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A Comparative Orthognathic Cephalometric Study Among Saudi, African-American and Japanese Adults: Hard Tissue Measurements

Laila F. Baidas[1] and Sahar F. Al-Barakati[2]

[1]*Assistant Professor, Orthodontics, College of Dentistry, King Saud University, Riyadh, Saudi Arabia*
E-mail: lailabaidas2003@yahoo.com
[2]*Associate Professor, Orthodontics, College of Dentistry, King Saud University, Riyadh, Saudi Arabia*
E-mail: salbarakati@gmail.com

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Abstract. The purpose of the present investigation was to compare hard tissue analysis obtained from Saudi adults with reference data of Japanese and African-American adults in order to determine the differences of the hard tissue analysis between different ethnic groups. Sixty-two lateral cephalometric radiographs were collected from the archives of cephalometric radiograph files taken by dental students of King Saud University, College of Dentistry (31 females and 31 males), age range was 22-24 years. The lateral cephalometric radiographs were analyzed and the mean values of hard and dental measurement were compared with those of African-American adults, and the Japanese adults. The results showed Saudi males compared to Black had significantly: increased anterior cranial base, and reduced posterior cranial base, reduced facial convexity, maxillary protrusion, and maxillary length. Saudi adult females had smaller upper posterior facial height and lower anterior facial height, downward tipping of maxilla, smaller vertical dental heights, reduced total mandibular body length, and less proclination of lower incisors. Saudi adults compared to Japanese had significantly: increased anterior cranial base, reduced posterior cranial base, prognathic maxilla, prominent chin, smaller vertical lower dental heights, smaller ramus and obtuse gonial angle in males, less proclination of upper and lower incisors, and less steep occlusal plane to horizontal plane.

This study may be useful in providing racially specific cephalometric values for diagnosis and treatment planning for orthognathic surgery of Saudi adults. It might represent true differences in skeletal and dental features between the three racial groups.

Introduction

The term "ethnic group" refers to a population or nation with a common bond such as a geographical boundary, a cultural or language, or being racially or historically related (Barnhart, 1953). In a multicultural society, racial and ethnic differences are assuming an increasing level of importance. It brings with it the need to recognize that single standard norms may not be appropriate when making diagnostic and treatment planning decisions for a patient from diverse racial and ethnic backgrounds. Races are classified into three groups: Asiatic (Mongoloid), Black (Negroid) and White (or Caucasian) (Montague, 1942; Coon *et al*., 1950). Each group has its own characteristics to distinguish them from each other. Furthermore, within the same race, subgroups have their own characteristics (Burstone, 1958; Holdaway, 1983). Arabs are considered as a subgroup of Caucasian (Coon *et al*., 1950).

Cephalometric norms for Saudi Arabians were studied since 1987 until today using different cephalometric analyses. Sarhan and Nashashibi (1988) compared cephalometric norms for Saudi boys aged from 9-12 years with a British sample with same age. The Saudi boys demonstrated a slightly prognathic-faces, more protrusive upper and lower incisors, and low gonial and saddle angles. Nashashibi *et al*. (1990) found that Saudi boys had a more protrusive maxillary apical base and double dental protrusion. Al-Jasser (2005) compared cephalometric norms of Saudis and European-Americans using Downs and Steiner analysis. He found normal Saudis have slightly protrusive maxillas, a tendency to Class II facial pattern, and a

high mandibular plane angle. Al-Barakati and Talic (2007) compared Saudi dental student cephalometric norms using McNamara's analysis, with European American norms. Their results showed the Saudis have a greater convex profile with reduced chin prominence, steeper mandible and more bimaxillary protrusion. Al-Barakati and Baidas (2009) conducted a cephalometric study on a sample of Saudi dental students using Burstone analysis. They concluded that Saudi had an increase in cranial base length; the mandible was more posterior to maxilla, increase in mandibular plane angle, backward rotation of the mandible, less prominent chin, shorter maxillary length, and also less proclination of lower incisors than the Burstone sample.

Maxillofacial and oral surgeons and orthodontists currently treat an increasing number of patients needing orthognathic surgical procedures. The cephalometric analysis for orthognathic surgery of Burstone *et al.* (1978) was especially adapted to the diagnosis and treatment planning for orthognathic surgery cases because it was based largely upon rectilinear measurements that can be used at surgery. Normal values for cephalometric analysis for orthognathic surgery have been developed for white American (Burstone *et al*., 1978), Japanese (Alcalde *et al.*, 1998), and American black (Flynn *et al*., 1989). Further, Connor and Moshiri (1985) and Flynn *et al*. (1989) showed that the cephalometric measurements established for North Americans using Burstone analysis (Burstone *et al*., 1978) were at variance to those measurements found in a black South African population group. Furthermore, Miyajima *et al*. (1996), Alcalde *et al*. (1998) and Ioi *et al*. (2007) found fundamental variations exist in the craniofacial structure of Japanese and European-Americans. Accordingly, Surgical and orthodontic cephalometric analyses developed for one population have been shown to be inadequate for other racial groups. Therefore, the purpose of the present investigation was to compare cephalometric hard tissue measurements of orthognathic surgery between Saudi Arabian adults (Al-Barakati and Baidas, 2009) to Japanese adults (Alcalde *et al*., 1998) and to Black American (Flynn *et al*., 1989) adults in order to determine the dento-skeletal differences among them based on Burstone analysis (Burstone *et al.*, 1978).

