

Research & Reviews: Journal of Dental Sciences

Posteroanterior Cephalometric Analysis: The Norms for Iranian Population

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Research Article

Received date: 01/10/2015
Accepted date: 13/11/2015
Published date: 22/11/2015

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Keywords: Orthodontics, Facial symmetry, Posteroanterior radiograph analysis, Iranian population

ABSTRACT

Background: This research was designed to establish the posteroanterior (PA) radiograph norms for Iranian adult population. It also aims to distinguish any possible differences between genders. Finally, it will compare these norms with the norms of other populations.

Materials and Method: The population enrolled in the study was 60 Iranians aged between 18 and 45 years. Those included in the study satisfied the most important inclusion criteria: (i) Iranian origin (ii) bilateral Angle class I molar and canine relationship (iii) no history of orthodontic, orthognathic or orthopedic treatment. Purposive sampling technique was used to select participants for the study. Posteroanterior Radiographs were taken with teeth in centric occlusion and lips at rest position. Fourteen skeletal and dental linear measurements were determined on each radiograph. The ANOVA and Independent t-test were undertaken to analyze the data.

Results: There was no statistically significant difference between dental measurements, among different age groups. Eight of ten skeletal measurements showed significant difference in both genders, but no differences were found within different age groups. The Iranians PA radiograph norms were different from those of other nations.

Conclusion: Iranian PA radiograph norms are unique and should be incorporated in orthodontic treatment plan for Iranian patients.

INTRODUCTION

The important purpose of orthodontic treatment planning is the establishment of facial balance. Radiographic and clinical records in orthodontics are the basic tools for this objective. It is very important to thoroughly evaluate the frontal and lateral appearance of patient, according to the radiograph indices. Due to the diverse ethnic background, each population needs the development of unique radiograph norms individually. This is performed based upon facial features and characteristics of ideal members of that population. A comprehensive and systematic assessment of the 3 key elements of face (skeletal, dental, and soft tissue) as a whole is required to design a suitable treatment plan for a specific patient. In fact, only dental analysis is not sufficient for planning an ideal treatment.

Facial features are variable and specific to populations and ethnic groupings; as a consequence, there are no universal radiograph norms as the basis for orthodontic treatment. For this reason and as a quest to provide culturally sensitive and appropriate orthodontic treatment, norms ought to be developed for each population grouping as a basis for management. These norms include skeletal, dental, and soft tissues structures.

There are three major elements for production of good facial esthetics ^[1]. These are: symmetry, balance, and morphology.

They provide norms for various facial measurements and proportions. In addition, the facial thirds should be of the same basic morphologic configuration for establishment of facial harmony. Sarver et al. proposed the rule of fifth as a facial proportional analysis [2]. He emphasized on the importance of "esthetics" in orthodontic and orthognathic treatments. Another study also attempted to introduce the "crista galli" as a more dependable landmark for diagnosis of facial symmetry [3].

The growth of the cranial base has an important effect on craniofacial development. For instance, the growth of upper facial skeleton is closely related to the growth of anterior cranial fossa; and the posterior cranial fossa articulate with the mandible through the temporomandibular joint [4].

As a part of comprehensive orthodontic treatment, radiographs always are required for evaluation of the initial status of the patient, final outcome of treatment, and the comparison. Due to alteration of the facial structures, the changes cannot be understood without radiograph superimposition. The use of PA radiograph films is for the assessment of frontal aspect of facial asymmetry [5]. The tracing of PA radiogram should be carried out by placing the cephalograph in front of the examiner as if he/she is looking at the skeletal structure of the patient [6].

A number of studies have performed for different nations to find out the possible facial differences between populations [7-10]. A study compared dentofacial pattern of Iranians with Americans [7]. They found that Iranians are of a flat skeletal profile and large vertical dimensions, both anteriorly and posteriorly. In addition, Iranians demonstrate more lip protrusion than Americans do. Another study on Arab population concluded that no difference exists between Jordanian males and females for any of the cephalometric measurements [8].

