

Original Article

Cephalometric for orthognathic surgery (COGS): Determination of values applicable to Malaysian Malay and Chinese population

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Abstract: The present study aims to investigate and compare the hard and soft tissue cephalometric measurement among Malaysian Malay and Chinese subjects. This study is a cross-sectional study of secondary data. Data consists of 470 standardized lateral cephalometric radiographs of Malaysian Malay and Chinese adults which were picked randomly among orthodontic patients of Hospital USM. The criteria of selection were pre-treatment lateral cephalometric film of Malay and Chinese orthodontic patients aged 18-25 years which has good quality with visible landmarks. All cephalometric landmarks were located and determined and subsequently all measurements were done per COGS analysis using CASSOS software. Independent t-tests were performed for statistical comparison. Out of the 38 measurements, 4 were found significantly different between the sexes for Malaysian Chinese and 18 were found significantly different between the sexes for Malaysian Malay. Statistically significant disparities were also found between Malaysian Malay and Chinese as 16 measurements has *p*-value of < 0.05. Disparities were observed in COGS values between the two races and each sex group.

Keywords: Cephalometry; COGS analysis; Malaysian Malay; Malaysian Chinese.

Introduction

Cephalometric analysis is among the most commonly used method to diagnose skeletal and dental problems, which is significant in orthodontic treatment planning and evaluation of treatment changes (Athanasίου, 1995; Singh *et al.*, 2013). As in the current perspective facial aesthetics is a major concern for the patient, and sometimes orthodontic treatment alone might not be enough to attain this. In those cases, to achieve harmonious dental, skeletal as well as soft tissue relationships, a combination of fixed orthodontic therapy and orthognathic surgery is required (Robinson and Holm, 2010; Upadhyay *et al.*, 2013). Orthognathic surgery is carried out to modify the shape of the jaws to improve the stability of dental occlusion, improve the function of temporomandibular joint, open the oropharyngeal airway, and improve the patient's facial proportions (Upadhyay *et al.*, 2013).

A deliberate diagnosis of facial, skeletal and dental problems is very crucial to ensure good prognosis of orthognathic surgery (Alam *et al.*, 2013). In order to successfully attain this, a specialized cephalometric appraisal system known as cephalometric for orthognathic surgery analysis (COGS) with regards to the hard tissue of the face was previously developed (Burstone *et al.*, 1978). By using a constant coordinate system, COGS describes the horizontal and vertical position of facial bones, involving numerous linear and angular measurements which are measured either parallel or perpendicular to true horizontal plane (HP) (Alam *et al.*, 2013; Singh *et al.*, 2013; Tikku *et al.*, 2014).

Malaysia is a multicultural country typified by three major ethnic groups namely Malay, Chinese, and Indian (Ibrahim, 2007). A study done in 1994 to compare Chinese, Malay and Indian ethnic cephalometric ideals using Steiner analysis showed that there are cephalometric differences present between

Chinese and Indians as well as the Malays and Indians (Lew, 1994). These differences demonstrate intrinsic ethnic differences and emphasize the need to treat patients of different ethnic groups using cephalometric norms which are peculiar to their own group (Lew, 1994).

There were also previous studies that discovered craniofacial features distinct in certain ethnic groups as compared to those of other populations (Trivedi *et al.*, 2010; Alam *et al.*, 2013; Singh *et al.*, 2013; Bagwan *et al.*, 2014). Due to this ethnic variation, it is unscientific to use or apply cephalometric norms specific for one racial group on a different population (Alam *et al.*, 2013). Suitable application of any cephalometric analysis can be attained when used with norms acquired from populations similar to the patients with consideration to their ethnic group, age, and gender (Cooke and Wei, 1989; Wu *et al.*, 2007). By identifying different landmarks and measurements that can be altered by various surgical procedures, COGS analysis (Burstone *et al.*, 1978) is specially designed for patients who require orthognathic surgery (Singh *et al.*, 2013; Upadhyay *et al.*, 2013; Tikku *et al.*, 2014).

The purpose of this study was to investigate and compare the hard and soft tissue cephalometric norms for orthognathic surgery (COGS) for Malaysian Malay and Chinese adults.