Material and Methods

Sixty-two lateral cephalometric radiographs of Saudi subjects (31 females and 31 males) with a mean age of 23 ± 1 year were analyzed. 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 at College of Dentistry, King Saud University (the students were informed about their rights to take the radiographs). The inclusion criteria of sample were:

- A pleasing and balanced facial profile with competent lips.
- Class I molar and canine relationship.
- Normal overjet (1-4 mm).
- Normal overbite (35-50%).
- Average skeletal relationship (ANB = 1-4.5°).
- No obvious craniofacial deformities.
- No previous orthodontic treatment.

All lateral cephalometric radiographs were taken in maximum intercuspation with head in natural head position and lips in repose. Each radiograph was scanned into a digital format using Epson® perfection 4990 photo scanner (Seiko Epson Corporation, Nagano, Japan), and was digitized by the same examiner in a darkened room using specific points required by the software. Linear and angular measurements according to Burstone analysis (Burstone *et al*., 1978) were calculated electronically using the Dolphin® version 10 software (Dolphin Imaging and Management Solutions, Chatsworth, Calif., USA) and recorded in print out. The computer analysis software was adjusted for the magnification factor using two points on the radiograph at a distinct distance.

The published data for Japanese (Alcalde *et al*., 1998) and African-American (Flynn *et al.*, 1989) adults were used as the reference sample for the purpose of comparison with Saudi adults. Hard tissue landmarks and reference lines of Burstone *et al.* (1978) analysis were illustrated in Fig. 1. From the digitized points, 6 angular and 17 linear measurements were obtained (Table 1) (Figs. 1, 2 and 3).

Error of the method

The error of the method was performed using coefficient of reliability (Guilford and Fruchter, 1984) by repeated measurements of 15 cephalometric radiographs in two week interval by the same examiner to determine the error of the measurement method. The coefficient of reliability was calculated as follows: coefficient of reliability=1- $(Se^2 \div St^2)$, where Se^2 is the variance due to random error, and St^2 is the total variance of the measurements, and it is indicated that the measurements were highly correlated and ranged between 0.99 and 0.95.

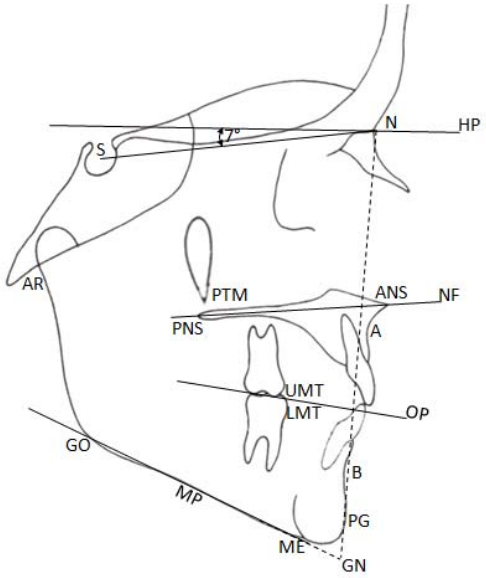

Fig. 1. The major landmarks and reference planes used in Burstone et al. analysis:
Nasion (N), sella (S), anterior nasal spine (ANS), posterior nasal spine (PNS), pterygomaxillary fissure (PTM), point A (A), point B (B), pogonion (PG), gnathion (GN), menton (ME), gonion (GO), articular (AR), mesiobuccal cusp tip of upper first molar (UMT), mesiobuccal cusp tip of lower first molar (LMT).
The reference planes: Mandibular plane (MP), Nasal floor plane (NF), Horizontal plane (HP) a line 7° from SN plane, Occlusal Plane(OP) a line from buccal groove of both 1st molars through a point 1mm apical of incisal edge of lower central incisor

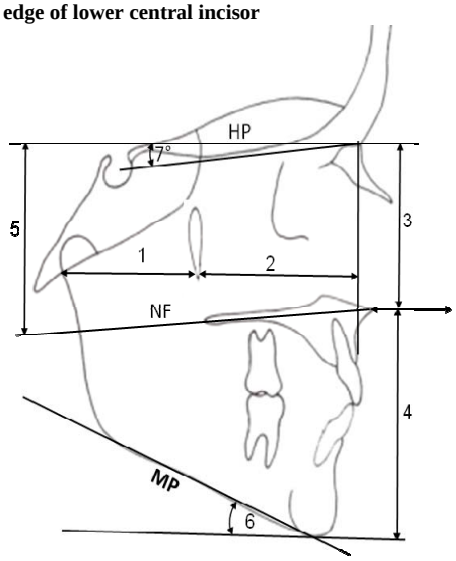

Fig. 2. Cranial base length and vertical skeletal measurements: 1; Posterior cranial base length(AR-PTM), 2; Anterior cranial base length (PTM-N), 1 + 2; total cranial base length, 3; Upper anterior facial height (N-ANS), 4; Lower anterior facial height (ANS-GN), 5; Upper posterior facial height (PNS-N), 6; Mandibular plane angle (MP-HP).

