 493-499.
12. Bronfman, C. N., Janson, G., Pinzan, A., & Rocha, T. L. (2015). Cephalometric norms and esthetic profile preference for the Japanese: a systematic review. *Dental press journal of orthodontics*, *20*(6), 43-51.
13. Gu, Y., McNamara Jr, J. A., Sigler, L. M., & Baccetti, T. (2010). Comparison of craniofacial characteristics of typical Chinese and Caucasian young adults. *The European Journal of Orthodontics*, *33*(2), 205-211.
14. Flynn, T. R., Ambrogio, R. I., & Zeichner, S. J. (1989). Cephalometric norms for orthognathic surgery in black American adults. *Journal of Oral and Maxillofacial Surgery*, *47*(1), 30-38.
15. Drummond, R. A. (1968). A determination of cephalometric norms for the Negro race. *American journal of orthodontics*, *54*(9), 670-682.
16. Fonseca, R. J., & Klein, W. D. (1978). A cephalometric evaluation of American Negro women. *American journal of orthodontics*, *73*(2), 152-160.
17. Richardson, E. R. (1991). Atlas of craniofacial growth in Americans of African descent. Monograph, Craniofacial Growth Series. Ann Arbor: Center for Human Growth and Development, the University of Michigan.
18. Shalhoub, S. Y., Sarhan, O. A., & Shaikh, H. S. (1987). Adult cephalometric norms for Saudi Arabians with a comparison of values for Saudi and North American Caucasians. *British Journal of Orthodontics*, *14*(4), 273-279.
19. Connor, A. M., & Moshiri, F. (1985). Orthognathic surgery norms for American black patients. *American journal of orthodontics*, *87*(2), 119-134.

20. Wylie, G., Fish, L., & Epker, B. (1987). Cephalometrics: a comparison of five analysis currently used in the diagnosis of dentofacial deformities. int J Adult Orthod Orthog Surg, 1(1),15-36.

21. Nanda, R., & Nanda, R. S. (1969). Cephalometric study of the dentofacial complex of North Indians. *The Angle Orthodontist*, *39*(1), 22-28.

22. Singh, S. P., Utreja, A. K., & Jena, A. K. (2013). Cephalometric norms for orthognathic surgery for North Indian population. *Contemporary clinical dentistry*, *4*(4), 460-466.

23. Gulati, R., & Jain, S. (2011). Cephalometric norms for orthognathic surgery for North India (Eastern Uttar Pradesh). *National journal of maxillofacial surgery*, *2*(1), 33.

24. Tikku, T., Khanna, R., Maurya, R. P., Verma, S. L., Srivastava, K., & Kadu, M. (2014). Cephalometric norms for orthognathic surgery in North Indian population using Nemoceph software. *Journal of oral biology and craniofacial research*, *4*(2), 94-103.

25. Garg, R., & Alexander, M. (2015). "Are We Similar to Caucasians": Orthognathic Surgery for North Indians. *Journal of maxillofacial and oral surgery*, *14*(2), 271-277.

26. Arunkumar, K. V., Reddy, V. V., & Tauro, D. P. (2010). Establishment of cephalometric norms for the South Indian (Karnataka) population based on Burstone's analysis. *Journal of maxillofacial and oral surgery*, *9*(2), 127-133.

27. Nachiappan, S., Tharanikumar, S., Chandran, A., Anusudha, P., Nandini, G. D., & Balasubramaniam, M. (2015). A study to evaluate cephalometric hard tissue profile of Tamil population for orthognathic surgery. *Journal of pharmacy & bioallied sciences*, *7*(Suppl 2), S680.

28. Shashikumar, G. M., Naik, D. P., Savakkanavar, M. B., Sreedhara, S., & Reddy, S. R. K. (2015). Hard Tissue Cephalometric Norms for Orthognathic Surgery in Karnataka Population. *Journal of International Oral Health*, *7*(11), 28-32.

29. Sahoo, N., Mohanty, R., Mohanty, P., Nayak, T., Nanda, S. B., & Garabadu, A. (2016). Cephalometric Norms for East Indian Population using Burstone Legan Analysis. *Journal of International Oral Health*, *8*(12), 1076.

30. Yadav, A. O., Walia, C. S., Borle, R. M., Chaoji, K. H., Rajan, R., & Datarkar, A. N. (2011). Cephalometric norms for Central Indian population using Burstone and Legan analysis. *Indian Journal of Dental Research*, *22*(1), 28-33

31. Trivedi, K., Singh, S., Shivamurthy, D. M., Doshi, J., Shyagali, T., & Patel, B. (2010). Analysis of cephalometrics for orthognathic surgery: Determination of norms applicable to Rajasthani population. *National journal of maxillofacial surgery*, *1*(2), 102-107.

32. Chan, G. K. H. (1972). A cephalometric appraisal of the Chinese (Cantonese). *American journal of orthodontics*, *61*(3), 279-285.

33. Miyajima, K., Mcnamara Jr, J. A., Kimura, T., Murata, S., & Iizuka, T. (1996). Craniofacial structure of Japanese and European-American adults with normal occlusions and well-balanced faces. *American Journal of Orthodontics and Dentofacial Orthopedics*, *110*(4), 431-438.

34. Valithan, M., & Suresh, V. A. (1999). A comparison of cephalometric norms of North and south Indians using Powell and Holdaway analyses. *J Ind Orthod Soc*, *32*, 122-126.

35. Grewal, H., Sidhu, S. S., & Kharbanda, O. P. (1994). A cephalometric appraisal of dento-facial and soft tissue pattern in Indo-Aryans. *Journal of Pierre Fauchard Academy (Pierre Fauchard Academy. India Section)*, *8*(3), 87-96.