Materials and methods

The sample size calculation was calculated using G*Power software (Düsseldorf, Germany) based on mean value from literature (Alam *et al.*, 2013) using power 80 & 85%, resulting in the sample size ranged from 470 to 546 respondents. The study sample consisted of 470 standardized lateral cephalometric radiographs of Malaysian Malay and Chinese adults: 348 Malay (97 male, 251 female) and 122 Chinese (44 male, 78 female). The subjects were selected based on inclusion criteria from the orthodontic patients in Hospital USM Orthodontic Clinic, Kelantan, Malaysia. The inclusion criteria of the subjects consisted of pre-treatment lateral cephalometric film of orthodontic patient in Hospital USM Orthodontic Clinic, patients

with known ethnicity, namely Malay and Chinese, lateral cephalometric film of patient aged 18 to 25 years old and good quality lateral cephalometric film, with visible landmarks and excellent clarity. The ethical clearance was obtained from the Human Ethics Committee, Universiti Sains Malaysia (Ref.: USM/JEPeM/16030135). The study was executed from August 2016 to February 2017.

Assessment

The cephalometric analysis was done per COGS analysis using a computer program called Computer-Assisted Simulation System for Orthognathic Surgery (CASSOSS) 2001, (Soft Enable Technology Ltd, Hong Kong). All tracings and measurements were done by a single operator after calibration with orthodontist. Tracing was done in a standard manner. The analyses employed according to the Caucasian COGS standards (Fig. 1) and the cephalometric parameters (Table 1).

Statistical Analysis

After collection of data, the data was verified and analyzed statistically using SPSS Statistics Version 22.0 (IBM Corp, 2013) with confidence level set at 5% ($p < 0.05$) to test for significance among the races and gender. A descriptive statistical analysis of the cephalometric analysis was carried out and statistical comparison was done using independent t-test.

Control of Error

The reliability of the method was analyzed by calculating the Dahlberg's formula:

$$D = \sqrt{\sum_{i=1}^N \frac{d_i^2}{2N}}$$

To determine the difference between 2 measurements which was made a month apart in which d_i is the difference between the first and second measure; N is the sample size which was re-measured. 10% randomly selected lateral cephalometric radiographs were retraced and remeasured to calculate the method error.

Results

The descriptive statistics of all lateral cephalometric radiographs for 38 measurements for the entire sample (470 subjects) were done. The differences of cephalometric measurements between gender and races have been tabulated. For each variable, mean, standard of deviation, and *p*-value were obtained.

Comparison by gender

By gender, among 38 variables in Burstone's COGS analysis, 18 were found significant in Malaysian Malay (Table 2) and 4 variables showed almost similar values in Malaysian Chinese (Table 3).

Comparison by races

Among the 38 variables, 16 parameters showed significant differences where Malaysian Chinese has bigger mean in almost all the significant parameters (Table 4).

Discussion

The present study determines the hard and soft tissue cephalometric measurements among Malaysian Malay and Chinese adults and compares the disparity between gender and races. It also compares the mean difference with the established Caucasian COGS standards (Burstone *et al.*, 1978). The sample size was 470, consisting of 348 Malay (97 males, 251 females) and 122 Chinese (44 males, 78 females) lateral cephalometric radiographs which were taken from Hospital USM Orthodontic Clinic.

Racial skeletal and dental uniqueness of the face have a crucial role in orthodontic and orthognathic treatment planning (Alam *et al.*, 2013). On the other hand, soft tissue profile also has a significant role in the planning of orthodontic therapy, since a well-balanced face, particularly of the lower third, optimal functional occlusion, and excellence of facial form are among of the prime objectives of orthodontic treatment (Upadhyay *et al.*, 2013; Alam *et al.*, 2014). However, it is well-established that surgical cephalometric analysis developed for one racial group is different from other racial groups (Trivedi *et al.*, 2010; Alam *et al.*, 2013; Singh *et al.*, 2013; Alam *et al.*, 2014).

This is due to the existence of skeletal, dental, as well as soft tissue variations in different groups of population (Bagwan *et al.*, 2014). Hence, one could not consider the mean values for measurements of one racial group to be similar with others (Lew, 1994; Alam *et al.*, 2013; Alam *et al.*, 2014).

Previous studies (Trivedi *et al.*, 2010; Alam *et al.*, 2013; Kathiravan *et al.*, 2013) have reported that the disparities between gender and racial group are apparent. The mean difference values for both Malaysia Chinese and Malay, males and females, were different when compared to the established Caucasian COGS analysis values (Burstone *et al.*, 1978). These results corresponded to the other previous studies (Trivedi *et al.*, 2010; Alam *et al.*, 2013).

