

Comparison of craniofacial characteristics of typical Chinese and Caucasian young adults

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SUMMARY The purpose of this study was to determine the cephalometric norms of typical Chinese young adult subjects with normal occlusions and well-balanced faces and to compare these norms with those derived from a matched Caucasian sample. Lateral cephalograms of 65 untreated Chinese adults (25 males, mean age 19.3 ± 3.0 years and 40 females, mean age 20.3 ± 3.4 years) were compared with a sample of 90 untreated Caucasian adults (30 males, mean age 24.1 ± 5.7 years and 60 females, mean age 22.9 ± 5.2 years). Each lateral cephalogram was traced and digitized, and conventional cephalometric analyses were applied. Independent sample *t*-tests were used to compare the values between the two ethnic samples.

Smaller midfaces and shorter mandibles were observed in Chinese young adults compared with those of Caucasians. The average value of lower anterior face height (ANS–Me) was longer in the Chinese females than that in the Caucasian females ($P < 0.001$). A greater vertical dimension also was seen in Chinese males compared with Caucasian males when evaluated by analysis of the facial axis angle ($P < 0.05$). The upper and lower lips were more protrusive in the Chinese, and a more convex facial profile was seen compared with the Caucasian sample.

Significant differences in hard and soft tissue characteristics were found between Chinese and Caucasian young adults with normal occlusions and well-balanced faces. Gender and racial/ethnic differences must be taken into consideration during orthodontic diagnosis and treatment planning for the individual patient.

Introduction

Many investigators have attempted to establish cephalometric norms for Pacific Rim populations, including Japanese, Korean, and Chinese (Fu and Mao, 1965; Cooke and Wei, 1988, 1989; Park *et al.*, 1989; Miyajima *et al.*, 1996; Hwang *et al.*, 2002; Loi *et al.*, 2005). These studies have shown ethnic differences among these three groups as well as substantial morphological variations when compared with Caucasians. Such studies include comparisons of native-born Japanese (Miyajima *et al.*, 1996) and Korean (Hwang *et al.*, 2002) adults with normal (near ideal) occlusions and well-balanced faces with a matched group of Caucasians subjects.

Another ethnic group that must be considered is the Chinese, a term that encompasses multiple ethnic groups. Most Chinese reside in the People's Republic of China (PRC), a country that has the largest population (1.3 billion people) and the third largest land area of any nation. Some cephalometric studies of the Chinese are based on samples of Taiwanese, American, Hong Kong, and southern Asian Chinese (Malaysian and Singapore) (Wei, 1968, 1969; Chan, 1972; Yen, 1973; Johnson *et al.*, 1978; Lin, 1985; Foo, 1986; So *et al.*, 1990; Lew, 1992, 1994; Moate and Darendeliler, 2002; Yeong and Huggare, 2004; Wu *et al.*, 2007). The majority of the subject in these Chinese samples originate

from the Guangdong and Fujian Provinces of China, which comprise only 3 per cent of the land area in the PRC and are located geographically in the southern coastal area of China.

A few studies have compared Chinese with Caucasians (Johnson *et al.*, 1978; Cooke and Wei, 1989; Wu *et al.*, 2007), but no reports exist from the PRC regarding a direct comparison of Chinese and Caucasian samples of untreated subjects with normal occlusions and well-balanced faces. The purpose of this study was (1) to present cephalometric norms based on a sample of typical Chinese subjects residing outside Guangdong and Fujian Provinces who presented with normal occlusions and well-balanced faces, (2) to evaluate sexual dimorphism for craniofacial features within Chinese and Caucasian young adult samples, and (3) to compare the norms with those derived from a matched Caucasian sample.

Subjects and methods

Chinese sample

The sample comprised 25 males (mean age 19.3 ± 3.0 years) and 40 females (mean age 20.3 ± 3.4 years). The records were selected from the files in the Department of Orthodontics, Peking University School and Hospital of Stomatology, from

subjects who originally were not from the Guangdong and Fujian Provinces. These untreated individuals had a normal occlusion with no or minimal crowding, spacing less than 1 mm, and a dental midline discrepancy less than 1 mm, as judged on the basis of a clinical examination and/or study models. Lateral headfilms were evaluated by three Chinese orthodontic specialists and three Chinese laypersons to determine the presence of a well-balanced facial profile. The maturational stage of each subject had to be at cervical stage 6, based on the cervical vertebral maturation method, to ensure that most active growth had ceased (Baccetti *et al.*, 2005).

