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Morphology of Singapore Chinese

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SUMMARY The aims of this study were to provide a description of the craniofacial morphology of Singaporean Chinese children and to compare gender differences.

Lateral cephalometric radiographs were obtained of 81 Singaporean Chinese children (31 boys and 50 girls; mean age 12.7 and 12.5 years, respectively, standard deviation = 0.7) with Class I incisor relationships. The radiographs were traced and 27 hard and soft tissue cephalometric landmarks digitized. Fourteen linear and 13 angular cephalometric variables were obtained using the Neodigiplot™ computerized cephalometric analysis software.

A comparison of the genders showed that girls had greater maxillary and mandibular protrusion, but the upper and lower incisor inclinations were reduced. In addition, girls showed reduced facial convexity and reduced upper lip prominence. Pogonion to nasion perpendicular was greater for boys. Although not statistically significant, the values of intermaxillary protrusion and Wits showed a tendency for the girls towards a Class III skeletal base. The boys also had statistically significantly longer cranial base lengths, and anterior and posterior face heights.

Overall, the results reflect gender differences in both angular and linear cephalometric craniofacial measurements, which should be taken into account when establishing cephalometric reference data for Singaporean Chinese children.

Introduction

Since the introduction of cephalometrics by Broadbent (1931), cephalometric standards have been derived for various population groups. The use of cephalometrics extends from the study of facial form to the development of cephalometric norms for the diagnosis, management and outcome assessment of orthodontic care. However, it is apparent that Caucasian norms are inappropriate for application to different ethnic groups, as racial characteristics lead to important cephalometric variations.

Cooke and Wei (1989), in their study of southern Chinese children in Hong Kong, compared cephalometric data for 12-year-old Chinese children with that of Caucasian children and found them to have alveolar protrusion and bimaxillary proclination of the incisors. The Chinese soft tissue profile also displayed a less prominent and more obtuse nose and chin, but with more protrusive upper and lower lips.

Cephalometric standards have been derived for different ethnic groups and are reported in the literature, for example: Caucasians (Downs, 1948); Koreans (Suh, 1967); Japanese (Mitani, 1980); North Indians (Nanda and Nanda, 1969); Afro-Caribbean (Drummond, 1968).

There are a number of previous cephalometric studies of Chinese, including Yen (1973), Lin (1985) and Guo (1971) who studied Taiwanese Chinese, Wei (1965) who investigated Chinese students at the University of Adelaide, Chang (1964) whose research looked at American Chinese, Chan's (1972, 1974) studies of Hong Kong Chinese, Fu and Mao's (1975) data on Peking Chinese, and Foo's (1986) research on Malaysian Chinese university students.

It has also been shown that differences within the same ethnic group can exist. Uesato and Kinoshita (1978) noted that the craniofacial form of American-Japanese was different from their native counterparts. Huggare (1986, 1987, 1992) also observed differences in the craniofacial morphology and anatomy of the first cervical vertebra between Finns living in the north compared with a matched group of Finns living in the south.

With the wide geographical distribution of Chinese, there may also be craniofacial differences within this ethnic group. This would mean that Chinese norms derived for other Chinese populations may not be directly applicable to the local population.

There are limited published cephalometric reference data for Singaporean Chinese. Johnson (1958) and Johnson *et al.* (1978) studied Chinese children in Singapore using a handmade cephalostat. However, there was limited hard and no soft tissue analysis. Johnson (1958) undertook a simple cephalometric analysis in which he found SNA and SNB to be 83 and 78 degrees, respectively, giving an ANB angle of 5 degrees. In addition, MMPA was 32 degrees and the interincisal angle 129 degrees. The angular measurements between the incisors and the maxillary and mandibular planes were low at 109 and 90 degrees, respectively.

Lew (1992) analysed 48 tracings of Singaporean Chinese adults with aesthetically pleasing profiles. Using the analysis described by Legan and Burstone (1980), he found the Chinese facial form to be less convex (g–sn–pg') compared with Caucasians, with the maxilla more posteriorly located in the Chinese. In addition, the upper lip was more protrusive and the nasolabial angle less obtuse. In comparison with Holdaway's standards for Caucasians, he found the Chinese nose to be less prominent, the lip curvature greater, chin thickness decreased and the lips not harmonious with the H line.

In a later study, Lew (1994) obtained cephalometric data from 105 adult female subjects (35 Chinese, 35 Malay, 35 Indian) with good dental occlusion and pleasing profiles. For the Chinese subjects, he found SNA, SNB and ANB to be 84.6, 82 and 2.4 degrees, respectively and upper and lower lip protrusions 3.4 and 3.5 mm, respectively.

Local data on craniofacial morphology assists in the diagnosis, management and outcome assessment of orthodontic care. It is inaccurate to extrapolate results of studies based on other population groups. This study aimed to establish a cephalometric description of the craniofacial morphology of Singaporean Chinese children.

Subjects and methods

Eighty-one Singaporean children, all of whom had a standardized lateral cephalometric radiograph available, were consecutively selected from the National Dental Centre. The study sample comprised 50 girls [mean age 12.5 years, standard deviation (SD) = 0.7] and 31 boys (mean age 12.7 years, SD = 0.7). Children were included in the study if they had a Class I incisor relationship (British Standards Institute, 1983) and had not undergone any previous orthodontic treatment. Study models were available for all subjects for incisor classification.

Equipment

Cephalometric radiographs were taken by trained radiographers using a Cranex C SL 4/ PT-11 (Soredex-Finndent, Orion Corporation, Helsinki, Finland) radiographic unit with ear-posts. The magnification was calculated to be 10 per cent for the mid-sagittal structures.

