Cephalometric norms for Saudi sample using McNamara analysis

Sahar F. Al-Barakati, BDS, MS*
Nabeel F. Talic, BDS, MS, PhD**

أجريت هذه الدراسة على ٦٥ صورة شعاعيه جانبية لقياس الرأس لطلاب السنة الرابعة بكلية طب الأسنان (٣٦ ذكور و٢٩ إناث) لتأسيس مقاييس مرجعية حسب تحليل مكنامارا وتقييم فيما إذا كان هناك تباين ملحوظ بين المقاييس السعودية والمقاييس الأمريكية والأوروبية. تضمن معيار الاختيار اطباق طبيعي مع مظهر مقبول للنسيج الوجهي الرخو، اطباق طبيعي وعدم وجود أي تاريخ للرض وعدم وجود أية معالجة تقويمية سابقة. تم إجراء عشرة قياسات سنية وعظمية. واستخدمت تحاليل إحصائية لتحليل البيانات. أظهرت النتائج وجود اختلافات إحصائية واضحة بين مقاييس السعوديين من كلا الجنسين مع ما تضمنته دراسة مكنامارا على الأمريكان والأوربيين. بينت النتائج أن السعوديين لديهم مظهر وجهي متميزيتضمن بروزعام للاسنان في الفكين العلوي والسفلي وتقوس وجهي جانبي وانحدار خلفي للفك السفلي.

OBJECTIVES: The present study was carried out on 65 standardized lateral cephalometric radiographs (36 males and 29 females) of 4th year dental students to determine cephalometric norms according to McNamara's analysis, and to evaluate whether a significant difference exists between Saudi and European-American norms. ***METHODS:*** The criteria of selection were normal occlusion, pleasant soft tissue profiles, no history of trauma, and no previous orthodontic treatment. Ten skeletal and dental variables were investigated. Descriptive analysis and independent student t-test were carried out on the data. ***RESULTS:*** The results showed statistical significant differences between the Saudi males and females when compared to the norms suggested for European-Americans by McNamara. The results demonstrated that the Saudis have distinct cephalometric facial features. Generally, they revealed a greater convex profile with reduced chin prominence, steeper mandible and more bimaxillary protrusion.

INTRODUCTION

A cephalometric radiograph is an essential tool in orthodontics to assist research workers and orthodontic clinicians in diagnosis and treatment planning. Since the introduction of craniostat by Broadbent,[1] many analyses[2-10] have been produced to assess skeletal, dental and soft tissue patterns by relating the patient's malocclusion to their associated norms.

Mills[11] stated that genetics play a major role in producing the face and the dentition of the individuals. Accordingly, the differences for populations in their characters, size, growth and shape make the differences in the measurements for various craniofacial structures and that motivated researchers to investigate the cephalometric norms of different racial and ethnic groups in different countries for different populations such as American, European, African,[12] Japanese[13] and Chinese[14] populations.

A literature review revealed that little cephalometric studies have been conducted for Arabs[15-17] in general and for Saudis[18-26] in particular. Saudi population was found to have distinct craniofacial features as compared with other populations and due to ethnic variation, it is illogical to use cephalometric norms of specific racial group for another different population.[18-26] Shalhoub *et al*.[18] carried out a study on lateral cephalometric radiographs of 48 adult Saudis with reasonably balanced profile, compared them with a North American sample and a set of cephalometric norms for male and female Saudi adults were established. Nashashibi *et al*.[20] conducted a cephalometric study using Steiner's analysis to establish norms of Saudi boys with pleasant facial proportions with a

*Assistant Professor and Director of Clinics
**Assistant Professor & Head
Division of Orthodontics
Department of Preventive Dental Sciences
College of Dentistry, King Saud University