Caucasian sample

The lateral headfilms chosen for inclusion in the Caucasian sample were obtained from the studies of McNamara and Ellis (1988) and McNamara *et al.* (1993). The criteria used for inclusion were virtually identical to those used for the Chinese sample. The Caucasian sample consisted of 30 males (average age 24.1 ± 5.7 years) and 60 females (22.9 ± 5.2 years) all of whom were Caucasians of North European ancestry. Subsets of records from the studies of McNamara and Ellis (1988) and McNamara *et al.* (1993) have been used previously in comparative studies of Japanese (Miyajima *et al.*, 1996) and Koreans (Hwang *et al.*, 2002).

Cephalometric analysis

The landmarks and reference lines for the McNamara analysis and other conventional cephalometric analysis have been defined previously (Ricketts, 1968; McNamara, 1984). A customized digitization regimen and analysis provided by Dentofacial Planner Software (Toronto, Ontario, Canada) were used for all the cephalograms. The cephalometric analysis required the digitization of 77 landmarks. The lateral cephalograms were hand traced by one investigator (YG) and then anatomical outlines and landmark identification were verified by another investigator (JAMcN). Any disagreement was resolved to the mutual satisfaction of both authors. All cephalograms were standardized at a magnification of 8 per cent.

Method error

Sixty randomly chosen lateral cephalograms were digitized and measured twice by the same examiner (YG) to determine whether any intra-examiner error resulted from landmark selection, tracing, and measurement error. A *t*-test for repeated measures was performed and no significant differences were noted.

Table 1 Comparison of the adult Chinese group cephalometric means and standard deviation (SD) between female and male subjects.

Cephalometric measurements	Female, <i>n</i> = 40		Male, <i>n</i> = 25		Female versus male		
	Mean	SD	Mean	SD	Mean difference	<i>P</i> value (Independent sample Student's <i>t</i> -test)	
Maxillary A-P skeletal							
SNA (°)	83.6	3.6	85.1	3.3	-1.5	0.121	NS
Pt A-N perpendicular (mm)	0.0	4.0	1.0	2.6	-1.0	0.259	NS
Co-Pt A (mm)	87.5	4.8	92.0	5.5	-4.5	0.001	***
Mandibular A-P skeletal							
SNB (°)	79.7	3.6	81.6	3.5	-1.9	0.046	*
Pg-N perpendicular (mm)	-6.6	9.4	-3.2	7.3	-3.4	0.133	NS
Co-Gn (mm)	119.4	7.9	125.4	6.9	-6.0	0.003	**
Intermaxillary							
ANB (°)	3.9	1.8	3.5	1.4	0.4	0.303	NS
Wits (mm)	-1.1	3.3	-0.6	2.6	-0.5	0.505	NS
Maximum/Minimum difference (mm)	31.8	4.8	33.4	4.0	-1.6	0.158	NS
Vertical skeletal							
Facial axis (°)	-2.2	7.7	-5.4	4.8	3.2	0.069	NS
MP (°)	30.4	5.9	28.2	6.6	2.2	0.167	NS
LAFH (mm)	69.4	6.2	74.9	4.8	-5.4	0.000	***
Maxillary dentoalveolar							
U1-SN (°)	115.0	7.5	114.6	6.3	0.4	0.81	NS
U1-Pt A vertical (mm)	4.5	2.4	5.2	2.4	-0.7	0.295	NS
Mandibular dentoalveolar							
IMPA (°)	94.5	7.1	94.4	5.4	0.1	0.96	NS
L1-APg (mm)	4.1	1.9	4.1	2.4	0.0	0.981	NS
Soft tissue							
UL to E line (mm)	-1.5	2.4	-0.3	2.2	-1.2	0.061	NS
LL to E line (mm)	0.9	2.5	1.7	2.2	-0.8	0.223	NS
Nasolabial angle (°)	103.6	9.9	104.9	9.5	-1.3	0.598	NS

NS, not significant. **P* < 0.05; ***P* < 0.01; ****P* < 0.001.

