

Designing Orthodontic Craniofacial Templates for 8-14 year-old Iranian Girls Based on Cephalometric Norms

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Abstract

Objectives: Cephalometry and its related analyses have an important role in the evaluation of orthodontic patients. Access to an analysis that gives maximum information in the least possible time is an effective way to indicate craniofacial disharmony; therefore, craniofacial templates are very useful tools. The purpose of the present study was to provide orthodontic craniofacial templates for 8-14-year-old Iranian girls.

Materials and Methods: One thousand two-hundred and nine girls (age range, 8-14 years) were examined. Eighty of these cases were finally chosen for the study and their lateral cephalograms were traced. Both Basion-Nasion (Ba-N) and Sella-Nasion (S-N) lines were selected for superimposition in this study. Based on these two mentioned lines, a template for each age was designed. Simple linear regression and multivariate regression analysis were used to evaluate the angles and to landmark the vectors, respectively.

Results: Findings show that most points change significantly at different ages in the S-N method. In the Ba-N method, all points except for S and Ba have significant changes at different ages.

Conclusion: Templates that resulted from both methods were the same and alteration in the reference line and points does not change the total form of the average tracings of each age.

Key Words: Cephalometry; Cephalometry; Malocclusion; Orthodontics; Analysis

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INTRODUCTION

Cephalometric analysis is an important part of the dentofacial morphology assessment, which has a great role in orthodontic treatment plan-

ning and evaluation of treatment changes.

Since the introduction of cephalometry, many cephalometric methods and related analyses have been explained [1-3]. Cephalometry is

also a useful method of understanding the craniofacial characteristics of various ethnic populations. Numerous investigations have shown that cephalometric norms vary between different ages, genders and racial groups [4-9]. Therefore, for accurate application of cephalometric analysis, it is preferable to use cephalometric norms for specific populations, genders and ages.

As most patients seeking orthodontic treatment are children and juveniles, it seems necessary to give priority to these age groups for obtaining norms. Cephalometric template is a fast and easy visualization of craniofacial harmony. Templates also give complete information only by a single cephalometric film. Several templates have been introduced over years. Usually, templates have been designed based on specific populations, genders and ages.

Using Burlington's growth study center records, Popovich designed templates for 3, 6, 8, 10 and 12-year-old children. All these templates were associated with acceptable occlusions and facial profiles [10].

Mesh diagrams were suggested by Moorrees. This type of template gives the opportunity to evaluate proportions of each part of the face in association with other structures, without using any norms [11]. Several templates have also been designed to different age groups, including those by Moyers, Ackerman and Broadbent [12, 13]. Furthermore, Jacobson introduced templates that are applicable for various conditions of diagnosis and treatment planning; proportionate templates that were used for orthognatic surgery in adult patients and templates that were used for analytic studies of individuals aged from 6 to 16 years. Ali h Hassan has established cephalometric norms for children living in the western region of Saudi Arabia. In Iran, Akhoundi studied cephalometric norms for 8 to 16-year-old boys and compared the results to those of western templates [14]. The purpose of this study was to introduce cephalometric norms

and to establish templates for 8 to 14-year-old Iranian girls.

MATERIALS AND METHODS

A total of 1209 girls were examined in Tehran and 177 girls were selected. A second examiner re-evaluated the selected group and chose 127 girls who met the inclusion criteria. Finally, 80 lateral cephalometric X-rays were obtained after the parents signed informed consent.

The following inclusion criteria were used: the girls were 8 to 14-year-old and Iranian, a class I occlusion and normal overjet and overbite. They had balanced, acceptable or excellent profiles. Their upper and lower dental midlines were "on" in both open and closed mouth conditions. Cases with dental malalignment, anterior or posterior cross bite, missing teeth, supernumerary teeth, jaw deviation, great restorations particularly in the first permanent molar, temporomandibular dysfunction (TMD), systemic or congenital diseases, deviation in dental midlines and any history of previous orthodontic treatment were excluded from the study.