However, there are many differences between PA cephalographs of different nations, between Japanese and of European-American adults [9]. To establish a guide for facial balance, Arnett et al. studied on STCA (soft tissue cephalometric analysis) for treatment planning for facial deformity cases [10]. They also scrutinized on the correlation between soft tissue and frontal aspect of skeletal structure. Obviously, abnormal cephalometric measurements would not always rule out the necessity of a surgical procedure [11]. Even though the validity of cephalometric measurements is essentially not firm; it is always considered as a para-clinical diagnostic tool [12].

This study is designed to introduce PA cephalometric norms for Iranian population; and to compare if there are any differences between or similarities with people of other parts of the world.

MATERIALS and METHODS

This is a cross-sectional study and the descriptive method of research has been used in the study. The cases were evaluated both quantitatively and qualitatively. The subjects of this study were 60 Iranians adult within the age range of 18 to 45 years.

Iranians were defined as 100% Iranian blood, natural born, and raised in Iran. The selection criteria were based on the following qualifications: 1. Subjects of Iranian origin, 2. Bilateral class I molar and canine relationship based on Angle classification, 3. Balanced and symmetrical face, 4. No history of orthodontic, orthognathic, or orthopedic treatment, 5. Minor or no crowding, 6. Full set of normal permanent teeth in both jaws excluding third molars, 7. No history of facial trauma, 8. Full set of orthodontic documentations.

The patients were divided into five age brackets. The participants of age 18-20 years were categorized as group one, 21-25 years, as group two, 26-30 years, as group three, 31-35 years, as group four, and the patient older than 36 years, as group five.

Facial balance and profile were determined by three calibrated expert clinicians. Only those subjects who qualified and consented to participate in the study had a PA radiograph taken. Radiographs were taken from individuals with their teeth in centric occlusion and lips at rest position. All cephalographs were taken by one operator with the use of Kodak 8000C (Kodak Corp, Japan) digital panoramic and radiograph machine. The films were taken at 5 feet distance from the Radiograph tube and the porionic axis where it was placed close to the nose. Ten skeletal and four dental linear measurements were drawn according to the bilateral radiograph (right and left) landmarks (**Figures 1 and 2**).

The following fourteen lines that were used for this investigation are:

1. Cranial width (Cr-Cr): the width of cranium from the most lateral points on the cranium parallel to the superior aspect of the orbits.
2. Anterior cranial base width (ACr-ACr): the distance between right and left sides of anterior cranial base width.
3. Bifrontozygomatic width (FrZ-FrZ): distance between the outer edges of the frontozygomatic width.
4. Facial width (ZA-AZ): the width of zygomatic arch at its most lateral aspects.
5. Bimastoid width (Mas-Mas): the distance between the apices of right and left mastoid processes.
6. Inter-orbital width (Or-Or): the distance between right and left side of inner bony wall of orbit.
7. Nasal width: the distance between NC and CN points.

8. Maxillary width (JR-JL): the width between JL and JR points.

9. Antegonial width (Ag-Ag): the distance between right and left antegonial points.

10. Mandibular width (bigonial width)(Go-GO): the width between right and left gonial points.

11. Maxillary intermolar width (Um-Um): the distance between left and right points A6 and 6A, which are perpendicular projections of the buccal surfaces of the maxillary first permanent molars to the frontal occlusal plane.

12. Mandibular intermolar width (Lm-Lm): the distance between left and right points B6 and 6B, which are perpendicular projections of the buccal surfaces of the mandibular first permanent molars to the frontal occlusal plane.

13. Upper midline deviation (UMD): the distance between the contact point of the maxillary central incisors and the midsagittal plane.

14. Lower midline deviation (LMD): the distance between the contact point of the mandibular central incisors and the midsagittal plane.