Address reprint requests to
Dr. Sahar F. Al-Barakati
Department of Preventive Dental Sciences
College of Dentistry, King Saud University
P.O. Box 5967, Riyadh 11432, KSA
E-mail: salbarakati @gmail.com

mean age of 12 years old and compared them with a similar British sample. They found Saudi faces and dentition are slightly more protrusive. Two studies were undertaken by Al Jasser[24,25] to describe the craniofacial characteristics and to formulate norms for Saudi students who have harmonious profiles and acceptable occlusions to compare them with European-American standards using Steiner and Downs analyses. It was concluded that Saudis have variations in the craniofacial features when compared with Steiner and Downs norms. Hassan[26] evaluated craniofacial features of cephalometric radiographs in a Saudi sample to establish cephalometric norms and to form polygon for easier use by orthodontists. The results showed Saudis have distinct cephalometric features, for which specific norms should be used as a reference in diagnosis and treatment planning.

It becomes apparent that cephalometric norms for Saudi population using McNamara analysis have as yet not been established. McNamara's norms should be used only as a guide and not as absolute values for each patient. The objectives of the current study were to determine norms for Saudi sample and to compare the data to the norms used by McNamara.[10]

MATERIALS AND METHODS

A total of 65 standardized lateral cephalometric radiographs (36 Male and 29 female) were analysed in the present study. These radiographs were selected from the archives of cephalometric radiograph files taken by the 4th year dental students used as part of their undergraduate orthodontic course requirements. The criteria of selection were normal occlusion, pleasant soft tissue profiles, no history of trauma, and no previous orthodontic treatment.

Two points were marked on each radiograph at a distinct distance. These marks were used to adjust the magnification of the radiographs. The radiographs were scanned and converted into a digital format. A cephalometric analysis computer software (Vistadent, GAC USA) was used to analyse the radiographs. The landmarks used for McNamara's analysis[10] are presented in Figure 1.

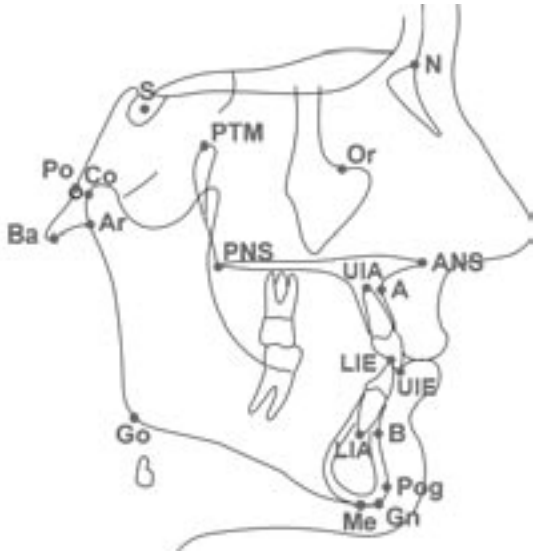

Fig. 1. The major landmarks used in McNamara's analysis.
Nasion (N), sella (S), basion (Ba), porion (Po), orbitale (Or), anterior nasal spine (ANS), posterior nasal spine (PNS), pterygomaxillary fissure (PTM), point A (A), point B (B), pogonion (Pog), gnathion (Gn), menton (Me), gonion (Go), articular (Ar), condylion (Co), upper incisal apex (UIA), upper incisal edge (UIE), lower incisal edge (LIE), lower incisal apex (LIA).

The major reference lines used in this analysis are the Frankfort plane, S-N plane, N-Ba plane and N-Perpendicular plane which is a line dropped from N, perpendicular to Frankfort plane. Angular and linear measurements of McNamara's analysis[10] are presented in Table 1.