After checking the quality of the radiographs, 19 cases with the age of 8, 20 cases with the age of 10, 20 cases with the age of 12, and 21 cases with the age of 14 were selected and traced by three operators and the necessary landmarks were assigned as defined (Table 1). Since there is no general agreement on the selection of a particular point or reference plane for cephalometric superimposition, Therefore, considering strength and weakness points of the mentioned plane, both sella-nasion (SN) and basion-nasion (BaN) planes were selected, so that landmarks changes by age could be investigated and compared using two different methods. In the first method, SN line and the line perpendicular to it at the sella point were selected as coordinate system axes and S as the origin; SN as the X axis (horizontal axis of the coordinate system) and the perpendicular line

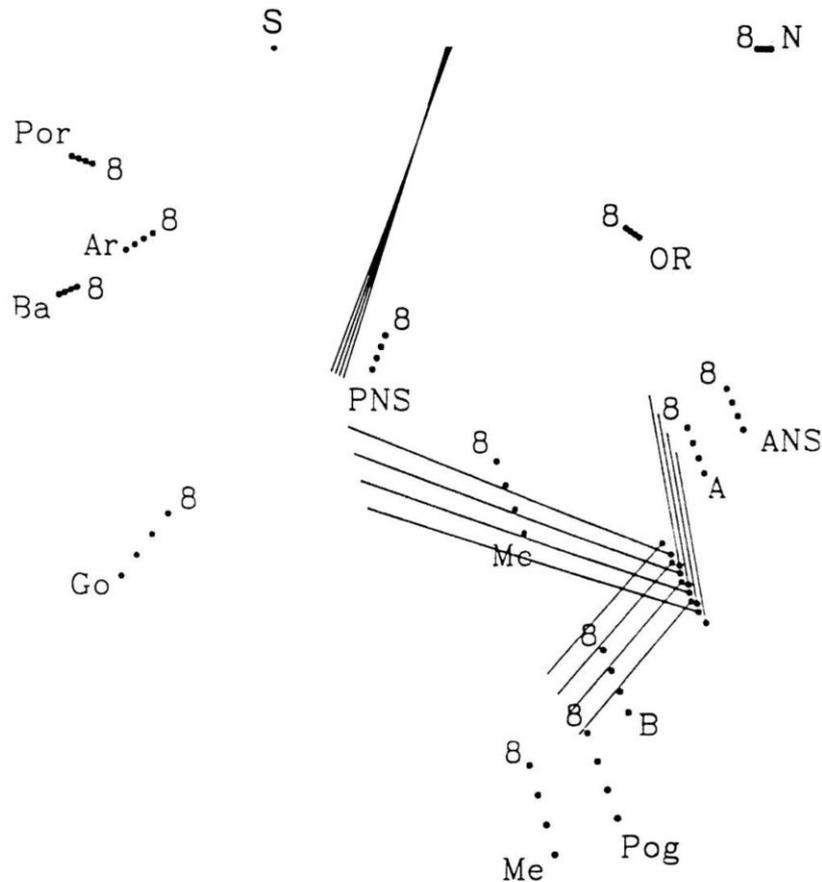


Fig 1. Graphic model (Template) derived by the first method

to SN at S point as the Y axis (vertical axis of the coordinate system). Then, coordinates of each landmark were calculated with 0.5 millimeter precision in this system. In addition, inclination of the upper incisor plane to SN "upper 1-SN", the inclination of the lower incisor to SN "lower 1-SN", the cant of occlusal plan as "occlusal plane-SN" and the cross angle of

pterygomaxillary plane to SN "PTM-SN" were also measured. The coordinates of the following points were calculated using the first method: PTM, MC, Ii, Is, Ba, Ar, Go, Me, Pog, B, A, PNS, ANS, Por, Or, N (by PTM is meant PTM cross point with SN).