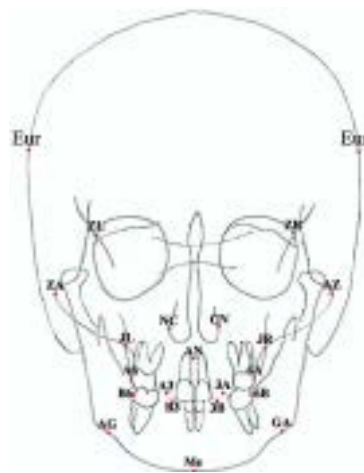


Figure 1: PA cephalometric landmarks used in study. ZL, intersection between left zygomatico-frontal suture and orbit; ZR, intersection between right zygomatico-frontal suture and orbit; ZA, intersection of lateral borders of left zygomatic arch; AZ, intersection of lateral borders of right zygomatic arch; NC, the widest part of left nasal cavity; CN, the widest part of right nasal cavity; Me, the most inferior point of mandibular symphysis, in midsagittal plane; ANS, anterior nasal spine; A3, cusp tip of maxillary left permanent canine; 3A, cusp tip of maxillary right permanent canine; A6, outermost point of maxillary left first permanent molar, determined perpendicularly to occlusal plane; 6A, outermost point of maxillary right first permanent molar, determined perpendicularly to occlusal plane; JL, intersection between processus zygomaticus and processus alveolaris of maxila on left side; JR, intersection between processus zygomaticus and processus alveolaris of maxila on right side; B3, cusp tip of mandibular left permanent canine; 3B, cusp tip of mandibular right permanent canine; B6, outermost points of mandibular left first permanent molar, determined perpendicularly to occlusal plane; 6B, outermost points of mandibular right first permanent molar, determined perpendicularly to occlusal plane; AG, lateral and inferior border of left antegonial notch; GA, lateral and inferior border of right antegonial notch.

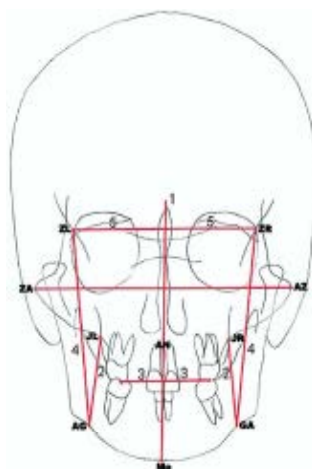


Figure 2: PA cephalometric reference planes of this study: 1, Midsagittal plane (AN-Me); 2, frontal tooth planes (FTP) (JL-AG and JR-GA); 3, occlusal plane (Occl P); 4, frontal face planes (FFP) (ZL-AG and ZR-GA); 5, Zygomatic plane (ZL-ZR).

The gathered data were carefully recorded, analyzed and interpreted. The descriptive analysis included mean, standard deviation, and the significance level. Data was analyzed by using SPSS, version 7.5. The level of significance was set at 0.05 probability rate. The method error was determined by retracting and re-measuring 10 randomly selected cases which generated an average error of less than 0.3 mm for the linear, 0.4 mm for the radiograph coordination and 0.4 for the angular measurement.

Statistical analysis of the difference between Iranian males and females was done by t-test. Analysis of variance (ANOVA) was also used to compare different age groups.

RESULTS

The number of participants of the age group one were 4 (6.7%), of the group two were 36 (60%), the group three were 15 (25%), of the group four were 3 (5%), and finally of the group five were 2 (3.3%). The majority of the subjects (60%) were within the age range of 21-25 years (group 2) (**Table 1**). The contribution of male and female genders was equal in this sampling group.

Table 1. Samples of study were divided into 5 age groups. The numbers of participants are defined and the percentages are also calculated.

Group #	Age Group	Frequency	Percentage
1	15-20	4	6.7
2	21-25	36	60.0
3	26-30	15	25.0
4	31-35	3	5.0
5	36-above	2	3.3
Total		60	100

Skeletal measurements: The result of ANOVA statistical test based upon skeletal measurements is presented according to different age groups (**Table 2**). The significant level of P-values for ten skeletal measurements was also calculated. There was no statistically significant difference between the 10 skeletal measurements of subjects in none the five age groups ($P\text{-value } 0.147 \leq X \leq 0.823$).

Table 2. Analysis of variance compares the skeletal measurements of the subjects when evaluated according to the age groups.

