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ORIGINAL RESEARCH

Cephalometric Norms for Indian Adults using Digital Posteroanterior Analysis

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ABSTRACT

Introduction: Facial and radiographic records in orthodontics are based on the profile. Aim of this study is to establish norms from digital posteroanterior (PA) cephalograms for Indian adults.

Materials and methods: The subjects included 45 Indian men and 55 Indian women, mean age 25 to 30 years. Subjects had ideal occlusion and a well-balanced face. About 12 linear measurements were determined using digital radiograph.

Results: There was statistically significant difference between male and female samples. Comparison between the Indian men and women indicated larger measurements for men.

Conclusion: According to these results new PA clinical norms are presented to Indian orthodontists for diagnosis and planning.

Abbreviations: ANS—Anterior nasal spine, A3-B3—Upper and lower canine right side, 3A-3B—Upper and lower canine left side Me—Menton.

Keywords: Digital cephalogram, Norms, Indian adults.

INTRODUCTION

Anthropometry is the measurement of living subjects. Many facial and radiographic records in orthodontics are based on the profile. Orthodontics is mainly concerned with esthetics. Symmetry plays a crucial role in esthetics, and it can be better assessed from the frontal view, since persons present to the world with their face forward.

The frontal view of the face and consequently postero-anterior (PA) cephalograms should be an integral part of facial evaluation. In recent years, there has been a growing demand for PA cephalograms in the treatment of craniofacial anomalies. Different racial groups must be treated according to their own characteristics.

Very few studies have been undertaken to determine the Indian population's ideal norms.

Hence, it was decided to give ideal values using digital posteroanterior cephalograms for the Indian adult population.

The most extensive data on the Indian adults so far has been reported by Farkas[1] with 14 measurements which were recorded from various parts of the craniofacial complex.

The longitudinal assessment of craniofacial morphology is well recognized, and is now a universally used cephalometric technique. Downs,[2] Steiner and Tweed[3] developed cephalometric norms and analyses in an attempt to define skeletal characteristics of an ideal face and occlusion. The sample population consisted of white North American children and young adults with time; it became apparent that cephalometric standards for one ethnic group did not necessarily apply to the other ethnic groups.

PA cephalometric films can be analyzed to evaluate the vertical, transverse and sagittal dimensions.[4] Various dental and skeletal widths and skeletal asymmetries that are not available from the lateral cephalogram can be quantified from a frontal radiograph.[5]

AIMS

The aim of this study is to establish cephalometric norms from digital posteroanterior cephalograms for Indian adults to identify possible gender difference in these norms to compare Indian norms with the norms of other groups and to identify possible correlations between all investigated transverse linear measurements.

MATERIALS AND METHODS

This radiographic study was carried out in the Department of Orthodontics and Dentofacial Orthopedics, Manipal College of Dental Sciences, Manipal. The study design was reviewed and approved by the Institutional Ethical Committee of our institution for study on human subjects (IEC 134/2009).

A total sample of 50 north Indian and 50 south Indian subjects was selected to find ethnic difference between them.

The subjects included 45 Indian men (mean age, 25-30 years) and 55 Indian women (mean age, 25-30 years). A standard posteroanterior digital radiograph with teeth in centric occlusion and well-balanced face of each individual was done (Fig. 1). Twelve linear measurements were determined on each radiograph using digital radiograph (Fig. 2). The midline was measured from crista galli to the menton.