In the second method, the cross point of PTM line and BaN was selected as the origin of the

coordinate system and PTM as the Y axis and the line perpendicular to PTM at the cross point as the X axis. In this method also, the coordinates of similar points were calculated using the first method, with the difference that there was no PTM point in this method and the coordinates of S point were calculated instead. Since the angle between the anterior cranial base (SN) and the posterior cranial base (BaS) undergo change during cranial base angulation and also the position of the sella will change as a result of posterior and superior drift of the sella turcica, BaN line seems a more reliable reference plane than SN or BaS as it is not affected by the position of the sella point [15]. In addition, using computer superimpositions, Ricketts et al. have shown that the Frankfurt Horizontal plane (FH) and the vertical pterygoid lines are more reliable than the SN line [16]. All the measurements were made at least twice or three times.

The simple linear regression and the multivariate regression analysis were used to assess the angles and evaluation of landmark vectors, respectively. The significance level was 0.05 and the SAS software was used for statistical manipulations.

RESULT

In the first method, changes in all points were significant by age, except for the PTM point ($\alpha=0.05$) (Table 2). However, changes in Y axis of Por and Ba points are not significant. The table indicates that the X and Y components of all points tend to move away from the coordinate axis, while changes in the Y component of Por point tend to move toward the X axis. This matter is also true for the X component of PNS point. Changes in the X component of the PNS point tend to approach the Y axis. The related graphic model is shown in figure 1.

Table 2 shows that the upper and lower incisor angle changes in the first method are not significant despite their relative increase; however, the occipital plane and PTM angles demon-

strate significant changes despite their relative decrease. Table 3 demonstrates the results of multivariate regression analysis in the second method. This table suggests that changes in S and Ba points by age are not significant.

However, changes in the Y component of Ba point are significant. On the other hand, changes in the X component of N, PNS and Go as well as changes in the Y component of Por, ANS, A and Ii are not statistically significant. In this method, changes in the X component of Go point, unlike other points, tend to move toward the Y axis. The related model is shown in figure 2.

DISCUSSION

This study provided graphic models or craniofacial templates for girls in the 8 to 14-year-old age group. Considering limitations, including lack of growth centers and consequently cephalometric reservoirs in the country as well as time restrictions and lack of possibility for preparing series of radiographies for a special individual during growth ages, this research was performed as a cross sectional. The findings of the research verify the hypothesis that graphic models change in different ages. As it was mentioned in the results section, most of the cephalometric landmarks undergo significant changes by age which mainly appear in the form of increases in the X and Y age axes.

The first method reveals that changes in most of the cephalometric landmarks by are significant, the further these points are from the origin, the more changes observed.

For example, changes in N and Or points in the direction of X axis are 0.33 and 0.32 millimeters, respectively and also the changes in both Por and Ba points in the direction of Y axis is 0.18 millimeter every year or the changes in the Y component of B, Pog, Me and Go is 1.5, 2.03, 2.13 and 1.5 millimeters increase every year. In this method, the changes in all the points except for Or, Por, Ar and Ba points are in the direction of Y axis.

In other words, vertical changes exceed changes in the direction of X axis or horizontal dimension.

An observation of the graphic model obtained from the first method and considering that SN is considered as the plane of cranial base verifies the claim that most landmarks tend to move away from the cranial base during their growth in the vertical and horizontal directions and the cranial base is regarded as a relatively stable area during growth. In the first method, the changes in N, Ba and Por points that are located in the cranial base structure are low, while the distance of Ar to the origin does not exceed that of Ba. In the second method also, the changes in Por, Ba and S points by age are low. However, these points in comparison with Ar and PNS are located in a farther distance from the origin.

The importance of selecting the cranial basis to evaluate the origin is revealed by observing the orientation of growth components of points such as ANS, A, B, Pog and Me.

