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REVIEW ARTICLE

Lateral cephalometric norms for Saudi adults: A meta-analysis

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Abstract Orthodontic diagnosis and treatment planning require careful evaluation of the patient's cephalometric values and comparison to known population cephalometric means or norms. Despite the availability of several published studies on Saudi cephalometric norms, Caucasian norms are still referred to when Saudi patients are treated. To reach a consensus between these studies and to establish more accurately cephalometric norms for Saudis, a meta-analysis of the relevant literature was performed. Electronic database (PubMed), Saudi Dental Journal and Master theses were searched for studies reporting cephalometric values of normal male and female Saudi adults with numerical data and 8 studies with a total sample size of 485 met the inclusion criteria. A meta-analysis with results from these studies was completed. The combined mean estimates and SD of common cephalometric measurements were calculated. The data included in this comprehensive meta-analysis were compared with Caucasian norms and results indicated that Saudis have distinct cephalometric features. Saudis tend to have slightly more convex profiles and more proclined incisors than the Caucasians. These findings confirm the previously published results and should serve as more accurate reference values that were drawn from a large sample size.

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1. Introduction

Orthodontic treatment has the ability to modify the dentofacial skeleton and affect facial esthetics. Researchers have found that the nature of the configuration of the dentofacial structures are so marked that the ethnic or racial norms of one group, applied to individuals of another group, are an inadequate basis for orthodontic treatment planning. Since the introduction of cephalometrics by Broadbent (1931), numerous studies have been conducted to establish craniofacial norms of different races (Drummond, 1968; Uesato et al., 1978; Al-Jame et al., 2006; Lew et al., 1992; Valiathan, 1979). Several cephalometric studies have also been carried out so far in Saudi population. Jones (1987), Shalhoub et al. (1987), Sarhan and Nashashibi (1988), Toms (1989), Nashashibi et al. (1990), Al-Jasser (2000, 2003, 2005)), Al-Barakati (2002), Al-Deaij (2001), Hashim (2003), Hashim and Al-Barakati; 2003), Namankani and Bukhary (2005), Bukhary (2005), Hassan (2005, 2006), Al-Barakati and Talic (2007) and Taibah and Feteih (2007), evaluated the cephalometric measurements of Saudi individuals according to various standards. Despite the availability of several published studies on Saudi cephalometric norms, Caucasian norms are still referred to when Saudi patients are treated.

A meta-analysis is defined as "the statistical analysis of a large collection of results from individual studies for the purpose of integrating findings" (Glass, 1976). It is also a review that uses quantitative methods to combine the statistical measures from two or more studies and generate a weighted average of the accuracy of the diagnostic test i.e. normal values of the population (Ismail and Bader, 2004). For clinical research, the main objective of meta-analysis is to arrive at a general conclusion (L'Abbe et al., 1987). It can also be named in the literature as "data pooling".

The purpose of this investigation was, first, to gather all the studies that evaluated the cephalometric norms for Saudi adults; and second, to reach a consensus between previously published studies on Saudi cephalometric norms by calculating more accurately cephalometric standards for Saudis drawn from all these papers. Due to the limited number of subjects in individual studies, meta-analysis was used to increase the sample size and provide stronger statistical support for conclusions drawn concerning normal cephalometric standards for Saudi adults.

2. Materials and methods

Electronic database PubMed was searched from the year 1966 until December 2008 using subject heading *Saudi* and *Cephalometric*. The entire collection (June 1989 until December 2008) of Saudi Dental Journal was searched along with the unpublished Master theses submitted at the College of Dentistry, King Saud University using the same keywords. Further published studies were then located from bibliographies and from cited references of articles already found.

Research papers were selected for inclusion and analysis if they met the following criteria:

(1) Reporting the cephalometric values of normal male and female Saudi adults (falling in the age range of 16–45).
(2) Numerical data must be available to show the different measurements.
(3) Data must not be derived from another study being used in the meta-analysis.

The reference list of selected articles was searched and references to related articles were followed up. Mean values of the reported cephalometric measurements and standard deviations

Table 1 Studies selected for inclusion in the analysis.