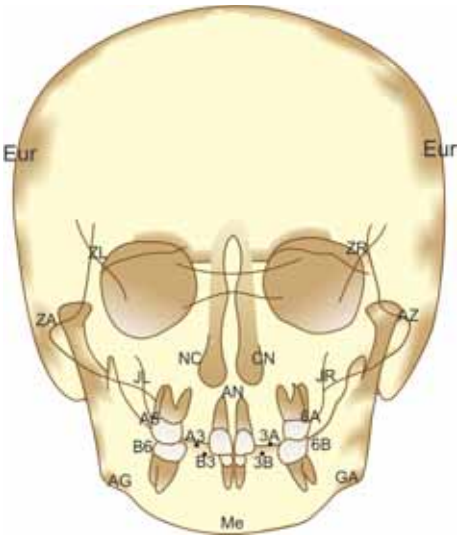

Fig. 1: Standard PA cephalogram

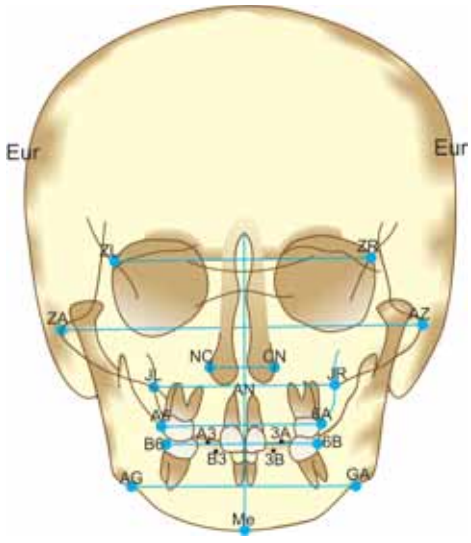

Fig. 2: Twelve linear measurements

There was no significant medical history; no history of trauma and any previous orthodontic or prosthodontic treatment or maxillofacial or plastic surgery. PA cephalograms were taken with the distance between the X-ray tube and the ear post axis fixed at 5 feet (1.524 m). An informed consent from each of the selected subjects was taken for roentgenography. The radiographic minification error was eliminated by standardizing the radiographs.

Measurements

1. Cranial width (Eur-Eur)
2. ZL-ZR
3. Facial width (ZA-AZ)
4. Nasal width (NC-CN)
5. Maxillary width (JL-JR)
6. Mandibular width (AG-GA)
7. Maxillary intermolar width
8. Mandibular intermolar width
9. A6-B6 difference
10. 6A-6B difference
11. Upper midline deviation
12. Lower midline deviation

Z—superior aspect of the orbit

ZA-AZ (facial width)—width of the zygomatic arch at its lateral aspect.

Method Error

The accuracy of the measurements was evaluated by standardizing the radiographs using 1 cm of stainless steel wire while taking the radiographs on cranial, zygomatic, maxillary and mandibular region of the face. Formula used (for a minification image), actual image = object image × magnification factor.

STATISTICS

The cephalograms obtained from the Kodak digital X-ray machine were measured using Kodak dental imaging software 6.6. All statistical analyses were performed with a commercial software package (Statistical Package for Social Sciences for Windows 2007, version 11.5; SPSS,Chicago, III).

For the assessment of the difference between the south Indian and north Indian population, paired t-test was used. For each variable, the arithmetic mean, the standard deviation, and the minimum and maximum values were calculated. An independent-samples t-test and the Pearson product-moment correlation coefficient were decided to indicate the relationship between all investigated linear dimensions.

RESULTS

There was no statistically significant difference found between the south Indian and north Indian samples for the parameters used; therefore, both the samples were clubbed together for this study (Table 1).

The structures located in the PA cephalometric analysis were generally well visualized on the digital cephalograms. Table 2 shows the PA cephalometric combined norms, standard deviations, and minimum and maximum values of 12 linear transverse measurements for Indian adults. The following results were obtained through the independent-samples t-test applied to compare the measurement differences between men and women. Tables 3 and 4 present the descriptive statistic results of the measurements for the samples of adult Indian women and men respectively.

These results were obtained through the independent-samples t-test applied to compare the measurement differences between men and women. Male samples had higher value than the female samples.

Table 1: Correlation for south Indian and north Indian samples

	NISI	N	Mean	Std. deviation	p-value
Cranial width	1.00	49	139.686	7.5026	0.146
	2.00	50	137.490	7.4207	
ZL-ZR	1.00	49	87.061	5.2771	0.223
	2.00	50	88.186	3.7225	
Facial width	1.00	49	129.563	6.6676	0.350
	2.00	50	128.384	5.8000	
Nasal width	1.00	49	33.641	2.6553	0.907
	2.00	50	33.710	3.1815	
Max. width	1.00	49	62.684	5.1758	0.937
	2.00	50	62.614	3.3929	
Mand. width	1.00	49	86.606	7.3536	0.504
	2.00	50	85.696	6.1168	
Max. int. width	1.00	49	62.753	3.5601	0.909
	2.00	50	62.674	3.2841	
Mand. int. width	1.00	49	52.543	5.6653	0.096
	2.00	50	54.382	5.2281	
A6-B6	1.00	49	12.847	7.9584	0.392
	2.00	50	11.842	2.2223	
6A-6B	1.00	49	11.839	7.1989	0.352
	2.00	50	10.846	2.0935	
Upper midline	1.00	49	1.567	0.9698	0.890
	2.00	50	1.544	0.6923	
Lower midline	1.00	49	1.490	0.8912	0.843
	2.00	50	1.456	0.8011	

Table 2: Descriptive statistics of PA cephalometric measurements (in millimeters) for 100 Indian adults