Downward and forward movement of facial landmarks, which has been emphasized by Broadbent and Popovich, is confirmed by regression analysis in this study. Increasing maxillary length and also forward and downward movement of the maxilla and maxillary dentition in relation to the cranial base (SN) were obtained by the first method. Changes in the mandible are clockwise rotation that is accompanied with ramus and body length increase. An annual decrease of 0.69 degrees in the occlusal plan angle that was demonstrated in the first method indicates a higher downward movement of the posterior part of this plane compared to the anterior part.

Table 1. Definitions of the Landmarks Selected for Tracing

Landmarks	Definitions
S	The constructed point as the center of Sella Turcica
N	Nasion: The most superior Anterior point of the nasion bone
Or	Orbitale: The Lower-most point of the orbit
Por	Porion: The highest point on the bony external acoustic meatus
ANS	Anterior Nasal Spine
PNS	Posterior Nasal Spine
A	Point A: Subspinale
B	Point B: Supramentale
Pog	Pogonion : The most anterior point of bony chin
Me	Menton: The lowermost point on the mandibular symphysis
Go	Gonion : The most posterior Inferior point on the angle of the mandible, A constructed
Ar	Articulare : A constructed point at the intersection of the images between posterior border of ramus and cranial base
Ba	Basion : Lowest point on the anterior margin of the foramen magnum
Is	Incision superius
Ii	Incision Inferius
Mc	The most mesial contact point of the first molar & it's mesial tooth
PTM	The Anterior border of the pterygopalatine fossa

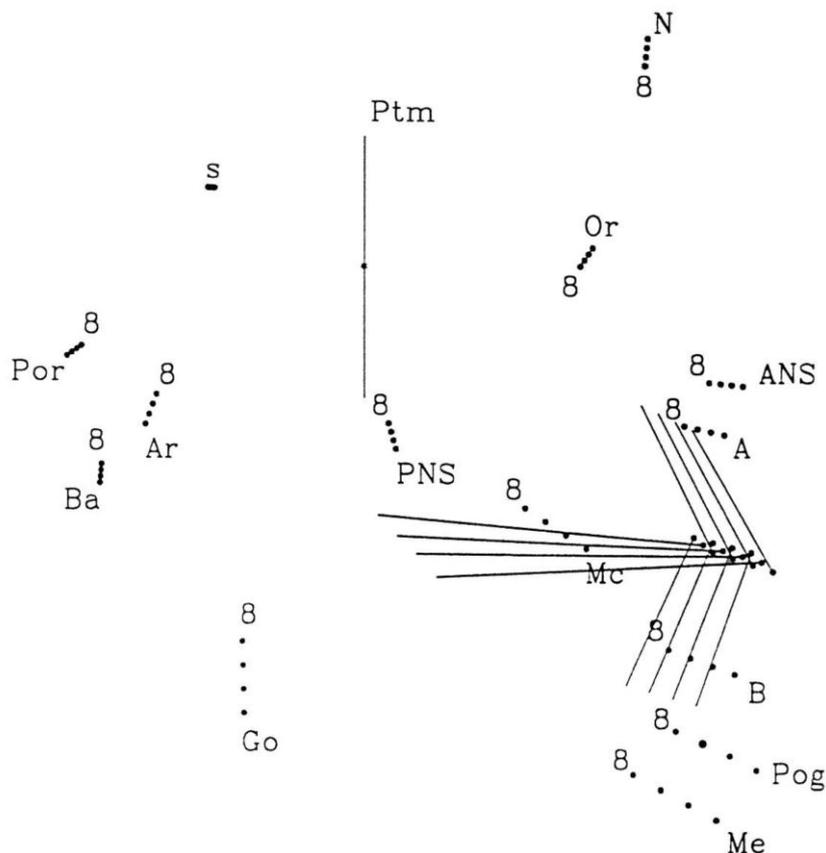


Fig 2. Graphic model (Template) derived by the second method

The 1.29 degree decrease for every year of age in the second method also confirms this claim. Clockwise rotation and also a tendency to growth in the vertical direction are observed in most facial parts including the maxilla and mandible; while the occlusal plane changes occur counter clockwise. The results of these two rotations make us doubtful about the possibility of vertical height increase in the anterior facial dimension and also opening of the bite. These findings may justify the counter clockwise rotation of the occlusal plane.