*	Variable	Age Group	Mean (mm)	Standard Deviation	P-value
1	Cranial width (Cr-Cr)	1	173.5	6.13	0.539 (not significant)
		2	169.86	8.17	
		3	173.00	12.30	
		4	177.00	6.24	
		5	176.00	14.14	
2	Anterior cranial base width (ACr-ACr)	1	111.50	5.06	0.654 (not significant)
		2	109.86	5.11	
		3	111.13	4.42	
		4	108.33	6.66	
		5	114.00	5.66	
3	Bifrontozygomatic width (FrZ-FrZ)	1	129.25	6.70	0.147 (not significant)
		2	123.50	8.85	
		3	128.87	8.88	
		4	123.33	3.05	
		5	134.00	9.90	
4	Facial width (AZ-AZ)	1	153.00	8.16	0.354 (not significant)
		2	146.55	13.11	
		3	154.33	10.94	
		4	145.66	6.02	
		5	146.50	11.65	
5	Bimastoid width (Mas-Mas)	1	140.75	4.27	0.578 (not significant)
		2	133.36	9.00	
		3	134.33	9.34	
		4	138.00	4.00	
		5	135.00	9.79	
6	Inter-orbital width (Or-Or)	1	32.25	2.06	0.535 (not significant)
		2	29.81	3.53	
		3	31.27	3.67	
		4	30.66	5.13	
		5	29.00	5.66	
7	Nasal width (Nas-Nas)	1	32.50	2.38	0.173 (not significant)
		2	37.92	4.68	
		3	38.06	2.37	
		4	38.00	4.36	
		5	37.00	1.41	

8	Maxillary width (JR-JL)	1	15-20	72.75	6.65	0.823 (not significant)
		2	21-25	74.72	4.97	
		3	26-30	74.93	3.26	
		4	31-35	74.00	3.00	
		5	36-above	77.50	6.36	
9	Antegonial width (Ag-Ag)	1	15-20	110.25	8.42	0.570 (not significant)
		2	21-25	104.27	8.13	
		3	26-30	103.20	8.42	
		4	31-35	104.66	0.58	
		5	36-above	100.50	2.12	
10	Bigonial width (Go-Go)	1	15-20	123.00	5.88	0.260 (not significant)
		2	21-25	115.02	7.08	
		3	26-30	114.60	8.87	
		4	31-35	119.33	3.79	
		5	36-above	113.60	3.53	

Eight out of ten skeletal measurements showed significant difference according to gender variance (**Table 3**). These include: the cranial width (P-value=0.000), anterior cranial base width (P-value=0.007), bifrontozygomatic width (P-value=0.001), facial width (P-value=0.004), bimastroid width (P-value=0.022), inter-orbital width (P-value=0.017), maxillary width (P-value=0.033), and bigonial width (P-value=0.011). The rest of variables, nasal and antegonial width of Iranian males showed no significant difference when compared to of females.

Table 3. The “t-test” analysis has compared the skeletal measurements of the subjects when grouped according to gender differences.

* Variable	Age	Mean (mm)	Standard Deviation	P-value
1 Intermolar width of maxillary first molars (Um- Um)	1 15-20	65.75	7.14	0.482 (not significant)
	2 21-25	70.72	5.86	
	3 26-30	70.60	3.90	
	4 31-35	70.66	5.68	
	5 36-above	73.00	.00	
2 Intermolar width of mandibular first molars (Lm- Lm)	1 15-20	71.75	4.99	0.480 (not significant)
	2 21-25	75.91	6.27	
	3 26-30	73.66	7.50	
	4 31-35	79.00	1.73	
	5 36-above	76.50	7.77	
3 Upper midline deviation (UMD)	1 15-20	0.12	0.25	0.441 (not significant)
	2 21-25	0.19	0.36	
	3 26-30	0.00	0.00	
	4 31-35	0.16	0.28	
	5 36-above	0.00	0.00	
4 Lower midline deviation (LMD)	1 15-20	0.00	0.00	0.433 (not significant)
	2 21-25	0.15	0.33	
	3 26-30	0.26	0.37	
	4 31-35	0.00	0.00	
	5 36-above	0.00	0.00	

Dental measurements: No significant difference was found in none of the four dental measurements when compared within age groups. (P-value $0.433 \leq X \leq 0.482$) (**Table 4**). The growth of maxilla, and later on of mandible, becomes inactive after pubertal age. Therefore, the changes in the intermolar width dimension of both upper (P-value=0.482) and lower arch (P-value=0.480) were not obviously significant.