	N	Minimum	Maximum	Mean	Std. deviation
Cranial width	100	122.3	162.8	138.712	7.5134
ZL-ZR	100	73.3	100.3	87.622	4.5414
Facial width	100	115.9	143.5	129.037	6.2490
Nasal width	100	26.7	44.8	33.689	2.9304
Max. width	100	36.7	70.7	62.708	4.3392
Mand. width	100	56.9	100.6	86.177	6.7272
Max. int. width	100	55.8	70.0	62.741	3.3998
Mand. int. width	100	43.0	73.0	53.530	5.5020
A6-B6	100	9.0	66.0	12.290	5.7880
6A-6B	100	7.0	59.4	11.333	5.2484
Upper midline	100	0.0	4.2	1.527	0.8322
Lower midline	100	0.0	3.8	1.443	0.8362
Valid N (listwise)	100				

Of the 12 craniofacial transverse measurements, there was statistically significant difference found in the cranial width, facial width, maxillary width, mandibular width and maxillary intermolar width for male and female samples (Table 5). Comparison between the Indian men and women indicated larger measurements for men in all investigated linear transverse measurements.

To study the correlations between each of the 12 measurements, Pearson correlation coefficients were calculated and have been shown in Table 6.

The interexaminer errors of measurements for several distances were less than 0.5 mm, and the corresponding intraclass correlation coefficients were greater than r = 0.98.

DISCUSSION

This study is the first to investigate samples of untreated Indian adults with ideal occlusion and well-balanced faces. The inclusion criteria and methodology were oriented to identify normative values that can assist in the diagnosis and treatment planning of Indian adults seeking orthodontic treatment or orthognathic surgery. Adults 25 to 30 years of age of both sexes were included in the sample because most orthognathic surgeries are performed in this age group.

Many articles have been published concerning normative data related to facial structures studied with lateral cephalometry; however, publications describing the use of PA

Table 3: Descriptive statistics of PA cephalometric measurements (in millimeters) for 55 Indian women

	N	Minimum	Maximum	Mean	Std. deviation
Cranial width	55	122.3	150.4	136.498	6.8498
ZL-ZR	55	77.5	100.3	87.349	3.9984
Facial width	55	115.9	138.3	126.496	6.0603
Nasal width	55	26.7	44.8	33.607	3.2614
Max. width	55	55.1	69.9	61.824	3.3905
Mand. width	55	59.0	94.0	84.442	5.8908
Max. int. width	55	55.8	69.6	61.760	3.3574
Mand. int. width	55	43.0	72.0	52.890	5.4230
A6-B6	55	9.0	15.0	11.410	1.6620
6A-6B	55	7.0	14.9	10.498	1.6821
Upper midline	55	0.3	3.2	1.522	0.7443
Lower midline	55	0.3	3.8	1.464	0.8061

Table 4: Descriptive statistics of PA cephalometric measurements (in millimeters) for 45 Indian men

	N	Minimum	Maximum	Mean	Std. deviation
Cranial width	45	127.4	162.8	141.418	7.4712
ZL-ZR	45	73.3	95.6	87.956	5.1554
Facial width	45	120.9	143.5	132.142	4.9859
Nasal width	45	28.5	39.2	33.789	2.4996
Max. width	45	36.7	70.7	63.789	5.1072
Mand. width	45	56.9	100.6	88.298	7.1325
Max. int. width	45	56.7	70.0	63.940	3.0820
Mand. int. width	45	44.0	73.0	54.320	5.5570
A6-B6	45	9.0	66.0	13.360	8.3580
6A-6B	45	7.7	59.4	12.353	7.5213
Upper midline	45	0.0	4.2	1.533	0.9371
Lower midline	45	0.0	3.1	1.418	0.8802

cephalograms are relatively few.[6-23] Attempts have been made to investigate the differences of the human face among various ethnic groups, including African-Americans, Africans, Chinese, Japanese, Koreans, Indians, Saudi Arabians, Mexican-Americans, Brazilians and Puerto Ricans. In a comparative study of Japanese and European-American adults, Miyajima et al reported greater ethnic differences in soft tissue relationships than in skeletal and dentitional relationships. The issue of soft tissue profiles, however, played a small part in the majority of the studies mentioned above.[6-22]

Athanasiou[24] indicated that all existing cephalometric data are of value for the diagnosis of various types of craniofacial anomalies and for monitoring groups according to age and race.