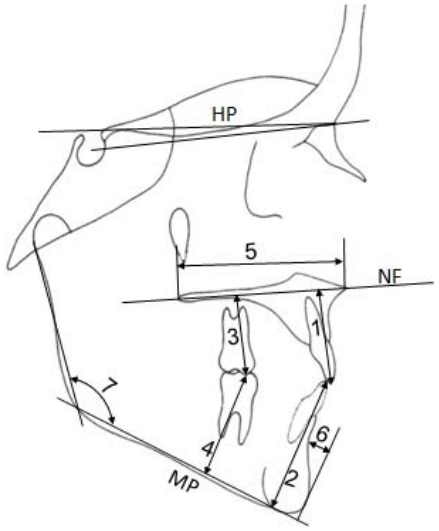

Fig. 3. Vertical dental and Maxilla/Mandible measurements: 1; Upper anterior dental height (U1-NF), 2; Lower anterior dental height (L1-MP), 3; Upper posterior dental height (UM-NF), 4; Lower posterior dental height (LM– MP), 5; Maxillary length (PNS-ANS), 6; Chin depth (B-PG), 7; Gonial angle (AR-GO-GN).

Error of the method

The error of the method was performed using coefficient of reliability (Guilford and Fruchter, 1984) by repeated measurements of 15 cephalometric radiographs in two-week interval by the same examiner to determine the error of the measurement method. The coefficient of reliability was calculated as follows: coefficient of reliability=1- ($Se^2 \div St^2$), where Se^2 is the variance due to random error, and St^2 is the total variance of the measurements, and it is indicated that the measurements were highly correlated and ranged between 0.99 and 0.95.

Statistical analysis of data

Data transferred to the computer for analysis using SPSS program for Windows (version 12 SPSS Inc., Chicago, IL, USA). Descriptive statistics (mean, standard deviation) were employed for each variable in both sexes separately. The significant difference of the mean values between the Saudi males, females and other ethnic groups, Japanese and African-American adults was tested using independent student's t- test at 5% level ($P < 0.05$).

Results

The results comparing of the hard tissue (skeletal and dental) cephalometric values in Saudi, African-American, and Japanese groups for both sexes are presented in Tables 2, 3, 4 and 5.

Table 1. Cephalometric measurements of Burstone *et al.* (1978) analysis

	Measurements	***Definitions***
Cranial Base:		
1.	Posterior cranial base (Ar-PTM mm):	A distance from Ar to PTM, parallel to Hp.
2.	Anterior cranial base (PTM-N) mm:	A distance from PTM to N, parallel to Hp.
Horizontal Skeletal Relationship:		
3.	Facial convexity (N-A-Pg):	An angle formed by the line N-A and the line A-pg.
4.	Maxillary protrusion (N-A) mm:	A distance from point A to perpendicular line from N, parallel to Hp.
5.	Mandibular protrusion (N-B) mm:	A distance from point B to perpendicular line from N, parallel to Hp.
6.	Chin protrusion (N-Pg) mm:	A distance from pogonion to a perpendicular line from N, parallel to Hp.
Vertical Skeletal Relationship:		
7.	Upper anterior facial height (N-ANS) mm:	A distance from N to ANS, perpendicular to Hp.
8.	Lower anterior facial height (ANS-Gn) mm:	A distance from ANS to Gn, perpendicular to Hp.
9.	Upper posterior facial height (PNS-N) mm:	A perpendicular distance from Hp to PNS.
10.	Mandibular plane angle (MP-HP):	An angle formed between Go-Gn line and Hp.
Vertical Dental Relationship:		
11.	Upper anterior dental height (U1-NF) mm:	A perpendicular line from the incisal edge of upper incisor to NF.
12.	Lower anterior dental height (L1-MP) mm:	A perpendicular line from the incisal edge of lower incisor to MP.
13.	Upper posterior dental height (UM-NF (mm):	A perpendicular line from the mesiobuccal cusp tip of upper first molar to NF.
14.	Lower posterior dental height (LM– MP) mm:	A perpendicular line from the mesiobuccal cusp tip of lower first molar to MP.
Maxilla and Mandible:		
15.	Maxillary length (PNS-ANS) mm:	A distance from PNS to ANS, parallel to Hp.
16.	Mandibular ramus length (Ar-Go) mm:	A line from Ar to Go.
17.	Mandibular body length (Go-Pg) mm:	A distance from Go to Pg.
18.	Chin depth (B-Pg) mm:	A distance from B point to a perpendicular line to MP through Pg.
19.	Gonial angle (Ar-Go-Gn):	An angle between ramal length and MP.
Dental Relationship:		
20.	Occlusal plane angle (OP – Hp):	An angle between OP and HP.
21.	Wits analysis (A-B/OP) mm:	Two perpendicular lines from points A and B to OP.
22.	Upper incisor inclination (U1-NF):	An angle between the lines from the upper incisal edge through the tip of the root to NF.
23.	Lower incisor inclination (L1-MP):	An angle between the lines from the lower incisal edge through the tip of the root to MP.