Table 4. Analysis of variance compares the dental measurements of the subjects when evaluated based upon the age groups.

* Variable	Age	Mean (mm)	Standard Deviation	P-value
1 Intermolar width of maxillary first molars (Um- Um)	1 15-20	65.75	7.14	0.482 (not significant)
	2 21-25	70.72	5.86	
	3 26-30	70.60	3.90	
	4 31-35	70.66	5.68	
	5 36-above	73.00	.00	
2 Intermolar width of mandibular first molars (Lm- Lm)	1 15-20	71.75	4.99	0.480 (not significant)
	2 21-25	75.91	6.27	
	3 26-30	73.66	7.50	
	4 31-35	79.00	1.73	
	5 36-above	76.50	7.77	

3	Upper midline deviation (UMD)	1	15-20	0.12	0.25	0.441 (not significant)
		2	21-25	0.19	0.36	
		3	26-30	0.00	0.00	
		4	31-35	0.16	0.28	
		5	36-above	0.00	0.00	
4	Lower midline deviation (LMD)	1	15-20	0.00	0.00	0.433 (not significant)
		2	21-25	0.15	0.33	
		3	26-30	0.26	0.37	
		4	31-35	0.00	0.00	
		5	36-above	0.00	0.00	

Four dental measurements showed no significant difference when compared on gender basis (**Table 5**). According to the T-test analysis, both gender had similar values. In other words, the changes of dental measurements between male and female were not statistically significant ($P\text{-value } 0.193 \leq X \leq 0.770$).

Table 5. The "T-test" analysis has compared the dental measurements of the subjects when grouped according to gender differences.

*	Variable	Gender	Mean (mm)	Standard deviation	P-value
1	Intermolar width of maxillary first molars (Um- Um)	Male	70.72	5.54	0.667 (not significant)
		Female	70.11	5.38	
2	Intermolar width of mandibular first molars (Lm- Lm)	Male	76.09	5.35	0.282 (not significant)
		Female	74.29	7.49	
3	Upper midline deviation (UMD)	Male	0.14	0.32	0.770 (not significant)
		Female	0.12	0.29	
4	Lower midline deviation (LMD)	Male	0.19	0.33	0.193 (not significant)
		Female	0.12	0.32	

DISCUSSION

Comparing the skeletal features of different nations, this study showed that cranial width of Iranians (171.75 mm) is wider than of Palestinians (148.71 mm). This value was 150.31 mm for females and 177.09 mm for males, while this measurement for Palestinians was 147.46 mm for females and 150.31 mm for males^[13]. However, no differences were found between Jordanians males and females^[8].

A comparative study was performed by Davoody et al. to determine dentofacial pattern differences between Iranians and Americans^[7]. They found that Iranians are of a flat skeletal profile and large vertical dimensions, both anteriorly and posteriorly. They also noticed that the most difference between the two nationalities was in the lower anterior facial height dimension. In addition, Iranians demonstrated more lip protrusion than Americans did.

Furthermore, the anterior cranial base of Iranian adults is wider than of Palestinians^[13]. It should be noted, that the growth of anterior cranial base ceases progressively till age 7, while the posterior cranial base continue growing till late adolescent years^[14]. Again, this value was averagely 110.35 mm. The mean value for males was 111.94 mm and 108.54 mm for females, while Palestinian adults showed the anterior cranial base of 103.99 mm in men and 100.25 mm in women^[15].