The radiographs were digitized and landmarks were identified. The process of digitization, landmark identification and analysis was carried out by one

Table 1. Different angular and linear measurements of McNamara's analysis

Measurement	Definition
Maxilla to cranial base	The linear distance between nasion perpendicular and point A. An anterior position of point A is a positive, and a posterior position is a negative value
Effective midfacial length	The length in mm from condylion to point A
Mandible to cranial base	The distance between pogonion and nasion perpendicular. An anterior position of pogonion is a positive value and posterior position is negative value
Effective mandibular length	The length in mm from condylion to gnathion
Max-mandibular difference	The midfacial length is subtracted the mandibular length
Lower anterior face height	The distance from ANS to menton
Mandibular plane angle to FHP	The angle between mandibular plane and Frankfort horizontal plane
Facial angle	The angle between the line PTM to gnathion and the basion-nasion plane
Upper incisor to point A	The distance between the facial surface of the upper incisor and the line passing through point A parallel to N-perpendicular
Lower incisor to A-Pog plane	The distance between the edge of the lower incisor and the point A to pogonion plane

investigator. The computer analysis software produced the measurements according to McNamara's analysis.[10] The computer analysis software adjusted for the magnification using the two marks present at a known distance on the radiographs. The measurements were recorded for each radiograph. Descriptive data, means and standard deviations were calculated for the Saudi male and female sample. The means of the Saudi male and female sample were compared to the means of the European-American male and female sample reported by McNamara[10] using independent student t-test to find out whether there was significant difference at 5% level ($P < 0.05$).

Method error of the study in identifying and locating the anatomical landmarks during tracing and measurements were assessed by using paired t-test. Five cephalometric radiographs were randomly selected and digitized again after three weeks interval by the same investigator to determine the intra-examiner error. The t-test revealed no significant difference between the two occasions of measurements ($P<0.05$).

RESULTS

The means and standard deviations of the ten angular and linear measurements for Saudi males and females according to McNamara's analysis[10] were presented in Tables 2 and 3.

Table 2 shows the comparison of the mean values of cephalometric measurements between the Saudi and European-American males based on McNamara's study.[10] Saudi males were found to have retruded maxilla, significantly reduced chin prominence and a steeper mandible. In addition, lower incisors position was significantly more protrusive ($P<0.05$). On the other hand, no significant differences were found for the upper incisor position and lower anterior face height ($P>0.05$).

Table 3 demonstrated statistical comparison of mean values between Saudi and European-American females.[10] The midfacial and mandibular lengths were significantly larger in Saudi females. They also showed reduced chin prominence and steeper mandible. Furthermore, the lower incisors were significantly more protruded while the upper incisors are more retruded than in European Americans. In comparison, no significant difference was found for the maxilla position in which it was retruded in both ethnic groups.

Table 2. Statistical comparison of the cephalometric measurements between Saudi and European-American males according to McNamara's norms

	Saudis males		European-American males			
	N=36		N=38			
Variable	Mean	SD	Mean	SD	t-test	*P*-value
Sagittal skeletal relationship						
Maxilla						
Maxilla to cranial base (N perp. to point A mm)	-2.0	5.0	1.1	2.7	-3.3	0.001**
Effective Midfacial length mm	101.7	4.7	99.8	6	1.5	0.13
Mandible						
Mandible to cranial base (N perp. to Pog. mm)	-6.1	6.9	-0.3	3.8	-4.4	0.00***
Effective mandibular length	133.4	5.2	134.3	6.8	-0.6	0.54
Max-mandibular difference	31.8	4.4	34.5	4	-2.8	0.006**
Vertical skeletal relationship						
Lower anterior facial height	76.1	4.5	74.6	5	1.3	0.18
Mandibular plane angle	24.9	5.7	21.3	3.9	3.1	0.002**
Facial angle	2.8	3.1	0.5	3.5	2.9	0.004**
Dental relationship						
Upper incisor to point A vert.	6.2	2.5	5.3	2	1.5	0.095
Lower Incisor to A-pog	4.4	2.4	2.3	2.1	4.0	0.00***

*P<0.05
**P<0.01
***P<0.001

Table 3. Statistical comparison of the cephalometric measurements between Saudi and European-American females according to McNamara's norms