Authors	Year of Publication	Sample Size
Shalhoub et al., 1987	1987	24 Males, 24 Females
Al-Jasser, 2000	2000	74 Males, 13 Females
Al-Showial, 2000	2000	30 Males, 30 Females
Al-Barakati, 2002	2002	30 Males, 30 Females
Al-Jasser, 2003	2003	20 Males, 20 Females
Namankani, 2004	2004	30 Males, 30 Females
Al-Jasser, 2005	2005	30 Males, 30 Females
Hassan, 2006	2006	38 Males, 32 Females

Table 2 Studies that were excluded from the meta-analysis and the reasons for exclusion.

Authors	Reason for Exclusion
Jones, 1987	Studied orthodontic patients with malocclusion
Sarhan and Nashashibi, 1988	Studied boys aged 9 to 12 years
Toms, 1989	Studied non-Class III as control
Nashashibi et al., 1990	Studied boys aged 10 to 14 years
Al-Deaij, 2001	Studied patients with dentofacial deformities
Hashim, 2003	Studied adult females only
Namankani and Bukhary, 2005	Studied adult females only
Bukhary, 2005	Included Class III adult females only
Al-Barakati and Talic, 2007	Used a new cephalometric analysis
Taibah and Feteih, 2007	Studied a sample aged 9 to 20 years

Table 3 Summary of the 8 studies included in the review and the combined means (SD).

No.	Author(s)	Sample	Sagittal Relationship				Vertical relationship	Dental Relationship				SoftTissue
		Size	SNA	SNB	ANB	Wits	SN-MP	UI-SN	UI-PP	UI-NA	LI-MP	LI-NB	NLA
1.	Shalhoub et al., 1987	24 M,24 F	82.86° (5.29)	79.90° (4.88)	2.96° (2.14)	−0.48 mm(2.71)	30.91° (4.87)		115.05° (8.10)		95.01° (6.56)		110.20° (13.77)
2.	Al-Jasser, 2000	74 M,13 F	82.70° (3.97)	79.82° (3.61)	2.88° (1.90)		30.45° (4.73)			23.62° (5.40)		28.30° (5.03)	
3.	Al-Showial, 2000	30 M,30 F	82.95° (2.77)	80.22° (2.59)	2.73° (2.68)		31.22° (3.84)	108.51° (4.32)	115.60° (3.94)	25.60° (3.60)	97.73° (4.39)	25.91° (3.12)	
4.	Al-Barakati, 2002	30 M,30 F				0.62 mm(2.25)							
5.	Al-Jasser, 2003	20 M,20 F											101.35° (7.04)
6.	Namankani, 2004	30 M, 30 F	82.85° (4.12)	80.39° (3.73)	2.53° (2.01)		33.58° (4.94)	106.58° (5.66)	115.89° (5.46)	24.56° (5.46)	95.26° (5.46)	26.96° (3.72)	106.82° (11.75)
7.	Al-Jasser, 2005	30 M, 30 F	83.60° (4.30)	81.00° (3.70)	2.50° (2.00)		31.00° (5.10)			24.80° (5.60)	96.40° (5.60)	27.80° (4.30)	
8.	Hassan, 2006	38 M, 32 F	80.31° (4.47)	76.42° (4.38)	3.88° (2.95)		34.39° (5.89)	106.07° (8.8)		23.32° (8.24)	97.09° (9.46)	30.05° (7.3)	
Combined means (SD)		276 M, 209 F	82.49° (4.17)	79.55° (3.84)	2.93° (2.31)	0.13 mm(2.47)	31.92° (4.95)	107.00° (6.67)	115.55° (5.91)	24.29° (5.90)	96.38° (6.65)	27.91° (5.01)	106.44° (11.44)
Significance (P-value)			$P = 0.0002$*	$P < 0.0001$*	$P = 0.0071$*	$P = 0.0231$**	$P < 0.0001$*	$P = 0.0999$	$P = 0.7611$	$P = 0.165$	$P = 0.1381$	$P < 0.000$*	$P = 0.0018$*
Significantly Different Studies			8	8	8 and 6	8 and 7 1 and 4	8 with all except 6	Not Significant	Not Significant	Not Significant	Not Significant	2 and 3, 3 and 8, 6 and 8	1 and 5

* Significant statistical difference by ANOVA.
** Significant statistical difference by unpaired t-test.

for the male and the female subject in each study were combined.

A meta-analysis with results from the selected studies was completed. The combined means of the similar cephalometric measurements were calculated using the formula:

$$X = \frac{n_1x_1 + n_2x_2 + \cdots + n_xx_x}{n_1 + n_2 + \cdots + n_x}$$

where (x) refers to the mean and (n) refers to the sample size.