Rotation of the occlusal plane may also be observed in the Johnston template. Change in the location of Frankfurt plane is not the same as increase in age. On the other hand, change in the Frankfurt plane was not in the same manner.

In the first method, the changes in Or point are downward and forward and in Por point the changes are upward and backward, while in the second method, the changes in Or point are forward and upward and in the Por point the changes are downward and backward.

Table 2. First Method Multivariate Regression Analysis to Evaluate the Changes of Cephalometric Vectors Regarding Age

Points		$\beta x + \alpha$	angle	Vector
N	X	66.91 + 0.33 (age)	P=0.019	
	Y	0		P=0.019
Or	X	48.14 + 0.32 (age)	P=0.042	
	Y	-24.09 - 0.23 (age)	P=0.015	P=0.011
Por	X	-22.18 - 0.50 (age)	P=0.001	
	Y	-18.57 + 0.18 (age)	P=0.118	P=0.003
ANS	X	61.96 + 0.40 (age)	P=0.026	
	Y	-41.24 - 0.98 (age)	P=0.0001	P=0.0001
PNS	X	18.39 - 0.31 (age)	P=0.029	
	Y	-35.04 - 0.82 (age)	P=0.0001	P=0.0001
A	X	56.21 + 0.41 (age)	P=0.029	
	Y	-46.03 + 1.09 (age)	P=0.0001	P=0.0001
B	X	42.76 + 0.60 (age)	P=0.015	
	Y	-74.73 - 1.50 (age)	P=0.0001	P=0.0001
Pog	X	39.68 + 0.71 (age)	P=0.007	
	Y	-82.48 + 2.03 (age)	P=0.0001	P=0.0001
Me	X	32.05 + 0.62 (age)	P=0.020	
	Y	-86.29 - 2.13 (age)	P=0.0001	P=0.0001
Go	X	-5.89 - 1.14 (age)	P=0.0001	
	Y	-55.44 - 1.50 (age)	P=0.0001	P=0.0001
Ar	X	-11.90 - 0.67 (age)	P=0.0001	
	Y	-23.92 - 0.40 (age)	P=0.0004	P=0.0001
Ba	X	-24.95 - 0.43 (age)	P=0.005	
	Y	-33.46 - 0.18 (age)	P=0.284	P=0.008
Is	X	53.28 + 0.64 (age)	P=0.005	
	Y	-63.61 - 1.37 (age)	P=0.0001	P=0.0001
Ii	X	50.41 + 0.69 (age)	P=0.001	
	Y	-60.20 - 1.39 (age)	P=0.0001	P=0.0001
Mc	X	26.68 + 0.68 (age)	P=0.0006	
	Y	-45.98 + 1.71 (age)	P=0.0001	P=0.0001
Ptm	X	23.54 + 0.14 (age)	P=0.254	
	Y	0		P=0.254

Table 3. Second Method Multivariate Regression Analysis to Evaluate the Changes of Cephalometric Vectors Regarding Age