Table 2. Statistical comparison between adult Saudi and African-American males

Components	**No.**	**Variables**	**Saudi male no = 30**		**African male no = 15**		**t-value**	**P-value**	**Sig. level**
			mean	**SD**	**mean**	**SD**			
Cranial base	1	Ar-PTM	33.874	3.240	41.100	3.900	6.213	0.000	***
	2	PTM-N	57.610	4.420	51.500	3.100	5.419	0.000	***
Horizontal skeletal relation	3	N-A-PG	3.168	5.183	9.900	6.300	3.592	0.002	**
	4	N-A(HP)	-0.848	4.998	3.200	3.400	3.224	0.005	**
	5	N-B(HP)	-6.290	7.152	-3.500	6.700	1.295	0.404	NS
	6	N-PG	-4.871	7.378	-4.200	7.900	0.276	1.568	NS
Vertical skeletal and dental	7	N-ANS	56.297	2.884	55.800	2.600	0.586	1.122	NS
	8	ANS-GN	70.481	4.198	74.500	10.900	1.380	0.349	NS
	9	PNS-N	55.577	3.021	57.400	3.200	1.844	0.144	NS
	10	MP-HP	27.006	3.766	25.400	6.700	0.865	0.784	NS
	11	UI-NF	29.890	2.803	32.700	3.700	2.602	0.025	*
	12	U6-NF	25.326	1.812	27.100	1.800	3.127	0.006	**
	13	L6 -MP	31.097	3.310	39.600	2.600	9.482	0.000	***
	14	L1-MP	41.342	3.290	50.800	3.600	8.587	0.000	***
Maxilla and mandible	15	PNS-ANS	53.923	3.600	58.800	3.900	4.076	0.000	***
	16	AR-GO	51.371	5.380	53.500	4.400	1.427	0.321	NS
	17	GO-PG	82.119	4.860	87.300	6.900	2.611	0.025	*
	18	B-PG	6.923	1.662	5.900	2.800	1.307	0.396	NS
	19	AR-GO-GN	123.265	6.136	120.000	8.900	1.281	0.414	NS
Dental relationships	20	OP-HP	6.152	3.971	5.400	4.300	0.570	1.144	NS
	21	UI-NF	111.490	6.517	111.300	8.500	0.077	1.879	NS
	22	L1/GO-ME	91.242	5.979	97.700	6.000	3.426	0.003	**
	23	A-B(//OP)	-0.558	2.487	-2.500	5.100	1.397	0.339	NS

*P <0.05 **P <0.001 ***P <0.0001

Table 3. Statistical comparison between adult Saudi and African-American females

Components	No.	Variables	Saudi female no = 30		African female no = 18		t-value	p-value	Sig. level
			mean	SD	mean	SD			
Cranial base	1	Ar-PTM	29.432	3.421	37.200	4.000	6.903	0.000	***
	2	PTM-N	52.297	4.056	49.900	4.200	1.950	0.114	NS
Horizontal skeletal relation	3	N-A-PG	4.881	4.568	10.400	5.500	3.598	0.002	**
	4	N-A(HP)	0.119	3.820	3.500	4.000	2.899	0.011	*
	5	N-B(HP)	-5.239	6.126	-2.600	7.200	1.305	0.397	NS
	6	N-PG	-4.223	7.346	-3.300	8.400	0.388	1.400	NS
Vertical skeletal and dental	7	N-ANS	50.890	3.318	52.700	3.000	1.957	0.113	NS
	8	ANS-GN	62.619	4.924	69.300	6.500	3.777	0.001	**
	9	PNS-N	49.800	2.710	53.100	3.200	3.676	0.001	**
	10	MP-HP	27.790	5.584	25.300	6.200	1.405	0.333	NS
	11	UI-NF	27.968	2.950	31.100	3.900	2.952	0.010	*
	12	U6-NF	22.806	2.367	25.000	2.900	2.725	0.018	*
	13	L6 -MP	28.171	3.087	35.500	3.300	7.673	0.000	***
	14	L1-MP	37.468	3.526	45.000	4.600	5.999	0.000	***
Maxilla and mandible	15	PNS-ANS	50.326	3.753	56.400	3.800	5.419	0.000	***
	16	AR-GO	45.355	4.127	48.100	3.700	2.398	0.041	NS
	17	GO-PG	75.632	6.117	84.300	4.600	5.616	0.000	***
	18	B-PG	6.119	1.394	5.100	1.900	1.987	0.106	NS
	19	AR-GO-GN	122.577	5.948	119.100	5.400	2.093	0.084	NS
Dental relationships	20	OP-HP	7.877	4.313	8.600	5.100	0.505	1.231	NS
	21	UI-NF	112.594	6.233	115.200	6.100	1.430	0.318	NS
	22	L1/GO-ME	92.735	6.745	103.200	6.600	5.307	0.000	***
	23	A-B(//OP)	0.152	2.295	0.300	2.800	0.191	1.699	NS