And the pooled standard deviation was calculated using the formula:

$$s.d = \sqrt{\frac{n_1s_1^2 + n_2s_2^2 + \cdots + n_xs_x^2}{n_1 + n_2 + \cdots + n_x}}$$

The presence of statistical differences between the results of the available studies was investigated using ANOVA. To evaluate the statistical differences between the Saudi norms and currently used Caucasian norms, unpaired t-test was performed between the combined means and the published norms using the software GraphPad InStat 3® for Windows (GraphPad Software Inc., San Diego, California, USA).

3. Results

Through the computerized literature search, review of reference lists and the search of the Saudi Dental Journal and the unpublished Master theses, 8 studies with a total sample size of 485 met the inclusion criteria and they were listed in Table 1. Studies that were not selected for inclusion and the main reasons for exclusion were listed in Table 2.

A summary of the common cephalometric measurements selected and the combined means with their standard deviations are listed in Table 3. Significant statistical differences existed between the selected studies in all the listed cephalometric measurements except the upper incisors inclination to SN, palatal plane, and NA, as well as, lower incisors inclination to MP. Tuckey-Kramer multiple comparison test showed that SNA, SNB, and ANB values reported by Hassan were significantly different from measurements reported by the other studies (Hassan, 2006). Hassan evaluation of SN-MP angle was significantly more than the other values except for Namankani's (Namankani, 2004; Hassan, 2006) result. In addition, the inclination of the lower incisors to NB reported by Hassan was the highest value among the studies (Hassan, 2006).

Measurements were compared with Caucasian norms derived from Riedel (Riedel, 1952), Jacobson (Jacobson, 1975), and Connor and Moshiri (Connor and Moshiri, 1985) and the differences were investigated using independent sample t-test (Table 4). Parametric test (t-test) has been used because previous cephalometric analyses showed normal distribution of the overall population and the samples being compared in Table 4 were generally large. In addition, nonparametric tests require raw data and cannot be performed if averaged data are available only for comparison. Sample size and standard deviation values for the measurements: UI-NA and LI-NB were not available in the original Caucasian published norms and thus they were not included in the comparison (Steiner, 1953). Compared with Caucasians, Saudis were found to have increased facial convexity (ANB = 2.93° ± 2.31), although the sagittal relationship of the maxilla and the mandible to

Table 4 Unpaired t-test results of statistical comparison between Saudi adults average values and Caucasians norms.

Cephalometric Category	Parameter	Saudi Adults		Caucasians		
		Mean ± SD	*n*	Mean ± SD	*n*	Significance
Skeletal Relationships	SNA	82.49° ± 4.17	385	82.01 ± 3.89[1]	52	$P = 0.4328$
	SNB	79.55° ± 3.84	385	79.97 ± 3.69[1]	52	$P = 0.4575$
	ANB	2.93° ± 2.31	385	2.04 ± 1.81[1]	52	$P = 0.0079$**
	Wits	0.13 mm ± 2.47	108	0.48 ± 1.83[2]	46	$P = 0.3886$
	SN-MP	31.92° ± 4.95	385	31.71 ± 5.19[1]	52	$P = 0.7754$
Dental Relationships	UI-SN	107.00° ± 6.67	190	103.97 ± 5.75[1]	52	$P = 0.0031$**
	UI-PP	115.55° ± 5.91	168	109.87° ± 5.96[3]	50	$P < 0.0001$**
	LI-MP	96.38° ± 6.65	298	93.09° ± 6.78[1]	52	$P = 0.0011$**
Soft Tissue Relationships	NLA	106.44° ± 11.44	148	104.27° ± 9.91[3]	50	$P = 0.02325$*

* Significant statistical difference at 0.05 level.** Significant statistical difference at 0.01 level.
[1] Riedel, 1952.
[2] Jacobson, 1975.
[3] Connor and Moshiri, 1985.

the cranial base was not statistically different from Caucasian values. Vertically, the inclination of the mandibular plane was closely related in both ethnic groups, while the upper and the lower incisors were significantly more proclined in Saudis. The mean value of the nasolabial angle in the Saudi adults indicated that Saudis have slightly more obtuse NLA compared to Caucasian norms.