From the present study, it has been observed that for both Malay and Chinese, there are significant differences in some cephalometric measurements between genders; where males have larger measurements in most of the variables than female. It is found that Malay males had an increase in the posterior cranial base and anterior cranial base which agrees to the other previous studies (Arunkumar *et al.*, 2010; Trivedi *et al.*, 2010). For vertical skeletal and dental relations, Malay males had an increase in upper and lower anterior face height, which coincide with the previous result (Kathiravan *et al.*, 2013) and marked an increase in the upper posterior face height. They also showed an increase in the lower anterior dental height, upper and lower posterior dental height which corresponds to the previous analysis (Burstone *et al.*, 1978). It is also noted that Malay male also have larger maxillary and mandibular length. For facial form, male have been observed to have greater lower face-throat angle, which is the angle formed by the subnasale-pogonion line and the throat line and bigger lower face height-depth ratio (Bergman, 1999). Mentolabial sulcus depth was also observed as deeper in males when compared to females, which could be due to the increased amount of protrusion of lower lip. The latter finding is in accordance with the other previous studies (Al-Jasser, 2003; Bagwan *et al.*, 2014).

On the other hand, Malay females have more facial convexity compared to male, which contrasts with the study on the

Egyptian population (Bagwan *et al.*, 2014). The vertical height ratio in female is also increased which respectively indicate that, there is a decreased in the lower-third facial height in female than male. Malay female showed an increase in mandibular plane angle and upper occlusal plane where as nasiolabial angle showed that the male has a more significant acute angle compared to the female.

Concerning comparison of mean values between gender in Malaysian Chinese, we found that Chinese male have greater mandibular length. However, this finding is not in agreement with the previous study regarding Chinese norms of McNamara's cephalometric analysis (Wu *et al.*, 2007). In that study, it is stated that both genders have no significant difference in length of mandible, but it is observed that males have more retrognathic mandible, steeper mandibular plane and facial axis angle, and larger lower face height (Wu *et al.*, 2007). Chinese male also has larger chin depth measurement and showed an increase in lower face throat angle and lower face height-depth ratio than Chinese female.

Regarding comparison between Malaysian Malay and Chinese adults, Malaysian Chinese were found to have larger values in most of the parameters compared to Malaysian Malays. Malaysian Chinese adults showed an increase in upper anterior face height (UAFH), upper posterior face height (UPFH), lower anterior face height (LAFH), and both lower and upper anterior dental height and posterior dental height. However, the ratio of UAFH to LAFH is more crucial than the individual linear measurements of UAFH and LAFH, as UAFH differs with the superior-inferior dimension of the size of an adult skull while the ratio of UAFH/LAFH designates the balance of facial proportions (Pouliaki and Sidiropoulou, 2016).

It is also observed that Malaysian Chinese has larger mandibular length, larger mandibular body length, larger chin depth and increase lower face height depth ratio compared to Malaysian Malays. Variations in ramus height may affect open bite or deep bite (Fattahi *et al.*, 2014).

For soft tissue analysis, Malaysian Chinese has more protruded lower lip which is in accordance with the previous study

(Alam *et al.*, 2014). It also showed that Malaysian Chinese has more maxillary incisor exposure. On the other hand, Malaysian Malay has increased in gonial angle which is suggestive of more vertical growth pattern and has more convex profile than Malaysian Chinese.

It is also observed that Malaysian Malay has a greater lower face-throat angle. Previous study had suggested that appreciation of this angle is critical in planning treatment to correct anteroposterior facial dysphasia (Legan and Burstone, 1980). An obtuse lower face-throat angle should warn the clinician to avoid any procedures that reduce the prominence of the chin.

Even though there are various surgical cephalometric norms, they are mostly focused on the Caucasian population, which may lead to an inaccurate diagnosis in case of population other than the Caucasians (Alam *et al.*, 2013). Based from the findings of the present study, it is evident that there are disparities in COGS analysis between Malaysian Malay and Chinese. These differences should be taken into account when establishing a diagnosis and treatment plan to achieve good prognosis. It is our duty as practitioner to carefully diagnose, analyse and provide the best to our patients, by considering all the discussed factors.

Conclusion

Disparities were observed in COGS value between the gender for Malaysian Malay and Malaysian Chinese, and between the race of Malaysian Malay and Malaysian Chinese. This study may become an aid in providing specific COGS during diagnosis and treatment planning for orthognathic surgery for Malaysian Malay and Chinese.