*P <0.05 **P <0.001 ***P <0.0001

Table 4. Statistical comparison between adult Saudi and Japanese males

Components	No.	Variables	Saudi male no = 30		Japanese male no = 98		t-value	P-value	Sig. level
			mean	SD	mean	SD			
Cranial base	1	Ar-PTM	33.874	3.240	37.600	2.800	5.758	0.000	***
	2	PTM-N	57.610	4.420	51.600	3.700	6.849	0.000	***
Horizontal skeletal relation	3	N-A-PG	3.168	5.183	4.240	5.300	0.998	0.640	NS
	4	N-A(HP)	-0.848	4.998	-1.960	4.700	1.095	0.552	NS
	5	N-B(HP)	-6.290	7.152	-7.900	7.300	1.087	0.558	NS
	6	N-PG	-4.871	7.378	-8.000	8.600	1.975	0.101	NS
Vertical skeletal and dental	7	N-ANS	56.297	2.884	58.600	3.500	3.672	0.001	**
	8	ANS-GN	70.481	4.198	68.800	4.900	1.863	0.129	NS
	9	PNS-N	55.577	3.021	55.600	2.900	0.037	1.942	NS
	10	MP-HP	27.006	3.766	25.200	5.400	2.079	0.079	NS
	11	UI-NF	29.890	2.803	30.080	2.930	0.325	1.492	NS
	12	U6-NF	25.326	1.812	25.900	2.300	1.436	0.307	NS
	13	L6 -MP	31.097	3.310	37.700	2.500	10.222	0.000	***
	14	L1-MP	41.342	3.290	45.300	3.100	5.918	0.000	***
Maxilla and mandible	15	PNS-ANS	53.923	3.600	54.500	3.800	0.768	0.888	NS
	16	AR-GO	51.371	5.380	54.200	4.600	2.638	0.019	*
	17	GO-PG	82.119	4.860	80.950	4.900	1.165	0.492	NS
	18	B-PG	6.923	1.662	7.010	1.800	0.250	1.606	NS
	19	AR-GO-GN	123.265	6.136	117.900	6.050	4.257	0.000	***
Dental relationships	20	OP-HP	6.152	3.971	8.700	5.020	2.912	0.008	**
	21	UI-NF	111.490	6.517	116.350	6.600	3.608	0.001	**
	22	L1/GO-ME	91.242	5.979	95.090	6.670	3.035	0.006	**
	23	A-B(//OP)	-0.558	2.487	0.400	3.160	1.745	0.167	NS

*P <0.05 **P <0.001 ***P <0.0001

Table 5. Statistical comparison between adult Saudi and Japanese females

Components	No.	Variables	Saudi female no = 30		Japanese female no = 119		t-value	P-value	Sig. level
			mean	SD	mean	SD			
Cranial base	1	Ar-PTM	29.432	3.421	34.300	2.800	7.311	0.000	***
	2	PTM-N	52.297	4.056	47.900	3.200	5.599	0.000	***
Horizontal skeletal relation	3	N-A-PG	4.881	4.568	5.600	6.100	0.724	0.940	NS
	4	N-A(HP)	0.119	3.820	-1.980	4.000	2.699	0.016	*
	5	N-B(HP)	-5.239	6.126	-8.100	6.900	2.255	0.051	NS
	6	N-PG	-4.223	7.346	-9.100	8.100	3.222	0.003	**
Vertical skeletal and dental	7	N-ANS	50.890	3.318	53.700	3.000	4.281	0.000	***
	8	ANS-GN	62.619	4.924	63.800	4.900	1.190	0.472	NS
	9	PNS-N	49.800	2.710	51.600	2.600	3.321	0.002	**
	10	MP-HP	27.790	5.584	27.080	6.200	0.616	1.077	NS
	11	UI-NF	27.968	2.950	28.500	2.790	0.905	0.734	NS
	12	U6-NF	22.806	2.367	23.600	2.300	1.672	0.193	NS
	13	L6 -MP	28.171	3.087	34.200	2.700	9.931	0.000	***
	14	L1-MP	37.468	3.526	41.700	3.300	6.030	0.000	***
Maxilla and mandible	15	PNS-ANS	50.326	3.753	50.100	3.300	0.306	1.521	NS
	16	AR-GO	45.355	4.127	47.050	4.500	1.998	0.095	NS
	17	GO-PG	75.632	6.117	75.600	4.500	0.027	1.956	NS
	18	B-PG	6.119	1.394	6.100	1.600	0.067	1.894	NS
	19	AR-GO-GN	122.577	5.948	119.700	7.200	2.291	0.047	NS
Dental relationships	20	OP-HP	7.877	4.313	10.800	4.800	3.281	0.003	**
	21	UI-NF	112.594	6.233	114.700	6.900	1.638	0.207	NS
	22	L1/GO-ME	92.735	6.745	94.320	6.990	1.156	0.499	NS
	23	A-B(//OP)	0.152	2.295	1.300	3.050	2.306	0.045	NS

*P <0.05 **P <0.001 ***P <0.0001

Saudi – African-American comparison

Cephalometric standards and student's t-test results for the Saudi male and African-American male samples are summarized in Table 2. The results show that 11 out of 23 variables had significant differences at ($P < 0.01$). Posterior cranial base (AR-PTM) was much smaller in Saudi adult male than in the African-American ($P < 0.0001$), whereas the anterior cranial base (PTM-N) was notably larger in Saudi adult male ($P < 0.0001$). No major difference was observed in the total cranial base length (N-AR). Burstone *et al.* (1978) had described the total cranial base length as a relatively stable anatomical plane, and sum of the anterior and posterior base lengths.