Table 2 Comparison of the adult Caucasian cephalometric means and standard deviation (SD) between female and male subjects.

Cephalometric measurements	Female, <i>n</i> = 60		Male, <i>n</i> = 30		Female versus male		
	Mean	SD	Mean	SD	Mean difference	<i>P</i> value (Independent sample Student's <i>t</i> -test)	
Maxillary A–P skeletal							
SNA (°)	83.3	3.7	84.5	3.2	−1.2	0.165	NS
Pt A–N perpendicular (mm)	0.5	3.3	−0.3	4.3	0.8	0.338	NS
Co–Pt A (mm)	91.0	7.4	99.4	7.8	−8.4	0.000	***
Mandibular A–P skeletal							
SNB (°)	79.9	3.3	82.0	2.9	−2.1	0.005	**
Pg–N perpendicular (mm)	−3.1	5.9	−2.8	8.0	−0.3	0.844	NS
Co–Gn (mm)	123.0	10.0	136.7	9.9	−13.7	0.000	***
Intermaxillary							
ANB (°)	3.4	1.9	2.5	1.9	0.9	0.034	*
Wits (mm)	−0.8	2.4	−0.9	2.6	0.1	0.836	NS
Maximum/Minimum difference (mm)	31.9	5.6	37.2	5.7	−5.3	0.000	***
Vertical skeletal							
Facial axis (°)	−1.6	3.4	−2.5	3.6	0.9	0.219	NS
MP (°)	23.5	4.8	23.4	5.0	0.1	0.936	NS
LAFH (mm)	65.0	6.9	71.7	6.9	−6.7	0.000	***
Maxillary dentoalveolar							
U1–SN (°)	114.6	6.3	113.8	6.7	0.8	0.574	NS
U1–Pt A vertical (mm)	4.3	2.0	4.4	1.9	−0.1	0.768	NS
Mandibular dentoalveolar							
IMPA (°)	96.6	7.5	92.5	7.4	4.1	0.018	*
L1–APg (mm)	2.2	1.3	2.3	1.7	−0.1	0.766	NS
Soft tissue							
UL to E line (mm)	−5.8	2.9	−6.2	3.0	0.4	0.516	NS
LL to E line (mm)	−3.8	2.4	−5.0	3.0	1.2	0.035	*
Nasolabial angle (°)	111.6	9.5	111.4	10.8	0.2	0.936	NS

NS, not significant. * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Statistical analysis

Descriptive statistics for the cephalometric measurements of the male versus female groups within each of the Chinese and Caucasian samples were contrasted with Student's *t*-tests after checking for normality of distribution with the Shapiro–Wilk test. Independent sample *t*-tests also were used to compare the values between the two ethnic samples.

Results

Sexual dimorphism

Chinese group. Statistically significant sexual dimorphism in the Chinese group was noted in effective midface length (Co–A) and effective mandibular length (Co–Gn). Chinese female subjects presented smaller midfacial and mandibular lengths, with the average values of 87.5 and 119.4 mm, respectively, compared with 92.0 and 125.4 mm for Chinese males ($P < 0.001$). Chinese females had a slightly retrusive mandible when assessed by SNB angle, with an average difference in males of 1.9 degrees ($P < 0.05$). A greater vertical facial dimension was found for Chinese

males when lower anterior face height (LAFH) was measured (74.9 mm; $P < 0.001$) compared with 69.4 mm in Chinese females. The upper and lower lips were slightly more protrusive in Chinese males assessed with the E line (Ricketts, 1968), but no statistical significance was noted (Table 1).

Caucasian group. Statistically significant sexual dimorphism in the Caucasian sample was noted in the effective lengths of the midface and mandible. Female subjects displayed a smaller midface and a shorter mandible, with an average value of 91.0 and 123.0 mm, respectively, compared with 99.4 and 136.7 mm in Caucasian males ($P < 0.001$). Caucasian females showed a slightly more convex skeletal pattern due to a more retrusive mandible, with an average ANB value of 3.4 degrees as opposed to 2.5 degrees in males ($P < 0.05$). The maxillo-mandibular differential was also significantly larger in Caucasian males, with a mean value of 37.2 mm compared with 31.9 mm in females ($P < 0.001$). A larger LAFH value was observed in males, with an average value of 71.7 mm ($P < 0.001$). In Caucasian females, the lower incisors were more proclined (96.6 degrees) compared with their male counterparts (92.5 degrees), when evaluated by measurement of the lower incisor to the mandibular plane

Table 3 Comparison of adult female group cephalometric means and standard deviation (SD) between Caucasians and Chinese.