4. Discussion

Variables like race and gender affect the normal skeletal, dental and soft tissues characteristics of an individual. Identifying the normal features of a specific race or ethnic group should be the basis for proper diagnosis and treatment planning of orthodontic patients. The aim of this meta-analysis was to analyze the available cephalometric data of normal Saudi adults and to calculate more accurately reliable normal standards. This requires inclusion of all the studies that evaluated Saudi individuals from the different regions of the country, for the calculated standards to be applicable to all Saudi orthodontic patients. When conducting this study, common cephalometric measurements were selected that represented the different hard and soft features of normal Saudi subjects. Meta-analysis greatly increases the overall sample size by combining data from individual studies, thus increasing the statistical power of the analysis and the precision at assessing the normal values of the subjects. Because the data used for meta-analysis were derived from studies published in scientific journals, the quality of the meta-analysis depends heavily on the quality of these studies. All of the studies included in this meta-analysis selected the sample based on normal occlusion and pleasing profile with no history of trauma and no previous orthodontic treatment (Shalhoub et al., 1987; Al-Jasser, 2000, 2003, 2005; Al-Showial, 2000; Al-Barakati, 2002; Namankani, 2004; Hassan, 2006). This insures that there is consistency in the inclusion criteria and the individuals studied presented the common features of normal Saudi adults. Most of the studies also have included intra-reliability analysis to minimize tracing and digitization errors and appropriate statistical tests reported consistent and accurate measurements.

Saudis showed a greater tendency towards Class II facial pattern and more convex profile than Caucasians. The combined average range of ANB angle values for normal Saudi adults was approximately 1–5°, while for Caucasians it was reported to be 0–4° (Riedel, 1952). No statistical differences in the vertical relationship were detected between the Saudis and the Caucasians, however, the landmarks used for identifying the mandibular plane were probably different among the included studies. Mandibular plane was determined using Gonion (Go)-Gnathion (Gn) landmarks in Al-Jasser (2000), (2005)), Gonion (Go)-Menton (Me) landmarks in Shalhoub et al. (1987), Al-Showial (2000), and Namankani (2004), and it was not specified in Hassan's study (Hassan, 2006). These differences in the methods used for the determination of the mandibular plane may in part explain the variability in the measurements among the selected studies.

All dental inclination measurements were greater than the suggested norms for the Caucasian population. This was in agreement with the results obtained by the individual studies and it confirms that Saudis have a slight tendency towards bimaxillary protrusion with a slightly decreased inter-incisal angle. Adequate statistical comparison with Steiner norms for the upper and the lower incisors inclination (UI-NA = 22°, LI-NB = 25°) was not possible due to the unavailability of information about the sample size and the standard deviation in the original Steiner data (Steiner, 1953). However, direct comparison revealed that the normal inclination of the upper and the lower incisors of the Saudi population was 2–3° more than Steiner norms. The same was true for the other angular dental measurements analyzed, where the average range of the difference between the Saudi and the Caucasian norms was 3–5°. These findings revealed that there are fundamental variations in the dento-skeletal structures between the Saudi population and the widely used Caucasian norms. Thus, the application of these standards as objectives for treatment should not be a routine orthodontic practice.

Hassan has reported that Saudis living in the western area represented a new Saudi race established through interbreeding among the different communities and the multiracial population settled in the western province for a long period. When the results of normal cephalometric evaluation obtained by Hassan were compared with the other studies, significant differences were found in SNA, SNB, ANB and SN-MP measurements (Hassan, 2006). However, none of the incisors' inclination measurements showed a significant statistical difference except for the LI-NB angle. This might be due to the fact that subjects studied by Hassan have more retrusive mandibles and the lower incisors tended to be more proclined to

compensate for this skeletal relationship (Hassan, 2006). These results indicated that the individuals living in the western province, who were included in Hassan study, tend to have more retrognathic maxilla and mandible, more convex faces, and steeper mandibular plane than the rest of the Saudi adults studied by the other researchers (Hassan, 2006). All the other studies were performed in Riyadh and this should indicate that the subjects included were originally from the central province.

5. Conclusions

Through the process of meta-analysis, 8 published papers and unpublished master's theses that dealt with Saudi normal cephalometric values had been compiled. The following conclusions could be drawn from the data presented in this investigation:

(1) Saudi adults present normally with more convex profiles and more proclined incisors than Caucasians.
(2) Statistical differences existed between some of the available studies for normal cephalometric measurements of Saudi adults.
(3) The combined means and standard deviations reported in this study confirmed the previously published results and should serve as more accurate reference values for diagnosis and treatment of Saudi orthodontic patients because they were drawn from a large sample size.

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