Among horizontal skeletal relation, skeletal facial convexity (N-A-PG) and maxillary protrusion were considerably smaller in the Saudi male group compared with the African-American male ($P < 0.002$, and $P < 0.005$, respectively). Upper anterior dental height (UI-NF), upper posterior dental height (U6-NF), lower anterior dental height (L1-MP), and lower posterior dental height (L6-MP) were significantly smaller in Saudi adult male ($P < 0.02$, $P < 0.006$, and $P < 0.000$ respectively). Saudi male subjects had a significantly smaller maxillary length (PNS-ANS) and the mandibular body length (GO-PG). African-American male subjects had significantly more protruded lower incisors (L1/GO-ME) compared with Saudis.

Cephalometric standards and student's t-test results for the Saudi female and African-American female samples are summarized in Table 3. Thirteen out of 23 variables had significant differences at ($P < 0.01$). Posterior cranial base (AR-PTM) was significantly smaller in Saudi adult female than in the African-American ($P < 0.0001$). Consequently, total cranial base length (N-Ar) was smaller in Saudi female. Skeletal facial convexity (N-A-PG) and maxillary protrusion (N-A) were considerably smaller in the Saudi female group compared with the African-American female ($P < 0.002$, and $P < 0.01$ respectively). At the same time, the Saudi adult female had smaller lower anterior facial height (ANS-Gn) and upper posterior facial height (PNS-N) than African-American female ($P < 0.001$). Upper anterior dental height (UI-NF), upper posterior dental height (U6-NF), lower anterior dental height (L1-MP), and lower posterior dental (L6-MP) were significantly smaller in Saudi adult female ($P < 0.01$, $P < 0.01$, and $P < 0.000$, respectively). Saudi female subjects had a significantly smaller maxillary base length (PNS-ANS). The mandibular body length (GO-PG) was smaller in Saudi adult females ($P < 0.000$). The gonial angle (AR-Go-Gn) was larger in Saudi female than African-American but it was not significant. The only significantly different dental relationship between Saudi and African-American females was that Blacks had greater lower incisor proclination (L1/GO-ME).

Saudi – Japanese comparison

Table 4 presented cephalometric standards and student's t-test results for the Saudi male and Japanese male subjects. Posterior cranial base (Ar-PTM) was much smaller in Saudi adult male than in the Japanese ($P < 0.0001$), whereas the anterior cranial base (PTM-N) was notably larger in Saudi adult male ($P < 0.0001$). Saudi male group had reduced upper anterior facial height (N-ANS), lower anterior dental height (L1-MP), and lower posterior dental (L6–MP) compared to Japanese ($P < 0.001$ and $P < 0.000$, respectively). Mandibular ramus height (AR-Go) was smaller in Saudi male subject ($P < 0.019$). However, the gonial angle (AR-GO-GN) was significantly larger in Saudi than Japanese male subjects ($P < 0.000$). There are significantly different dental relationships between Saudi and Japanese males. Saudi had less proclination of upper and lower incisor (UI-NF, L1/GO-ME) compared to Japanese ($P < 0.001$). The angle formed between occlusal plane and mandibular plane (OP-HP) was steeper in Japanese compared to Saudis.

Table 5 displayed cephalometric standards and student's t-test results for the Saudi and Japanese female subjects. Posterior cranial base (Ar-PTM) was smaller, whereas the anterior cranial base (PTM-N) was notably larger in Saudi adult female ($P < 0.000$). Among horizontal skeletal relation, maxillary protrusion, and chin protrusion were slightly larger in the Saudi female group compared with the Japanese female ($P < 0.01$, and $P < 0.003$, respectively). Alternatively, the Saudi adult female had significantly smaller upper posterior facial height (PNS-N), upper anterior facial height (N-ANS), lower anterior dental height (L1-MP), and lower posterior dental (L6-MP) compared to Japanese ($P < 0.002$, $P < 0.000$, respectively). The occlusal plane formed a more obtuse angle with the mandibular plane in Japanese women.

Discussion

The objectives of this study were to compare orthognathic cephalometric measurements of Saudi adults to African-American and Japanese adults using Burstone analysis for orthognathic surgery, in order to determine if significant (ethnic races) differences exist. The groups were also divided by sex to determine if significant sex differences exist between races.