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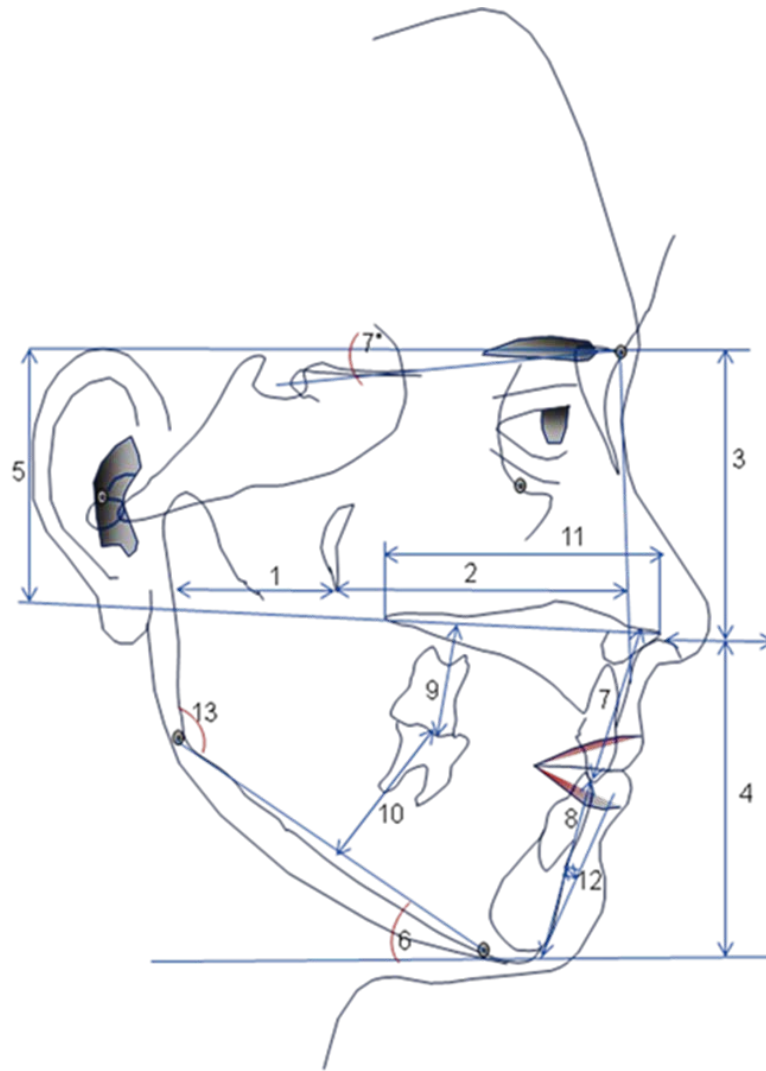


Fig. 1 Cranial base length and vertical skeletal, dental and maxilla/mandibular measurements: 1: posterior cranial base (AR–PTM), 2: anterior cranial base (PTM–N), 3: upper anterior facial height (N–ANS), 4: lower anterior facial height (ANS–GN), 5: upper posterior facial height (PNS–N), 6: mandibular plane angle (MP–HP), 7: upper anterior dental height (U1–NF), 8: lower anterior dental height (L1–MP), 9: upper posterior dental height (UM–NF). (Figure courtesy of Alam *et al.*, 2013).

Table 1 Cephalometric parameters and the description of parameters

Cephalometric parameters		Description of parameters
Cranial Base		
1.	Posterior cranial base	Ar-Ptm
2.	Anterior cranial base	Ptm-N
Horizontal skeletal and dental relations		
1.	Facial convexity	N-A-Pog
2.	Maxillary protrusion	N-A
3.	Mandibular protrusion	N-B
4.	Chin protrusion	N-Pog
Vertical skeletal and dental relations		
1.	Upper anterior face height	N-ANS
2.	Lower anterior face height	ANS-Gn
3.	Upper posterior face height	PNS-N
4.	Mandibular plane angle	MP-HP
5.	Upper anterior dental height	U1-NF
6.	Lower anterior dental height	L1-MP
7.	Upper posterior dental height	U6-NF
8.	Lower posterior dental height	L6-MP
Maxilla and mandible		
1.	Maxillary length	PNS-ANS
2.	Mandibular length	Ar-Go
3.	Mandibular body length	Go-Pog
4.	Chin depth	B-Pog
5.	Gonial angle	Ar-Go-Me
Dental relationships		
1.	Occlusal plane to horizontal plane angle	OP-HP
2.	Upper occlusal plan	U OP-HP
3.	Lower occlusal plane	L OP-HP
4.	Wits analysis	A-B
5.	Upper incisor angle	U1-NF
6.	Lower incisor angle	L1-MP
Facial Form		
1.	Facial Convexity	
2.	MX Prognathism	
3.	MD Prognathism	
4.	Vertical Height Ratio	
5.	L Face-Throat Angle	
6.	L Face Ht-Depth Rt	
Lip Position and Form		
1.	Naso-labial Angle	
2.	Upper Lip Protrusion	
3.	Lower Lip Protrusion	
4.	Mentolabial Sulcus	
5.	Vertical Lip-Chin Ratio	
6.	U1 Exposure	
7.	Interlabial Gap	