Points		$\beta x + \alpha$	angle	Vector
S	X	-22.20 - 0.16 (age)	P=0.206	P=0.451
	Y	11.90 + 0.01 (age)	P=0.951	
N	X	42.26 + 0.07 (age)	P=0.648	P=0.0002
	Y	25.74 - 0.69 (age)	P=0.0004	
Or	X	30.41 + 0.31 (age)	P=0.021	P=0.001
	Y	-3.51 + 0.47 (age)	P=0.004	
Por	X	-40.89 - 0.37 (age)	P=0.014	P=0.025
	Y	-9.93 - 0.26 (age)	P=0.232	
ANS	X	45.87 - 0.86 (age)	P=0.0001	P=0.0001
	Y	-16.77 - 0.09 (age)	P=0.627	
PNS	X	2.27 + 0.18 (age)	P=0.178	P=0.0001
	Y	-18.67 - 0.65 (age)	P=0.0001	
A	X	40.76 + 1.02 (age)	P=0.0001	P<0.0001
	Y	-22.25 - 0.23 (age)	P=0.242	
B	X	33.03 + 1.69 (age)	P=0.0001	P=0.0001
	Y	-53.28 - 0.63 (age)	P=0.007	
Pog	X	31.10 + 2.07 (age)	P=0.0001	P=0.0001
	Y	-63.14 - 0.95 (age)	P=0.0004	
Me	X	24.7 + 2.13 (age)	P=0.0001	P=0.0001
	Y	-68.03 - 1.17 (age)	P=0.0001	
Go	X	-19.43 - 0.05 (age)	P=0.820	P=0.0001
	Y	-42.69 - 1.82 (age)	P=0.0001	
Ar	X	-30.10 - 0.28 (age)	P=0.031	P=0.0002
	Y	-13.39 - 0.76 (age)	P=0.0004	
Ba	X	-40.41 - 0.04 (age)	P=0.812	P=0.060
	Y	-26.31 - 0.48 (age)	P=0.0020	
Is	X	41.02 + 1.54 (age)	P=0.0001	P=0.0001
	Y	-39.32 - 0.50 (age)	P=0.034	
Ii	X	38.63 + 1.47 (age)	P=0.0001	P=0.0001
	Y	-38.08 - 0.38 (age)	P=0.090	
Mc	X	11.99 + 1.56 (age)	P=0.0001	P=0.0001
	Y	-28.54 - 1.02 (age)	P=0.0001	

The selection of two different coordinate systems in this study was due to the lack of any consensus regarding selection of one of these reference lines as evaluation origin and the idea that any change in the reference line may affect the final result.

A comparison of the graphic models resulting from the two methods reveals the fact that the graphic models of every method in every age fully coincide.

These findings serve as a confirmation for accuracy of measurement stages, because the measurements in these two coordinate systems were made fully independent of each other and at different times and this conformity of the results may serve as an indicator of the precision of the stages performed.

Furthermore this shows that modifications in the reference point/line does not change the final results; meaning that any other line can serve as a reference in the general form of the graphic model in all age groups without causing any alterations.

Some of the reasons for selecting the SN line for this study were that it was located in the cranial basis range, singularity of the S and N points, as well as ease of finding these points. The S point was selected as the origin of the coordinate system in the first method.

A study of the results of the second method reveals that no significant changes occur in this point by age.

The location of the PTM line relative to patients' age does not change; instead it rotates around a single point on this line which could be considered as a constant area during growth. It is interesting to find that this point is almost located in the same area where BaN crosses the PTM line and it was selected as the origin of coordinate system in the second method. In addition, the relative 0.5 degree decrease of PTM line for increasing every year of age indicate non-significant change in the Ba point in the direction of Y axis in the first method, and also non significant changes in

the above point in the second method. This may serve as a proper selection of the origin and axes of the coordinate system in the second method. A comparison of the present template with Jacobson and Kilpatrick template in the age of 8 years reveals that the length of SN and Ba- S-N angle are almost similar. Despite the relative similarity in the location of points such as A, B, PNS and Or in both templates, downward and backward movements are observed in some points including ANS, Pog and Me. This causes uncertainty about the greater facial anterior heights in the current study samples. Go, Ba and Ar also show backward and downward movements. On the other hand, in a comparison of the current template with Johnston sample, the increase in the anterior height is observed more. Similar to Jacobson template, increase in the posterior facial height was demonstrated and no decrease in Jaraback index was observed and it even showed a little increase, indicating that its value has undergone a change from 60% in the mentioned template to 62% in the present study.