The Saudi adult male and female had smaller posterior cranial base than the African-American. It is consistent with previous report (Flynn *et al*., 1989) of reduced posterior cranial base in African-American compared to Caucasian. On the other hand, the anterior cranial base was significantly smaller in African-American male group compared to Saudi male. This finding was in agreement with D'Aloisio *et al*. (1992) and Jacobson (1978) who found that the anterior cranial base was smaller in Black American compared to Caucasian. The total cranial base was similar in the Saudi and African-American male groups, which was in agreement with Flynn *et al.* (1989) who found no difference between African-Americans and Caucasians. The similarity in the length of total cranial base length might result from differences in the lengths of the anterior and posterior cranial bases. Saudi group had long anterior cranial base and short posterior cranial base, whereas the opposite was true for the Black American group. Saudi female had larger anterior cranial base than African female but it is not significant. The total cranial base length was noticeably smaller for Saudi female group compared to African-American female group.

The present study results demonstrated significant differences in facial convexity between two comparisons. The Black American male and female displayed a significantly larger facial convexity than Saudi groups, which corresponded well with earlier findings (Flynn *et al*., 1989; Connor and Moshiri, 1985; Altemus, 1960; Cotton *et al*., 1951). In addition, African-American subjects showed greater maxillary skeletal prognathism than Saudi subjects, which agrees with previous studies (Flynn *et al*., 1989; Connor and Moshiri, 1985; Jacobson, 1978). In both sexes, the African-American had longer maxillary body length when compared with the Saudi sample values, which is consistent with previous studies (Flynn *et al*., 1989; Connor and Moshiri, 1985; Jacobson, 1978). The vertical relationship of the maxilla was significantly different between female groups. Saudi adult female had smaller upper posterior facial height and lower anterior facial height. This can be interpreted that the anterior part of the maxilla is rotated down (downward tipping). Other investigators (Flynn *et al*., 1989; Connor and Moshiri, 1985; Jacobson, 1978) agreed that African-American have excessive vertical maxillary growth compared to Caucasians and hence to Saudi.

The vertical dental heights with its anterior and posterior component were smaller in Saudi than African-American subjects, which is in agreement with (Flynn *et al*., 1989). The form of the mandible revealed differences between Saudi and African-American groups. The total body length of the mandible was smaller in Saudi groups compared to African-American, which is consistent with earlier

findings (Connor and Moshiri, 1985). The mandibular ramus length was similar in Saudi and African female adults. This finding was similar to Flynn *et al*. (1989) who found no difference between Black American and Caucasian. The gonial angle was larger in Saudi groups compared to Black American but this is not significant. The lower incisor proclination were greater in Black subjects compared to Saudi subjects, which was in agreement with previous study (Flynn *et al*., 1989; Jacobson, 1978; Altemus, 1960; Cotton *et al*., 1951).

The present study also shows distinct racial differences between Saudi and Japanese adults. The Saudi adult had smaller posterior cranial base and large anterior cranial base than Japanese groups. However, total cranial base length showed no major difference. Alcalde *et al.* (1998) reported the same finding for the Japanese female. Their result showed that the Japanese female had a similar cranial base length as the Saudi female, but the pterygomaxillary fissure was located anteriorly, producing a shorter anterior cranial base. The majority of previous studies (Miyajima *et al*., 1996; Masaki, 1980; Nezu *et al*., 1982; Cooke and Wei, 1989) that compared the craniofacial morphology between Asian and Caucasians with Class I occlusion reported that Asians had a reduced anterior cranial base.

In this study, Saudi maxillary and chin position relative to the nasion perpendicular line demonstrated a more protruded position in both males and females compared with Japanese. These values were significant in the female group, but they are not significant with the Saudi male. These results suggested that the Saudi population had prognathic maxilla and prominent chin compared to Japanese population. Other Japanese studies (Alcadle *et al*., 1998; Miyajima *et al*., 1996; Ioi *et al*., 2007; Nojima *et al*., 2002) demonstrated that the Japanese had forward position of maxilla, and a slight retruded mandible and chin, indicating a more skeletal Class II tendency.

Considering the vertical dimensions, the Saudi sample had a significantly smaller upper anterior facial height in both sexes than Japanese. In addition the Saudi female showed significantly reduced upper posterior facial height. However, there was no difference in the lower anterior facial height between Saudi and Japanese female groups. The interpretation of the findings suggested that Saudi had reduced facial height compared to Japanese, but this characteristic appears to be more significant in female than males. This finding support the result obtained by Alcalde *et al*. (1998) and Nezu *et al*. (1982) who concluded that the Japanese have longer faces. The lower incisors and lower molars to mandibular plane in Saudi sample were significantly smaller than that of Japanese. These differences might be attributed to the reduced facial height in Saudi adult. A similar result was seen by other studies (Ioi *et al*., 2007; Alcalde *et al*., 1998; Engel and Spolter, 1981).

Considering the mandibular dimensions were smaller in Saudi adults compared to Japanese but not significant, except for mandibular ramus length and gonial angle showed significant differences. Saudi male subjects had reduced mandibular ramus length compared to Japanese, which might contribute to the reduction in facial height. However, the gonial angle in Saudi groups male was significantly larger than Japanese groups. The disparity of this study found in the gonial angle between the two groups was in conflict with Alcadle *et al*. (1998). This is most likely due to error in landmark identifications. Points located on poorly defined outline or low contrast such as Articularie and Gonion had a significant error method as stated by Grybauskas *et al*. (2007).