Cephalometric measurements	Female (Caucasian), <i>n</i> = 60		Female (Chinese), <i>n</i> = 40		Female Caucasian versus female Chinese		
	Mean	SD	Mean	SD	Mean difference	<i>P</i> value (Independent sample Student's <i>t</i> -test)	
Maxillary A–P skeletal							
SNA (°)	83.3	3.7	83.6	3.6	–0.3	0.672	NS
Pt A–N perpendicular (mm)	0.5	3.3	0.0	4.0	0.5	0.485	NS
Co–Pt A (mm)	91.0	7.4	87.5	4.8	3.5	0.005	**
Mandibular A–P skeletal							
SNB (°)	79.9	3.3	79.7	3.6	0.2	0.774	NS
Pg–N perpendicular (mm)	–3.1	5.9	–6.6	9.4	3.5	0.022	*
Co–Gn (mm)	123.0	10.0	119.4	7.9	3.6	0.059	NS
Intermaxillary							
ANB (°)	3.4	1.9	3.9	1.8	–0.5	0.175	NS
Wits (mm)	–0.8	2.4	–1.1	3.3	0.3	0.528	NS
Maximum/Minimum difference (mm)	31.9	5.6	31.8	4.8	0.1	0.900	NS
Vertical skeletal							
Facial axis (°)	–1.6	3.4	–2.2	7.7	0.6	0.57	NS
MP (°)	23.5	4.8	30.4	5.9	–6.9	0.000	***
LAFH (mm)	65.0	6.9	69.4	6.2	–4.4	0.001	***
Maxillary dentoalveolar							
U1–SN (°)	114.6	6.3	115.0	7.5	–0.4	0.799	NS
U1–Pt A vertical (mm)	4.3	2.0	4.5	2.4	–0.2	0.645	NS
Mandibular dentoalveolar							
IMPA (°)	96.6	7.5	94.5	7.1	2.1	0.160	NS
L1–APg (mm)	2.2	1.3	4.1	1.9	–1.9	0.000	***
Soft tissue							
UL to E line (mm)	–5.8	2.9	–1.5	2.4	–4.3	0.000	***
LL to E line (mm)	–3.8	2.4	0.9	2.5	–4.7	0.000	***
Nasolabial angle (°)	111.6	9.5	103.6	9.9	8.0	0.000	***

NS, not significant. * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

($P < 0.05$). The lower lip was slightly more protrusive in Caucasian females, with an average value of –3.8 mm for the lower lip to E line measurement compared with –5.0 mm in males ($P < 0.05$) (Table 2).

Chinese–Caucasian comparisons.

Females. Chinese females had significantly smaller midfaces than Caucasian females, as evaluated by effective midface length ($P < 0.01$). Chinese females tended to have a slightly more retrusive position of point A relative to nasion perpendicular (0.0 mm) than Caucasian females (0.5 mm), but this difference was not statistically or clinically significant. A significantly retrusive chin point was noted in Chinese females (–6.6 mm) compared with their Caucasian counterparts (–3.1 mm; $P < 0.05$). The average value of LAFH (ANS–Me) was approximately 4.4 mm longer in Chinese females than in Caucasian females ($P < 0.001$). The mandibular plane was steeper in Chinese (30.4 degrees) compared with Caucasian (23.5 degrees; $P < 0.001$) females (Table 3).

The lower incisors were positioned more anteriorly in Chinese females than in their counterparts, as indicated by the measurement of the lower incisor to the APo line, with

an average difference of 1.9 mm ($P < 0.001$). The upper and lower lips of Chinese females were significantly more protrusive than in Caucasian females relative to the E line ($P < 0.001$). In addition, a more acute nasolabial angle was observed in Chinese (103.6 degrees) than in Caucasian (111.6 degrees; $P < 0.001$) females (Table 3).