Studies describing the use of PA cephalograms are relatively few.[4,25-31] Recently, there has been a growing demand for extended roentgenocephalometric control material, because of refinements in syndrome identification and advances in the treatment of craniofacial anomalies.[21]

George P Thomas, Valiathan Ashima, et al[30] in 2000, assessed the asymmetry between the right and left side of the face of the south Indian with clinically symmetrical and pleasing facial features and normal occlusion. The facial areas were studied separately and a comparison between the north and south Indians were made and it was found that the south Indians appeared to have a more prominent lateral maxillary area, cranial base and dentoalveolar regions than north Indians. There was no significant difference between north and south Indians, the overall structure appeared similar. Taking the result into consideration, the norms for Indian adults have been planned using the digital posteroanterior analysis.

Moyers et al[29] presented valuable normative data derived from the University of Michigan study. Wei[31] produced PA cephalometric normative data for Chinese subjects after examining 84 boys and 22 girls. With a similar aim, this study was carried out to establish cephalometric normative data from digital PA cephalograms for Indian adults.

WC Ngeow et al[32] found that males in general have higher measurement than females for the Malaysian Indian population. In our study also we found that males had higher values than female subjects.

In our study, we used PA cephalometric analysis measurements of Ricketts et al[33] to determine the normative data for Indian adults. Among several analyses,[34-37] the method of Ricketts et al[33] seems to be the most widely used, perhaps because it provides normative values for different ages.

Ricketts et al[33] found facial width (ZA-AZ) to have a mean value of 115.7 mm at the age of 9 years, with 2.4 mm increase per year; the ZA-AZ measurement was 137.3 mm for an adult, according to their prediction (nearly at age 18). In the present study, this measurement was 129.0 mm, which shows that the facial width is narrower than the clinical norm of Ricketts et al and Turkish adults (139.62 ± 7.25).

Ricketts et al[33] found that the width of the maxilla (JL-JR) was 61.9 mm for a 9-year-old subject and increased 0.6 mm

Table 5: Comparison of means and standard deviations of PA cephalometric measurements (in millimeters) between 45 men and 55 women

	Sex	N	Mean	Std. deviation	p-value
Cranial width	Male	45	141.418	7.4712	0.001
	Female	55	136.498	6.8498	
ZL-ZR	Male	45	87.956	5.1554	0.509
	Female	55	87.349	3.9984	
Facial width	Male	45	132.142	4.9859	0.000
	Female	55	126.496	6.0603	
Nasal width	Male	45	33.789	2.4996	0.760
	Female	55	33.607	3.2614	
Max. width	Male	45	63.789	5.1072	0.023
	Female	55	61.824	3.3905	
Mand. width	Male	45	88.298	7.1325	0.004
	Female	55	84.442	5.8908	
Max. int. width	Male	45	63.940	3.0820	0.001
	Female	55	61.760	3.3574	
Mand. int. width	Male	45	54.32	5.557	0.197
	Female	55	52.89	5.423	
A6-B6	Male	45	13.36	8.358	0.095
	Female	55	11.41	1.662	
6A-6B	Male	45	12.353	7.5213	0.079
	Female	55	10.498	1.6821	
Upper midline	Male	45	1.533	0.9371	0.946
	Female	55	1.522	0.7433	
Lower midline	Male	45	1.418	0.8802	0.787
	Female	55	1.464	0.8061	

Table 6: Correlation coefficients of all parameters

	Cranial width	ZL-ZR	Facial width	Nasal width	Max. width	Mand. width	Max. int. width	Mand. int. width	A6-B6 width	6A-6B width	Upper midline	Lower midline
Cranial width	1	0.427**	0.536**	0.075	0.128	0.344**	0.304**	0.264**	0.134	0.160	0.162	0.121
ZL-ZR	0.427**	1	0.461**	0.320**	0.189	0.321**	0.209*	0.147	0.028	0.050	0.045	0.023
Facial width	0.536**	0.461**	1	0.324**	0.410**	0.474**	0.429**	0.200*	0.131	0.141	0.146	0.122
Nasal width	0.075	0.320**	0.324**	1	0.393**	0.194	0.259**	0.045	0.022	–0.007	0.117	0.151
Max. width	0.128	0.189	0.410**	0.393**	1	0.261**	0.495**	0.217*	0.164	0.119	–0.035	–0.066
Mand. width	0.344**	0.321**	0.474**	0.194	0.261**	1	0.414**	0.226*	0.058	0.073	–0.003	–0.018
Max. int. width	0.304**	0.209*	0.429**	0.259**	0.495**	0.414**	1	0.514**	0.187	0.172	0.087	0.137
Mand. int width	0.264**	0.147	0.200*	0.045	0.217*	0.226*	0.514**	1	0.043	0.075	0.073	0.078
A6-B6	0.134	0.028	0.131	0.022	0.164	0.058	0.187	0.043	1	0.977**	–0.128	–0.066
6A-6B	0.160	0.050	0.141	–0.007	0.119	0.073	0.172	0.075	0.977**	1	–0.108	–0.059
Upper midline	0.162	0.045	0.146	0.117	–0.035	–0.003	0.087	0.073	–0.128	–0.108	1	0.883**
Lower midline	0.121	0.023	0.122	0.151	–0.066	–0.018	0.137	0.078	–0.066	–0.059	0.883**	1

**Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at the 0.05 level (2-tailed)

per year. According to them, at age 18, the JL-JR distance is approximately 67.3 mm. In the present study, the mean JL-JR distance was 61.8 ± 3.3 mm for women and 63.8 ± 5.10 mm for men, not much different from the Turkish study which shows 63.81± 3.33 for women and 69.86 ± 4.30 for men respectively. The Bolton study group value was JL-JR distance of 64.7 ± 2.7 mm which is similar to the results of our study.

Ricketts et al[33] found that mandibular width, as measured from the antegonial notch points (AG-GA), had a norm of 76.1 mm at age 9 years and increased 1.4 mm per year.

According to them, the AG-GA distance is approximately 88.7 mm for a young adult. Similarly, Cortella et al[4] determined PA cephalometric norms from the Bolton Study Group for AG-GA and JL-JR distances for a young adult population. They reported an AG-GA distance of 86.4 ± 4.5 mm and also in the Turkish adult population the (AG-GA) width was 98.03 ± 7.36 mm. In our study it was 88.2 ± 7.1, showing a narrower width.

Ricketts et al[33] found nasal width (NC-CN) to have a mean of 25 mm for the 9-year-old subject, increasing 0.7 mm per year. The NC-CN measurement was approximately 31.3 mm for an adult (at age 18). Measurement of 32.4 mm was found for the Turkish adults similar to the measurement found in our study (33.689 ± 2.9).

Snodell et al[27] indicated that there is an average increase in maxillary intermolar width (A6-6A) of 1.4 mm from 16 to 18 years for boys. They stated that, after age 18, insignificant growth changes occur in A6-6A distances. Tancan Uysal et al[23] showed that in the Turkish adults the intermolar distance norm value was 61.17 ± 3.45 mm. In our study, this measurement was similar (62.7-3.4 mm) in Indian adults.

Meredith[38] found that male subjects had greater facial widths than female subjects for each age group studied. In the current study, the data were separated according to sex to obtain more specific and useful cephalometric normative values; not surprisingly, the sexual dimorphism was found to be significant for 12 transverse linear measurements, not including the 6A-6B difference, and the lower midline deviation. Additionally, comparison between Indian men and women indicated larger measurements for men in all linear transverse measurements.

Nasal width was correlated with maxillary width ($r = 0.339$, $p < 0.01$), indicating a relationship between the airway and the width of the maxilla. Maxillary width correlated with all dental width measurements. All dental width measurements were highly correlated with each other. Significant correlation coefficients between jaw and arch widths were determined. Almost all correlation findings were narrower to those of Tancan Uysala et al.[23]

In our study, the facial width was significantly correlated with the cranial width ($r = 0.53$), ZL-ZR ($r = 0.46$), nasal width ($r = 0.32$), maxillary width ($r = 0.41$), mandibular width ($r = 0.47$), maxillary intermolar ($r = 0.42$), mandibular intermolar width ($r = 0.2$).

Maxillary intermolar width was significantly correlated with all the skeletal parameters and also mandibular intermolar width ($p < 0.05$). This finding might conceptually support the functional matrix premise of functional requirements influencing optimal form.[39]

CONCLUSION

PA transverse linear norms for Indian adults were determined. In general, most measurements were narrower to Ricketts' clinical norms and also Turkish norms. PA cephalometric standards for Indian adults were also determined. The results of this study have clinical implications in the diagnosis and treatment planning of Indian patients. Most of the Indian PA cephalometric linear measurements showed statistically significant sex differences. Comparisons between Indian men and women indicated higher measurements for men in all linear transverse measurements.

Cephalometric values measured in this study will be useful for the treatment planning and also assessment of facial measurements for orthognathic cases. However, it is not the purpose of these normal data to be used as a template. Orthodontic and orthognathic treatments should always be planned according to each patient's needs and desires.

According to these results, new PA clinical norms are presented to Indian orthodontists for diagnosis and the planning of orthodontic treatment and orthognathic surgery.

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