Dento-alveolar comparison indicated that the lower and upper incisors in Saudi adult were less protruded than those in Japanese; it is more evident in male Saudi group. Similar findings by Miyajima *et al.* (1996), Engel and Spolter (1981), and Nojma *et al*., (2002) who reported that the Japanese sample had a more dental protrusion compared to Caucasians. The occlusal plane to horizontal plane angle was significantly reduced in the Saudi adults; it might be associated with reduced facial height. However, the Japanese male and female had steeper occlusal plane, which agree with Alcalde *et al*. (1998) findings.

In view of the findings of the current study, there are fundamental variations in the craniofacial structure of Saudi adult compared to African-American and Japanese. The findings of this study support the premise that a single standard of cephalometric norms is not appropriate for application to diverse racial and ethnic groups. Additional research on the issue of soft tissue analysis of well-balanced profile in Saudi adults appears to be warranted. Further study is required to confirm this result on the Saudi population using a larger sample size, which can be a true representative sample across the entire Saudi population.

Conclusion

The major craniofacial differences between Saudi adult and African-Americans were as follows, Saudi adult had significantly: (1) increased anterior cranial base, and reduced posterior cranial base, (2) reduced facial convexity, maxillary protrusion, and maxillary

length, (3) smaller upper posterior facial height, lower anterior facial height, and downward tipping of maxilla, with adult female subjects, (4) Smaller vertical dental heights, (5) smaller total body length of mandible, and (6) less proclination of lower incisors.

Saudi adult compared to Japanese had significantly: (1) increased anterior cranial base, and reduced posterior cranial base, (2) prognathic maxilla and prominent chin in females, (3) smaller upper anterior facial height in both sexes, (4) significantly reduced upper posterior facial height with Saudi female subjects, (5) smaller vertical lower dental heights, (6) smaller ramus and obtuse gonial angle in males, (7) less proclination of upper and lower incisors, and (8) less steep occlusal plane to horizontal plane.

These differences between Saudi subjects with Black Americans and Japanese might represent true differences in skeletal and dental features between the three racial groups, or could simply reflect the nature of the samples. So, further investigation on this area is required.

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دراسة الأشعة الجانبية (سيفالوميترية) لمقارنة التقويم العظمي بين ثلاث مجموعات للمرضى البالغين: سعوديون، وأفارقة-أمريكيون، ويابانيون

ليلى فوزي بيداس[1]، وسحر فيصل البركاتي[2]

[1] *أستاذ مساعد تقويم الأسنان، كلية طب الأسنان، جامعة الملك سعود، الرياض*
lailabaidas2003@yahoo.com
[2] *أستاذ مشارك تقويم الأسنان، كلية طب الأسنان، جامعة الملك سعود، الرياض*
salbarakati@gmail.com

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ملخص البحث. الهدف من هذه الدراسة هو مقارنة التقويم العظمي بين ثلاث مجموعات مرضية وهم السعوديون وأفارقة-أمريكيون ويابانيون لمعرفة الاختلافات القياسية للأنسجة العظمية. تم جمع ٦٢ صورة شعاعية جانبية لمرضى سعوديين (٣١ مريض و٣١ مريضة) من الملفات الطبية المحفوظة في كلية طب الأسنان والمأخوذة من قبل طلاب وطالبات كلية طب الأسنان بجامعة الملك سعود وتتراوح أعمارهم بين ٢٢-٢٣ سنة. بعد ذلك تم تحليل الصور الشعاعية الجانبية وأُخذت القيم المتوسطة للقياسات السنية وللأنسجة الصلبة وتم مقارنتها مع الأفارقة-الأمريكيين واليابانيين.

أظهرت الدراسة أن المرضى السعوديون مقارنة بالأفارقة-الأمريكيون لديهم بشكل واضح: زيادة في طول القاعدة الأمامية للرأس، ونقص في طول القاعدة الخلفية للرأس، ونقص في تحدب الوجه، وبروز في الفك العلوي، وزيادة في طول الفك العلوي، أما مقارنة المريضات السعوديات بالأفارقة-الأمريكيات فقد أوضحت أن هناك انخفاضاً في طول الوجه السفلي الأمامي والخلفي، وميل أمامي للفك العلوي، وانخفاض في البعد العمودي للارتفاع السني، ونقص في طول الفك السفلي، وبروز في الأسنان الأمامية السفلية. أظهرت المقارنة بين السعوديين واليابانيين زيادة في الطول الأمامي لقاعدة القحف، ونقص في الطول الخلفي لقاعدة القحف، وبروز في الفك العلوي والذقن مع نقص في الارتفاع العمودي للأسنان السفلية، وزاوية فكية أصغر في الذكور، وبروز شفوي أقل للقواطع العلوية والسفلية، وأقل عمقاً في المستوى الطاحن والمستوى الأفقي.

يمكن أن تساهم هذه الدراسة في تزويدنا بقيم الأشعة الجانبية التي تفيد في التشخيص وخطة العلاج للجراحة التقويمية الفكية بين البالغين السعوديين، ومن الممكن أن توضح الفروق الحقيقية للمظاهر السنية والهيكلية العظمية بين مختلف المجموعات العرقية.