	Saudis females		European-American females			
	N=29		N=73			
Variable	Mean	SD	Mean	SD	t-test	*P*-value
Sagittal skeletal relationship						
Maxilla						
Maxilla to cranial base (N perp. to point A mm)	-0.2	3.7	0.4	2.3	-0.7	0.44
Effective midfacial length mm	98.2	5.4	91	4.3	6.4	0.00***
Mandible						
Mandible to cranial base (N perp. to Pog. mm)	-5.9	5.3	-1.8	4.5	-3.6	0.00***
Effective mandibular length	124.9	6.6	120.2	5.3	3.4	0.001**
Max-mandibular difference	26.8	3.7	29.2	3.3	-3.1	0.004**
Vertical skeletal relationship						
Lower anterior facial height	68.9	4.8	66.7	4.1	2.1	0.03*
Mandibular plane angle	25.0	4.6	22.7	4.3	2.3	0.02*
Facial angle	2.9	2.6	0.2	3.2	4.5	0.00***
Dental relationship						
Upper incisor to point A vert.	4.3	2.0	5.4	1.7	-2.6	0.013*
Lower incisor to A-pog	3.6	1.8	2.7	1.7	2.4	0.03**

* P< 0.05
** P< 0.01
*** P< 0.001

DISCUSSION

Previous cephalometric studies revealed that measurable skeletal and dental differences between racial groups exist. Considering the ethnic facial features of the patients thereby play a critical role in setting objectives for successful orthodontic treatment. Therefore, each different population would be best treated according to its individual's characteristics in order to achieve an esthetically pleasing face.

This investigation compared the sample of untreated Saudis to European-Americans to determine cephalometric norms. The sample was selected from the lateral cephalometric radiographs

taken by the 4th year dental students. The criteria of selection were normal occlusion, pleasant soft tissue profiles, no history of trauma, and/or orthodontic treatment. No previous studies of racial differences have compared the so-called ideal occlusion but several studies have used different selection criteria. Some were randomly collected and unselected, and most based their selection on occlusal evaluation, facial esthetics or both. The present study was in close agreement with other studies[13,14,27,28] which had selection criteria based on acceptable or normal occlusion and pleasing profile.

The mean values for skeletal Saudi males were significantly different in almost all measurable parameters when compared to the means of McNamara's norms.[10] It had been observed that the means of maxilla and mandible to cranial base, effective mandibular length, and maxillary-mandibular difference were significantly smaller than those of European- American sample. In contrast, lower anterior facial height, Frankfort mandibular plane angle and facial angle had significant greater mean values. Moreover, a highly significant difference was found for the mean of the lower incisors to A-pogonion which was more than those presented by McNamara.[10]

The present significant findings were in agreement with Miyajima *et al*.[13] who reported fundamental variations of Japanese and McNamara's norms[10], and also similar to the observations of Al-Jasser[24,25] and Garcia[29] which all indicated racial differences although different analyses were used.

The above mentioned hard tissue measurements can be interpreted as, (a) Saudis are not as maxillary protrusive as European-Americans, (b) point A was significantly retrusive relative to nasion perpendicular and prominent relative to pogonion. Furthermore, Saudis displayed a greater convex profile, tendency to Class II facial pattern and that could be explained by significant reduced chin prominence as well as increased lower facial height and backward rotation of mandibular growth. Similar findings were observed by Aljame *et al*.[30] who reported increase in profile convexity due to reduced chin prominence and steeper mandibular plane among adolescent Kuwaitis compared with the norms of McNamara[10] and other norms. The explanation of the increased vertical dimension in Saudis might suggest an increase potential for backward mandibular growth rotation and supported by the reduced chin prominence. The fact that the effective length of upper jaw was large and lower jaw was small may be interpreted as a relative increase in lower facial height. In addition, Saudi males showed that the positions of upper and lower incisors were more protrusive which indicated bimaxillary protrusion than those of European-American, this corresponds well with the findings of other Saudi studies.[20,25,26] The highly significant increase in a forward position of lower incisor could be explained by the significant reduction of mandibular prognathism in Saudi males is concomitant with some compensatory protrusion of the mandibular incisors for functional achievements. This explanation may be supported by the fact that the forward increase in mandibular incisors position is significantly larger than that of the maxillary incisors when comparing with the McNamara norms.[10]