Template analysis, as an auxiliary tool, may provide information on the cranial base length, length and position of the maxilla, mandible and also the position of the teeth in terms of vertical and anterior-posterior locations as well as future growth changes. It has to be mentioned that the aim of using templates is not to provide a general aim towards which treatment should be totally oriented. In addition to age, gender and population group differences, general differences in craniofacial structures should also be taken into account. Templates in general, including the present suggested template, demonstrate age related changes in a normal population; therefore, using them in individuals that exhibit deviations from normal growth patterns may not be suitable.

In order to present an accurate prediction of cranio-facial growth in these patients, development of graphic models in various age

groups with different types of malocclusion is suggested.

CONCLUSION

Templates that resulted from both methods including Sella- Nasion and Basion-Nasion references lines were the same and alteration in the reference line and points does not change the total form of the average tracings of each age.

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REFERENCES

1-Tweed CH. The Frankfurt-mandibular plane angle in orthodontic diagnosis, classification, treatment planning and prognosis. *Am J Orthod Oral Surg* 1946 Apr;32:175-230.
 2-Jacobson A. The wits appraisal of jaw disharmony. *Am J Orthod.* 1975 Feb;67(2):125-38.
 3- McNamara JA Jr. A method of cephalometric evaluation. *Am J Orthod.* 1984 Dec;86(6):449-69.
 4- Connor AM, Moshiri F. Orthognathic surgery norms for American black patients. *Am J Orthod.* 1985 Feb;87(2):119-34.
 5- Cotton WN, Takano WS, Wong WM. The Downs analysis applied the three other ethnic groups. *Angle Orthod.* 1951 Oct;21(4):213-20.
 6- Flynn TR, Ambrogio RI, Zeichner SJ. Cephalometric norms for orthognathic surgery in black American adults. *J Oral Maxillo-*

facSurg. 1989 Jan;47(1):30-9.

7- Naidoo LC, Miles LP. An evaluation of the mean cephalometric values for orthognathic surgery for black South African adults. Part 1: Hard tissue. *J Dent Assoc S Afr.* 1997 Jul;52(7):495-502.

8- Huang WJ, Taylor RW, Dasanayake AP. Determining cephalometric norms for Caucasians and African Americans in Birmingham. *Angle Orthod.* 1998 Dec;68(6):503-11.

9- Bailey KL, Taylor RW. Mesh diagram cephalometric norms for Americans of African descent. *Am J Orthod Dentofacial Orthop.* 1998 Aug;114(9):218-23.

10- Popovich R, Thompson GW. Craniofacial templates for orthodontic case analysis. *Am J Orthod.* 1977 Apr;71(4):406-20.

11- Moorrees CF, van Venrooij ME, Lebert LM, Glatky CG, Kent RL, Reed RB. New norms for the mesh diagram analysis. *Am J Orthod.* 1976, Jan,69(1):57-71.

12- Moyers RE, Jay P, editors. *Orthodontics in mid-century.* St Louis: CV Mosby; 1959:192-226.

13- Ackerman RJ. The Michigan School Study cephalometric norms expressed in template form. *Am J Orthod.* 1979 Mar;75(3):282-90.

14- Akhondi MSA, Chalipa J, Hosseinzadeh TN, Sodagar A, Hashemi R, Afzalifar R. A Comparison between *Craniofacial Template of Iranian and Western Populations.* *Acta Medica Iranica.* 2012;50(2):127-32.

15- Jacobson A. The proportionate template as a diagnostic aid. *Am J Orthod.* 1979 Feb;75(2):156-72.

16- Ricketts RM, Schulhof RJ, Bagha L. Orientation-sella nasion or Frankfort horizontal. *Am J Orthod.* 1976 Jun;69(6):648-54.