Table 2 Comparison of hard tissue cephalometric measurement among gender for Malaysian Malay

	Gender	Mean	SD	95% CI		p-value	Sig.
				Lower	Upper		
Ar-Ptm	M	56.63	14.287	1.862	7.776	0.004	**
	F	51.81	11.853	1.594	8.044		
Ptm-N	M	82.86	20.359	1.077	10.460	0.016	*
	F	77.09	19.795	1.001	10.536		
N-A-Pog	M	3.84	8.154	-3.617	-0.112	0.037	*
	F	5.71	7.165	-3.728	-0.001		
N-A	M	-4.19	9.398	-3.806	-0.087	0.068	NS
	F	-2.24	7.257	-4.039	0.146		
N-B	M	-14.22	14.973	-5.951	1.439	0.231	NS
	F	-11.96	15.991	-5.856	1.344		
N-Pog	M	-13.36	16.365	-5.035	2.282	0.460	NS
	F	-11.98	15.236	-5.168	2.414		
N-ANS	M	90.59	21.700	1.210	10.695	0.014	*
	F	84.63	19.546	0.965	10.940		
ANS-Gn	M	104.43	24.603	2.130	12.952	0.005	**
	F	96.89	22.370	1.874	13.208		
PNS-N	M	86.27	19.332	1.954	10.655	0.006	**
	F	79.96	18.173	1.816	10.793		
MP-HP	M	26.28	7.459	-3.358	-0.041	0.045	*
	F	27.98	6.891	-3.424	0.025		
U1-NF	M	45.14	10.321	-0.210	4.603	0.074	NS
	F	42.94	10.201	-0.231	4.624		
L1-MP	M	69.80	16.144	1.138	8.384	0.010	*
	F	65.04	15.117	1.016	8.506		
U6-NF	M	39.41	9.533	0.295	4.631	0.026	*
	F	36.95	9.088	0.240	4.685		
L6-MP	M	53.61	14.069	1.614	8.011	0.003	**
	F	48.79	13.349	1.525	8.100		
PNS-ANS	M	83.48	16.114	1.691	8.807	0.004	**
	F	78.23	14.724	1.532	8.967		
Ar-Go	M	79.55	19.519	3.215	12.118	0.001	**
	F	71.88	18.701	3.113	12.221		
Go-Pog	M	123.12	28.212	-0.682	11.922	0.080	NS
	F	117.50	26.237	-0.913	12.153		
B-Pog	M	8.38	3.276	-0.026	1.441	0.059	NS
	F	7.67	3.056	-0.052	1.467		
Ar-Go-Me	M	120.78	8.904	-2.012	1.563	0.805	NS
	F	121.01	7.038	-2.215	1.767		
OP-HP	M	7.87	5.622	-2.507	-0.007	0.049	*
	F	9.13	5.163	-2.561	0.047		
U OP-HP	M	9.65	13.141	-2.151	1.751	0.840	NS
	F	9.85	5.328	-2.941	2.541		
L OP-HP	M	7.26	6.201	-2.360	0.419	0.171	NS
	F	8.23	5.758	-2.412	0.472		

Table 2 (continued)