Generally, the results are in agreement with Hassan[26] study although Steiner analysis was used, and in disagreement with others Saudi studies[20,25] who concluded that Saudis had convex profile and tendency to Class II pattern, which has contributed to prognathism of maxilla rather than mandibular retrognathism when different analyses was used associated with different landmarks locations such as sella and nasion.

As with the male sample, the mean values of the whole skeletal parameters of Saudi females compared to McNamara norms[10] had significant differences except maxilla to cranial base which displayed no significant difference. The means of effective midfacial and mandibular length, lower anterior facial height, Frankfort mandibular plane angle, facial angle and the lower incisor to A-pog were more than those presented by the European-American sample. While mandible to cranial base, maxillary-mandibular difference, and upper incisors to point A were smaller than those of European-American norms, similar observations were reported by Miyajima *et al.*,[13] Al-Jasser[24, 25] and Garcia.[29]

The interpretation of the findings suggested that Saudi females had insignificantly retruded maxilla as well as significant reduction in chin prominence which resulted in convex profiles. They showed larger effective midfacial and mandibular lengths and more vertically oriented face than the European-American females. Similar findings were reported by Hassan[26] and Aljame *et al*.[30] but in contrast with Shalhoub *et al*.[18] observations. Moreover, Saudis revealed protrusive mandibular incisors while maxillary incisors were retrusive. This is contrary to the general belief that Saudi female dentitions are more protrusive in comparison to the norms for the European-Americans sample. One explanation may be that the tendency for a large increase in mandibular retrognathism in Saudi females is associated with some compensatory retrusion of the maxillary incisors for functional and esthetic achievements. Therefore, attempts should be made at exploring the need for evaluating different dentoalveolar norms for various patterns of skeletal morphology for Saudis.

The results of the present investigation have clinical implication in order to diagnose and treat Saudi patients properly using Saudi cephalometric norms. Saudi individuals demonstrated more tendencies towards convex profile pattern. Therefore, one would accept the slight bimaxillay protrusion in Saudi patients more than in European-American patients.

SUMMARY

1. There are several statistical differences between cephalometric mean values of Saudi sample when compared with McNamara's norms.
2. The results of the present study support the view that the norms of specific population should be used as reference for successful orthodontic treatment and not necessarily applied to different populations.
3. Saudis displayed distinct facial features, a greater convex profile, tendency to Class II facial pattern attributing to significant reduced chin prominence, increased lower facial height and backward rotation mandibular growth than did European-Americans.
4. Saudi males showed that the position of upper and lower incisors were more forward than those of European-American sample which indicate bimaxillary protrusion.
5. Saudi females revealed maxillary incisors were less prominent and mandibular incisors were more protrusive than European-Americans.
6. There were incisal compensations, suggesting a need to determine different norms for incisor protrusion and inclination for different skeletal patterns.