Athanasiou et al. studied on the transverse dimension of dentofacial structures of 6 to 15 years old Australian school children^[16]. They stated that the maxillary intermolar width did not increase during the period of 9-12 years of age, as well as the mandibular intermolar width did, as it remained approximately the same during the whole observation period. Usyal et al. in his investigation noted that Turkish adults have an Um-Um distance of 61.17 ± 3.45 mm and an Lm-Lm distance of 59.52 ± 3.68 mm^[17]. In the study of Taki et al. the mean value of 59.48 mm observed for Um-Um and 58.40 mm for Lm-Lm distance^[13].

This study found that Um-Um measure of Iranian more than of Australians and Turks (70.33 mm). This value, of course, was a bit different for males (70.72 mm) comparing to females (70.11 mm). This was also true with Lm-Lm value in Iranian population. This distance was averagely 75.25 mm, with a mean value of 76.09 mm in males and 74.28 in female gender.

Concerning the facial width (Za-Za), Rickets et al. stated that at age 9 years was 115.7 mm and later 2.4 mm increase per year with age^[15]. Thus, they predicted that at the age of 18 this distance would be 137.3 mm. However, this study observed higher value of this measurement (148.88 mm) for Iranian population.

Wei found that bifrontozygomatic and bigonial widths of Japanese and Chinese people are almost similar^[18]. His findings revealed that both nations have 132.80 mm bifrontozygomatic width with a difference of 0.95 mm and 98.3 mm bigonial width with a slight clinical difference, as well. These figures are 124.70 mm for bifrontozygomatic distance and 93.25 mm bigonial widths in American subjects. In fact, Iranian adults are in between above these three groups. These values are 125.57 mm for bifrontozygomatic dimension, but much wider bigonial width (115.62 mm) than all above populations.

Regarding the nasal width, Oladipo et al. in their study on Nigerian reported that the nasal width of males was 40.10 mm and of females was 39.30 mm^[19]. In comparison, this measurement for Palestinian was much less; 33.54 mm for male adults and for females was 31.14 mm^[13]. However, nasal width of Iranian adults averagely was 37.57 mm, and gender-based were 37.31 mm for males and a slightly wider 37.86 mm for females. Therefore, Iranian nasal width is shorter than of Nigerians but is wider than of Palestinians population. Additionally, Iranian adults have wider both bimaxillary (134.38 mm) and inter-orbitale (30.35 mm) width when compared to of Palestinian adults, 115.15 mm and 25.42 mm, respectively^[13].

Heurtas and Ghafuri, who studied on 30 samples (16 girls and 14 boys from the Bolton-Brush growth study) noticed that the mandibular width (AG-GA) was similar in boys and girls at age 10 but not at age 18^[20]. Hence, the maxillary width (JL-JR) was greater in boys than girls at both ages. The increase in AG-GA width (5.5 mm in boys and 3.9 mm in girls) was more than twice of JL-JR dimension (2.4 mm, boys; 1.2 mm girls). They also reported that arch width at first molar was nearly stable with age, indicating the compensatory occlusal adaptation to differential changes between maxillary and mandibular widths. Finally at age 18, the distance between the centers of the orbits, a surrogate measure for cranial width, was almost equal to JL-JR in girls and equal to AG-GA in boys.

The width of the maxilla (JL-JR) with 74.7 mm length and antegonial width (AG-GA) with 104.3 mm length are wider in Iranian adults as compared to the norms introduced by Ricketts et al. According to them, the mean value of JL-JR was 61.9 mm for 9 years old subjects, increasing 0.6 mm per year in their growing ages^[15]. At age 18, the JL-JR distance was estimated to be 67.3 mm. Their another finding was that the antegonial width of 76.1 mm at age 9 years increased 1.4 mm yearly ending with 88.7 mm at age 18^[16].

CONCLUSION

Based upon the findings of this study following conclusions are drawn:

1. The PA radiograph norms for Iranian are comparable to of other populations.
2. There is no significant difference between skeletal and dental measurements of various age groups of the present study.
3. The facial width, cranial width, anterior cranial base width, interorbital width, maxillary width, and bigonial width of adult males are wider in comparison to of female adults.

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