	Gender	Mean	SD	95% CI		p-value	Sig.
				Lower	Upper		
A-B	M	1.51	15.419	-0.577	4.203	0.137	NS
	F	-0.30	7.125	-1.430	5.057		
U1-NF	M	118.27	13.412	-3.028	1.642	0.560	NS
	F	118.96	8.210	-3.577	2.191		
L1-MP	M	98.42	14.701	-2.886	2.422	0.864	NS
	F	98.65	9.661	-3.422	2.958		
Facial Convexity	M	12.40	12.242	-0.908	3.133	0.279	NS
	F	11.29	6.680	-1.486	3.712		
MX Prognathism	M	6.28	11.969	-1.839	2.114	0.915	NS
	F	6.15	6.540	-2.403	2.679		
MD Prognathism	M	-7.57	15.894	-5.550	1.579	0.274	NS
	F	-5.59	14.868	-5.671	1.701		
Vertical Height Ratio	M	95.98	13.728	-7.412	-2.413	0.000	***
	F	100.90	9.165	-7.898	-1.927		
L Face-Throat Angle	M	101.22	15.209	1.104	6.322	0.005	**
	F	101.09	9.029	0.455	6.971		
L Face Ht-Depth Rt	M	142.86	23.578	9.172	19.046	0.000	***
	F	128.75	19.915	8.767	19.452		
Naso-labial Angle	M	92.47	11.199	-6.723	-1.418	0.003	**
	F	96.54	11.313	-6.720	-1.421		
Upper Lip Protrusion	M	10.68	4.067	-0.249	2.476	0.109	NS
	F	9.56	6.334	-0.018	2.245		
Lower Lip Protrusion	M	8.24	4.307	-0.723	1.529	0.482	NS
	F	7.83	4.959	-0.658	1.463		
Mentolabial Sulcus	M	7.59	3.270	0.477	1.950	0.001	**
	F	6.37	3.079	0.454	1.973		
Vertical Lip-Chin Ratio	M	49.45	7.457	-1.436	1.715	0.862	NS
	F	49.32	6.385	-1.555	1.834		
U1 Exposure	M	3.52	3.466	-1.248	.342	0.263	NS
	F	3.97	3.347	-1.263	.357		
Interlabial Gap	M	2.57	3.663	-0.362	1.057	0.336	NS
	F	2.23	2.730	-0.463	1.158		

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$, SD: standard deviation, CI: Confidence Interval, NS: not significant.

Table 3 Comparison of hard tissue cephalometric measurement among gender for Malaysian Chinese

	Gender	Mean	SD	95% CI		p-value	Sig.
				Lower	Upper		
Ar-Ptm	M	56.57	15.756	-2.675	7.859	0.332	NS
	F	53.98	13.098	-2.985	8.169		
Ptm-N	M	87.33	22.238	-0.352	14.647	0.062	NS
	F	80.18	18.783	-0.758	15.052		
N-A-Pog	M	2.20	8.235	-5.003	0.223	0.098	NS
	F	4.59	6.204	-5.234	0.454		
N-A	M	-4.51	8.893	-5.182	0.155	0.099	NS
	F	-2.00	5.957	-5.511	0.483		
N-B	M	-13.60	17.086	-7.492	2.800	0.420	NS
	F	-11.26	11.539	-8.113	3.421		
N-Pog	M	-12.40	19.775	-7.569	4.102	0.603	NS
	F	-10.67	12.745	-8.351	4.884		
N-ANS	M	97.02	22.869	-1.066	15.166	0.088	NS
	F	89.97	21.085	-1.291	15.390		
ANS-Gn	M	141.77	29.780	-1.203	19.288	0.083	NS
	F	105.46	26.051	-1.649	19.733		
PNS-N	M	94.01	22.053	-0.217	15.306	0.057	NS
	F	86.47	20.053	-0.464	15.553		
MP-HP	M	27.19	7.175	-2.824	2.502	0.905	NS
	F	27.35	7.111	-2.841	2.518		
U1-NF	M	49.62	15.087	-1.440	8.515	0.162	NS
	F	46.08	12.244	-1.769	8.844		
L1-MP	M	76.08	20.760	-0.431	13.301	0.066	NS
	F	69.64	16.926	-0.875	13.745		
U6-NF	M	43.76	12.431	-0.499	7.676	0.085	NS
	F	40.17	10.027	-0.777	7.954		
L6-MP	M	58.87	15.670	-0.125	10.365	0.056	NS
	F	53.75	13.058	-0.430	10.670		
PNS-ANS	M	85.24	16.961	-1.123	10.910	0.110	NS
	F	80.35	15.626	-1.291	11.078		
Ar-Go	M	87.25	23.356	0.723	17.081	0.033	*
	F	78.34	21.059	0.442	17.362		
Go-Pog	M	164.89	30.781	-3.967	17.884	0.210	NS
	F	123.14	28.387	-4.268	18.184		
B-Pog	M	10.08	4.145	0.245	3.091	0.022	*
	F	8.41	3.614	0.182	3.155		
Ar-Go-Me	M	117.28	17.872	-7.133	1.907	0.255	NS
	F	119.89	7.078	-8.257	3.031		
OP-HP	M	7.75	5.690	-2.527	1.198	0.481	NS
	F	8.42	4.551	-2.659	1.329		
U OP-HP	M	8.34	5.484	-2.341	1.369	0.605	NS
	F	8.83	4.656	-2.439	1.466		
L OP-HP	M	7.13	7.304	-3.014	1.508	0.549	NS
	F	7.88	5.232	-3.248	1.742		
A-B	M	-1.45	9.449	-3.016	2.757	0.936	NS
	F	-1.32	6.583	-3.339	3.080		