Males. Smaller midfaces and shorter mandibles were observed in Chinese males compared with the Caucasian sample, with an average difference of 7.4 mm in midfacial length ($P < 0.001$) and 11.3 mm in mandibular length ($P < 0.001$; Table 4). No significant differences in maxillary and mandibular position were found with regard to the positions of point A or Pg relative to nasion perpendicular. The relationship of the maxilla to the mandible as measured by ANB and the maxillo-mandibular differential showed significant difference between Chinese and Caucasian males, with an average difference of 1.0 degree ($P < 0.05$) and 3.9 mm ($P < 0.01$), respectively. A greater vertical dimension of the face was seen in Chinese males with a value of –5.4 degrees for the facial axis angle compared with –2.5 degrees in Caucasian males ($P < 0.05$). A steeper mandibular plane angle was also noted in Chinese males

Table 4 Comparison of the adult male group cephalometric means and standard deviation (SD) between Caucasian and Chinese.

Cephalometric measurements	Male (Caucasian), <i>n</i> = 30		Male (Chinese), <i>n</i> = 25		Male Caucasian versus male Chinese		
	Mean	SD	Mean	SD	Mean difference	<i>P</i> value (Independent sample Student's <i>t</i> -test)	
Maxillary A–P skeletal							
SNA (°)	84.5	3.2	85.1	3.3	0.4	0.487	NS
Pt A–N perpendicular (mm)	−0.3	4.3	1.0	2.6	−1.3	0.192	NS
Co–Pt A (mm)	99.4	7.8	92.0	5.5	7.4	0.000	***
Mandibular A–P skeletal							
SNB (°)	82.0	2.9	81.6	3.5	0.4	0.666	NS
Pg–Na perpendicular (mm)	−2.8	8.0	−3.2	7.3	0.4	0.815	NS
Co–Gn (mm)	136.7	9.9	125.4	6.9	11.3	0.000	***
Intermaxillary							
ANB (°)	2.5	1.9	3.5	1.4	−1.0	0.035	*
Wits (mm)	−0.9	2.6	−0.6	2.6	−0.3	0.699	NS
Maximum/Minimum difference (mm)	37.3	5.7	33.4	4.0	3.9	0.007	**
Vertical skeletal							
Facial axis (°)	−2.5	3.6	−5.4	4.8	2.9	0.014	*
MP (°)	23.4	5.0	28.2	6.6	−4.8	0.005	**
LAFH (mm)	71.7	6.9	74.9	4.8	−3.2	0.058	NS
Maxillary dentoalveolar							
U1–SN (°)	113.8	6.7	114.6	6.3	−0.8	0.678	NS
U1–Pt A vertical (mm)	4.4	1.9	5.2	2.4	−0.8	0.215	NS
Mandibular dentoalveolar							
IMPA (°)	92.5	7.4	94.4	5.4	−1.9	0.311	NS
L1–APg (mm)	2.3	1.7	4.1	2.4	−1.8	0.003	**
Soft tissue							
UL to E line (mm)	−6.2	3.0	−0.3	2.2	−5.9	0.000	***
LL to E line (mm)	−5.0	3.0	1.7	2.2	−6.7	0.000	***
Nasolabial angle (°)	111.4	10.8	104.9	9.5	6.5	0.022	*

NS, not significant. * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Table 5 Descriptive statistics for the adult female group cephalometric means among Chinese, Caucasian, Japanese (Miyajima *et al.*, 1996), and Korean samples (Hwang *et al.*, 2002); SD, standard deviation; LAFH, lower anterior face height.

Cephalometric measurements	Chinese, <i>n</i> = 40		Japanese, <i>n</i> = 28		Korean, <i>n</i> = 30		Caucasian, <i>n</i> = 60	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Soft tissue								
UL to E line (mm)	−1.5	2.4	−2.5	1.9	0.0	1.9	−5.8	2.9
LL to E line (mm)	0.9	2.5	0.9	1.9	1.4	2.2	−3.8	2.4
Nasolabial angle (°)	103.6	9.9	92.2	8.7	92.0	9.5	111.6	9.5
Hard tissue								
SNA (°)	83.6	3.6	82.1	3.1	80.2	3.4	83.3	3.7
SNB (°)	79.7	3.6	78.8	3.1	77.9	3.5	79.9	3.3
ANB (°)	3.9	1.8	3.3	1.8	2.4	1.9	3.4	1.9
Facial axis (°)	−2.2	7.7	−3.5	4.0	—	—	−1.6	3.4
LAFH (mm)	69.4	6.2	72.7	4.4	70.4	3.0	65.0	6.9

compared with Caucasian males when the mandibular plane angle was measured, with an average difference of 4.8 degrees ($P < 0.01$) (Table 4).