REFERENCES

1. Broadbent BH. A new x-ray technique and its application to orthodontia. Angle Orthod 1931; 1: 45–86.

2. Downs WB. Variation in facial relationships, their significance in treatment and prognosis. Am J Orthod 1948; 34:812-840.
3. Riedel RA. The relation of maxillary structures to cranium in malocclusion and normal occlusion. Angle Orthod 1952; 22: 142-145.
4. Steiner CG. Cephalometrics for you and me. Am J Orthod 1953; 39: 729-755.
5. Steiner CG. Cephalometrics in clinical practice. Angle Orthod 1959; 29: 8-29.
6. Ricketts RM. The influence of orthodontic treatment on facial growth and development. Angle Orthod 1960; 30: 103-133.
7. Tweed CH. The FMPA in orthodontic diagnosis, classification, treatment planning and prognosis. Am J Orthod Oral Surg 1946; 32: 175-230.
8. Tweed CH. Evolutionary trends in orthodontics past, present and future. Am J Orthod 1953; 39:81-108.
9. Jacobson A. The wits appraisal of jaw disharmony. Am J Orthod 1975; 67: 125-138.
10. McNamara JA. A method of cephalometric evaluation. Am J Orthod 1984; 86: 449-469.
11. Mills JR. Principles and practice of orthodontics. London: Churchill Livingstone, Longman Group Ltd., 1982.
12. Conner AM, Moshiri F. Orthognathic surgery norms for American black patients. Am J Orthod 1985; 87: 119-134.
13. Miyajima K, McNamara JA, Kimura T, Murata S, Lizuka T. Craniofacial structure of Japanese and European-American adults with normal occlusions and well-balanced faces. Am J Orthod Dentofacial Orthop 1996; 110: 431-438.
14. Lew KK, Ho KK, Keng SB, Ho KH. Soft-tissue cephalometric norms in Chinese adults with esthetic facial profiles. J Oral Maxillofac Surg 1992; 50:1184-1189.
15. Bishara SE, Abdalla EM, Hoppens BJ. Cephalometric comparisons of dentofacial parameters between Egyptian and North American adolescents. Am J Orthod Dentofacial Orthop 1990; 97: 413–421.
16. Mouakeh M. Cephalometric evaluation of craniofacial pattern of Syrian children with Class III malocclusion. Am J Orthod Dentofacial Orthop 2001; 119: 640–649.
17. Hamdan AM, Rock WP. Cephalometric norms in an Arabic population. J Orthod 2001; 28:297–300.
18. Shalhoub SY, Sarhan OA, Shaikh HS. Adult cephalometric norms for Saudi Arabian with comparison of values for Saudi and North American Caucasian. Br J Orthod 1987; 4: 273-279.
19. Sarhan OA, Nashashibi IA. A comparative study between two randomly selected samples from which to derive standards for craniofacial measurements. J Oral Rehabil 1988; 15:251–255.
20. Nashashibi IA, Shaikh HS, Sarhan OA. Cephalometric norms of Saudi boys. Saudi Dent J 1990;2:52–57.
21. AlBarakati S. Skeleto-dental characteristic features among Saudi female school children. A cephalometric study. Thesis 1996.
22. AlBarakati SF. The wits appraisal in a Saudi population sample. Saudi Dent J 2002; 14:89-92.
23. Hashim HA, AlBarakati SF. Cephalometric soft tissue profile analysis between two different ethnic groups: A comparative study. J Contemp Dent Pract 2003;4: 60-73.
24. Al Jasser NM. Cephalometric evaluation of craniofacial variation in normal Saudi population according to Steiner analysis. Saudi Med J 2000; 21:746–750.
25. Al Jasser NM. Cephalometric evalution for Saudi population using the Downs and Steiner analysis. J Contemp Dent Pract 2005; 6: 52-63.
26. Hassan AH. Cephalometric norms for Saudi adults living in the Western Region of Saudi Arabia. Angle Orthod 2006; 76:109-113.
27. Foo GC. A cephalometric study of the Chinese in profile. Australian Orthod J 1986; 9:285-288.
28. Swlerenga DO, Messersmith M. Cephalometric values for adult Mexican-American 1994; 106: 146-155.
29. Garcia CJ. Cephalometric evaluation of Mexican Americans using the Downs and Steiner analyses. Am J Orthod 1975; 68:67-74.
30. Al-Jame B, Årtun J, Al-Azemi R, Al-Behbehani F, BuHamra S. Lateral cephalometric norms for adolescent Kuwaitis: Hard tissue measurements. Med Princ Pract 2006;15:91-97.