Table 3 (continued)

	Gender	Mean	SD	95% CI		p-value	Sig.
				Lower	Upper		
U1-NF	M	119.75	7.802	-3.215	2.612	0.838	NS
	F	120.06	7.806	-3.225	2.621		
L1-MP	M	97.48	9.287	-3.996	1.951	0.497	NS
	F	98.50	7.122	-4.243	2.198		
Facial Convexity	M	9.75	8.536	-2.301	2.903	0.819	NS
	F	9.45	5.918	-2.595	3.197		
MX Prognathism	M	4.71	8.018	-3.549	1.606	0.489	NS
	F	5.68	6.198	-3.757	1.815		
MD Prognathism	M	-9.10	18.864	-10.073	1.291	0.173	NS
	F	-4.71	12.741	-10.758	1.977		
Vertical Height Ratio	M	98.16	8.538	-5.453	0.710	0.130	NS
	F	100.53	8.091	-5.513	0.769		
L Face-Throat Angle	M	104.63	12.905	1.028	9.193	0.015	*
	F	99.52	9.663	0.659	9.561		
L Face Ht-Depth Rt	M	157.26	25.736	4.073	22.434	0.005	**
	F	144.01	23.931	3.843	22.664		
Naso-labial Angle	M	96.67	12.760	-3.328	5.298	0.652	NS
	F	95.68	10.821	-3.556	5.526		
Upper Lip Protrusion	M	10.47	5.215	-0.697	2.366	0.342	NS
	F	9.64	3.325	-0.907	2.576		
Lower Lip Protrusion	M	10.12	5.334	-0.601	3.156	0.181	NS
	F	8.84	4.855	-0.660	3.215		
Mentolabial Sulcus	M	7.00	3.922	-0.090	2.172	0.071	NS
	F	5.96	2.390	-0.259	2.341		
Vertical Lip-Chin Ratio	M	49.77	8.185	-2.050	3.514	0.603	NS
	F	49.04	7.008	-2.188	3.652		
U1 Exposure	M	4.91	4.895	-0.987	1.892	0.535	NS
	F	4.46	3.129	-1.183	2.088		
Interlabial Gap	M	3.23	6.047	-0.164	2.814	0.081	NS
	F	1.91	2.090	-0.568	3.218		

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$, SD: standard deviation, CI: Confidence Interval, NS: not significant.

Table 4 Comparison of hard tissue cephalometric measurement among Malaysian Malay and Chinese