The lower incisors were positioned more anteriorly relative to the APg line in Chinese males than in their counterparts, with average values of 4.1 and 2.3 mm, respectively ($P < 0.01$). Chinese males showed an overall

more protrusive facial profile than Caucasian males. The upper and lower lips of Chinese males were significantly more protrusive than those of Caucasian males relative to the E line, with an average difference of 5.9 and 6.7 mm, respectively ($P < 0.001$). The nasolabial angle was also more acute in Chinese males and the average difference was 6.5 degrees ($P < 0.05$) (Table 4).

Table 6 Descriptive statistics for the adult male group cephalometric means and standard deviation (SD) among Chinese, Caucasian, Japanese (Miyajima *et al.*, 1996), and Korean samples (Hwang *et al.*, 2002).

Cephalometric measurements	Chinese, <i>n</i> = 25		Japanese, <i>n</i> = 26		Korean, <i>n</i> = 30		Caucasian, <i>n</i> = 30	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Soft tissue								
UL to E line (mm)	-0.3	2.2	-2.9	2.2	-0.5	2.4	-6.2	3.0
LL to E line (mm)	1.7	2.2	-0.3	2.6	1.0	2.1	-5.0	3.0
Nasolabial angle (°)	104.9	9.5	90.7	10.4	91.1	8.1	111.4	10.8
Hard tissue								
SNA (°)	85.1	3.3	82.2	3.0	82.1	3.4	84.5	3.2
SNB (°)	81.6	3.5	79.4	3.4	79.5	3.6	82.0	2.9
ANB (°)	3.5	1.4	2.8	2.0	2.6	1.7	2.5	1.9
Facial axis (°)	-5.4	4.8	-4.2	3.2	—	—	-2.5	3.6
LAFH (mm)	74.9	4.8	75.1	4.1	73.0	4.1	71.7	6.9

Discussion

The current study revealed significant differences in craniofacial morphology between individuals of typical Chinese and Caucasian ancestry. Furthermore, there were significant gender differences in both ethnic samples. Sexual dimorphism has been identified previously in cephalometric evaluations of Chinese (Fu and Mao, 1965; Chan, 1972; Yen, 1973; Cooke and Wei, 1988; Wu *et al.*, 2007) and Caucasian (Riolo *et al.*, 1974; McNamara and Ellis, 1988; Miyajima *et al.*, 1996; Hwang *et al.*, 2002) populations.

The Chinese sample evaluated in the current study was restricted to those residing outside Guangdong and Fujian Provinces, which geographically occupy only a very small part of the land area of China. Therefore, the inclusion of subjects from more than two-thirds of the total provinces in the PRC in the current sample provides a reasonable representation of the indigenous mainland Chinese population. The data derived from this investigation, which can be differentiated from previous studies based on so-called Southern Chinese samples, will assist in diagnosis, treatment planning, and outcome evaluation for the majority of Chinese.

The results showed that Chinese females presented with smaller linear facial dimensions than Chinese males and the same was found in the Caucasian group. Chinese males showed a significant tendency towards longer vertical dimensions (Tables 1 and 2). The main differences between Chinese and Caucasian young adults (Tables 3 and 4) included smaller linear dimensions of the face in the Chinese sample, along with a significantly more hyperdivergent facial pattern in Chinese females and males when compared with their Caucasian counterparts. According to the soft tissue data, the Chinese samples exhibited significantly more protrusive upper and lower lips than Caucasians. The protrusion of the lower lip on the profile of the Chinese male and female subjects was associated with a significant labial inclination of the lower incisors.