	Races	Mean	SD	95% CI		p-value	Sig.
				Lower	Upper		
Ar-Ptm	Malay	53.15	12.742	-4.471	0.949	0.202	NS
	Chinese	54.92	14.105	-4.618	1.095		
Ptm-N	Malay	78.70	20.092	-8.232	0.098	0.056	NS
	Chinese	82.76	20.301	-8.267	0.132		
N-A-Pog	Malay	5.19	7.489	-0.069	2.984	0.061	NS
	Chinese	3.73	7.066	-0.031	2.946		
N-A	Malay	-2.78	7.947	-1.481	1.731	0.879	NS
	Chinese	-2.91	7.222	-1.413	1.662		
N-B	Malay	-12.59	15.725	-3.643	2.661	0.760	NS
	Chinese	-12.10	13.775	-3.456	2.474		
N-Pog	Malay	-12.36	15.547	-4.288	2.146	0.513	NS
	Chinese	-11.29	15.589	-4.302	2.160		
N-ANS	Malay	86.29	20.314	-10.511	-1.935	0.007	**
	Chinese	92.52	21.916	-10.687	-1.760		
ANS-Gn	Malay	98.99	23.226	-14.780	-4.668	0.001	**
	Chinese	118.55	27.678	-15.244	-4.204		
PNS-N	Malay	81.72	18.690	-11.463	-3.474	0.001	**
	Chinese	89.19	21.023	-11.711	-3.226		
MP-HP	Malay	27.51	7.084	-1.248	1.683	0.771	NS
	Chinese	27.29	7.105	-1.255	1.690		
U1-NF	Malay	43.55	10.267	-6.111	-1.498	0.005	**
	Chinese	47.36	13.387	-6.432	-1.177		
L1-MP	Malay	66.36	15.534	-8.987	-2.215	0.003	**
	Chinese	71.96	18.577	-9.304	-1.898		
U6-NF	Malay	37.64	9.267	-5.843	-1.807	0.001	**
	Chinese	41.46	11.040	-6.027	-1.622		
L6-MP	Malay	50.13	13.702	-8.335	-2.612	0.000	***
	Chinese	55.60	14.208	-8.395	-2.552		
PNS-ANS	Malay	79.70	15.285	-5.624	0.801	0.141	NS
	Chinese	82.11	16.223	-5.729	0.906		
Ar-Go	Malay	74.02	19.215	-11.676	-3.389	0.001	**
	Chinese	81.55	22.237	-11.993	-3.071		
Go-Pog	Malay	119.07	26.879	-12.273	-0.886	0.031	*
	Chinese	138.20	29.338	-12.539	-0.620		
B-Pog	Malay	7.87	3.131	-1.838	-0.456	0.004	**
	Chinese	9.01	3.881	-1.915	-0.379		
Ar-Go-Me	Malay	120.95	7.591	0.136	3.851	0.035	*
	Chinese	118.95	12.123	-0.319	4.306		
OP-HP	Malay	8.78	5.316	-0.483	1.682	0.277	NS
	Chinese	8.18	4.979	-0.452	1.651		
U OP-HP	Malay	9.79	8.249	-0.419	2.698	0.152	NS
	Chinese	8.65	4.954	-0.101	2.380		
L OP-HP	Malay	7.96	5.891	-0.876	1.578	0.575	NS
	Chinese	7.61	6.042	-0.895	1.597		

Table 4 (continued)

	Races	Mean	SD	95% CI		p-value	Sig.
				Lower	Upper		
A-B	Malay	0.20	10.137	-0.410	3.549	0.120	NS
	Chinese	-1.37	7.702	-0.173	3.312		
U1-NF	Malay	118.77	9.921	-3.126	0.766	0.234	NS
	Chinese	119.95	7.774	-2.917	0.557		
L1-MP	Malay	98.59	11.271	-1.716	2.631	0.680	NS
	Chinese	98.13	7.948	-1.392	2.306		
Facial Convexity	Malay	11.60	8.594	0.346	3.736	0.018	*
	Chinese	9.56	6.943	0.506	3.575		
MX Prognathism	Malay	6.19	8.394	-0.804	2.518	0.311	NS
	Chinese	5.33	6.892	-0.658	2.372		
MD Prognathism	Malay	-6.14	15.164	-2.987	3.299	0.922	NS
	Chinese	-6.30	15.305	-3.011	3.323		
Vertical Height Ratio	Malay	99.53	10.840	-2.268	1.968	0.890	NS
	Chinese	99.68	8.299	-2.020	1.720		
L Face-Throat Angle	Malay	101.12	11.203	-5.138	-0.510	0.017	*
	Chinese	101.36	11.166	-5.142	-0.506		
L Face Ht-Depth Rt	Malay	132.68	21.902	-20.826	-11.385	0.000	***
	Chinese	148.79	25.311	-21.185	-11.026		
Naso-labial Angle	Malay	95.41	11.413	-2.996	1.735	0.601	NS
	Chinese	96.04	11.515	-3.013	1.752		
Upper Lip Protrusion	Malay	9.87	5.808	-1.184	1.057	0.911	NS
	Chinese	9.94	4.106	-1.018	0.890		
Lower Lip Protrusion	Malay	7.95	4.784	-2.359	-0.352	0.008	**
	Chinese	9.30	5.049	-2.389	-0.322		
Mentolabial Sulcus	Malay	6.71	3.176	-0.271	1.030	0.252	NS
	Chinese	6.33	3.058	-0.261	1.020		
Vertical Lip-Chin Ratio	Malay	49.35	6.690	-1.373	1.476	0.943	NS
	Chinese	49.30	7.429	-1.452	1.555		
U1 Exposure	Malay	3.85	3.382	-1.499	-0.049	0.036	*
	Chinese	4.62	3.846	-1.549	0.000		
Interlabial Gap	Malay	2.32	3.018	-0.747	0.620	0.856	NS
	Chinese	2.39	4.023	-0.850	0.723		

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$, SD: standard deviation, CI: Confidence Interval, NS: not significant.