The data derived from the current study can be compared indirectly with that derived from Hong Kong Chinese. Wu *et al.* (2007) evaluated lateral headfilms of 200 male and

205 female 12-year-old Hong Kong Chinese schoolchildren. A general comparison of these data, adjusted for the age difference between the two samples, indicate that the Hong Kong Chinese had more protrusive upper and lower dentitions, shorter LAFH, and smaller craniofacial dimensions than the typical Chinese considered in the current study.

Similarities and differences among Asian ethnic groups can be identified by reviewing cephalometric data of the three largest ethnic groups of Pacific Rim ancestry, Japanese, Korean, and Chinese. Miyajima *et al.* (1996) compared a sample of 54 Japanese adults (26 males and 28 females, 20–25 years of age) with near ideal occlusions and well-balanced faces with a group of 125 Caucasian adults (44 males and 81 females), a subsample of the same database used in the current investigation. Another study of Korean adults (30 males, mean age 18 years 9 months and 30 females, mean age 18 years 10 months) with similar enrollment criteria and the same Caucasian database (15 males and 27 females) was published by Hwang *et al.* (2002). Although the latter study focused primarily on the soft tissue profile, some general comments about both soft and hard tissue parameters can be made from analysis of selected published data that are presented in Tables 5 and 6.

With regard to the soft tissue profile, heterogeneity exists when Chinese adults are compared with Japanese and Korean adults, all with well-balanced faces as judged by investigators of the same ethnicity as the sample selected. The upper lip was most retrusive in Japanese relative to the E line, whereas Chinese male adults had the most protrusive upper lip (Table 6). Korean females and Chinese males presented with the most protrusive lower lip when compared with the other two ethnic groups. The Korean and Japanese groups showed similar values for the nasolabial angle (close to 90 degrees), whereas a more obtuse nasolabial angle (about 104 degrees) was observed in the Chinese adults. A possible explanation for this difference in angulation may be that Chinese adults have less prominent nasal tips and a steeper nasal bridge.

In comparison with the three Asian samples, Caucasians had a much flatter soft tissue profile with less protrusion of the

upper and lower lips relative to the E line. The nasolabial angle was also more obtuse, approaching 111 degrees for Caucasian males and females. The results of this soft tissue comparison were similar to previous observations that also indicated that the Chinese have a more convex profile than Caucasians (Chan, 1972; Yen, 1973; Lin, 1985; Foo, 1986; Cooke and Wei, 1988; So *et al.*, 1990; Lew, 1994; Moate and Darendeliler, 2002; Yeong and Huggare, 2004; Wu *et al.*, 2007)

A few comments also can be made regarding the hard tissue structures of the three Pacific Rim groups (Tables 5 and 6). Differences were found when Chinese females were compared with Japanese and Korean females. The SNA angle was 1.5 degrees larger in Chinese females than in Japanese females and 3.4 degrees larger than that in Korean females. Moreover, the sagittal position of the mandible, as indicated by the SNB angle, was more prominent in the Chinese females (79.7 degrees) than in the Japanese (78.8 degrees) or Korean (77.9 degrees) females.

Differences were also noted between the Chinese males and the males of the other two ethnic groups. In the Chinese males, point B was slightly more anterior than in the other two groups. Overall, the Chinese adults had a larger average ANB angle than Japanese or Korean adults. Both genders of all three groups had relatively long LAFH and vertical growth directions, as indicated by the facial axis angle. The largest LAFH was seen in the Japanese.

When the Caucasian group was added to the comparison of the hard tissues, there were differences among the Asian groups relative to the Caucasian group. For instance, LAFH in the Caucasian males (71.7 mm) was similar to the Koreans (73.0 mm) but shorter than in the Chinese (74.9 mm) and Japanese males (75.1 mm). Of the four groups considered, the Caucasians had the most orthognathic profile with the least protrusive lips.

Based on these results, it appears that the craniofacial morphology of the Chinese exhibits different craniofacial characteristics than other Asian ethnic groups. Thus, universal cephalometric norms are not appropriate for all Asian populations.

Conclusions

1. There were significant hard and soft tissue differences between Chinese and Caucasian young adults with normal occlusions and well-balanced faces.
2. Sexual dimorphism was present in both the Chinese and Caucasian groups considered.
3. Cephalometric characteristics for this Chinese population illustrate the ethnic differences not only from Caucasians but also from Pacific Rim ethnic groups.

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