The radiographs were traced onto acetate paper by one author (PY) and the cephalometric landmarks digitized (Calcomp Drawing board III 34240, Calcomp Inc., Anaheim, California, USA) attached to a personal computer (AST M166, AST Computer, Irvine, California, USA). Nineteen hard tissue and eight soft tissue landmarks were digitized (Table 1, Figure 1). Eight hard and soft tissue reference lines were constructed (Table 2). From these, 14 linear and 13 angular variables were obtained using the Neodigiplot™ computerized cephalometrc analysis software developed at the National University of Singapore in 1997 (Table 3).

All linear measurements were corrected for magnification differences prior to statistical analyses. Statistics were generated using the Statistical Package for Social Sciences 9.0 (SPSS Inc., Chicago, Illinois, USA).

Method error

The error involved in this study consisted of both operator and machine errors. The following methods were used to quantify the errors.

Duplicate determination of cephalometric landmarks. To reduce errors due to intra-operator variability, 10 lateral cephalometric radiographs were chosen at

Table 1 Hard and soft tissue landmarks.

ai	Apex inferius	The apex of the root of the most prominent lower central incisor.
as	Apex superius	The apex of the root of the most prominent upper central incisor.
ba	Basion	The most postero-inferior point on the margin of the foramen magnum.
co	Condylion	The most supero-posterior point on the condylar head.
gn	Gnathion	The most antero–inferior point on the symphysis of the chin constructed from a line drawn perpendicular to the line connecting menton and pogonion.
go	Gonion	The most postero–inferior point on the angle of the mandible.
id	Infradentale	The most antero-superior point on the lower alveolar margin.
ii	Incision inferius	The midpoint of the incisor edge of the most prominent lower central incisor.
is	Incision superius	The midpoint of the incisal edge of the most prominent upper central incisor.
me	Menton	The most inferior point on the mandibular symphysis.
n	Nasion	Situated at the frontonasal suture.
or	Orbitale	The most inferior point on the inferior orbital margin.
pg	Pogonion	The most anterior point on the mandibular symphysis.
po	Porion (anatomic)	The most superior point on the external auditory meatus.
pm	Pterygomaxillare	The intersection between the nasal floor and the posterior contour of the maxilla.
s	Sella	The centre of sella turcica.
sm	Supramentale	Point B. The most posterior point on the anterior contour of the lower alveolar process.
sp	Spinal point	The apex of anterior nasal spine.
ss	Subspinale	Point A. The most posterior point on the anterior contour of the upper alveolar process.
cm	Columella point	The most anterior point on the columella of the nose.
ct	Chin tangent point	The lower tangent point on the chin of the nose–chin line.
g	Glabella	The most prominent point on the forehead.
int	Lower nasal tangent point	The upper tangent on the nose of the nose–chin line.
li	Labrale inferius	The most prominent point of the prolabium of the lower lip.
ls	Labrale superius	The most prominent point on the prolabium of the upper lip.
pg’	Soft tissue pogonion	The most prominent point on the chin.
sn	Subnasale	The deepest point in the nasolabial sulcus.

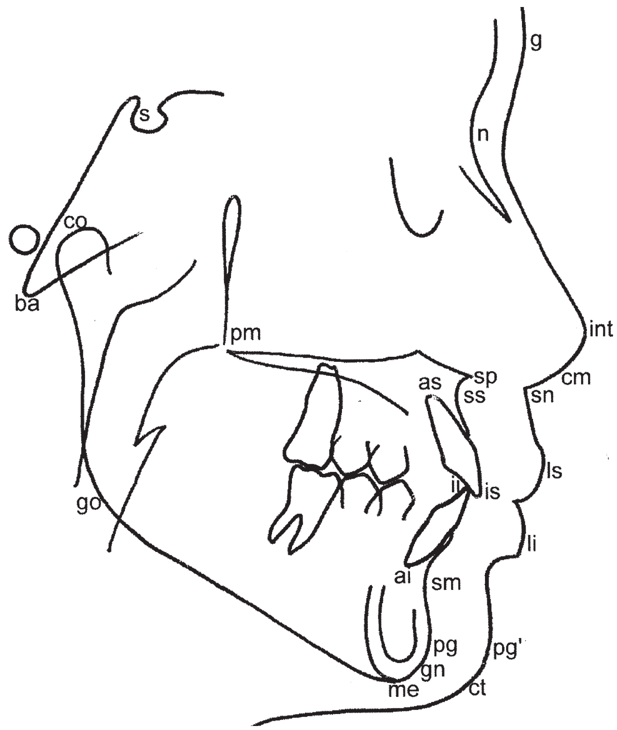

Figure 1 Hard and soft tissue cephalometric landmarks (see Table 1 for definitions).

random and re-traced on a separate session under identical conditions. The method error was assessed using Dahlberg's (1940) formula:

$$ME = \sqrt{(\Sigma d^2/2n)}$$

where d represents the difference in the value of the repeated readings and n is the number of repeated readings.

Testing the linearity of the digitizer. To ensure linearity of the digitizer, nine pin-holes were made in a piece of paper and the distance between the holes constituted eight lines of predetermined length. The lines were then digitized 10 times. This sheet of paper was moved across the recording area of the digitizing table to ensure that the area assessed corresponded with the recording area of the digitizer.

The actual lengths were predetermined using a steel rule with a vernier gauge, accurate to one decimal place. Ten sets of readings were obtained and the method error was calculated using the differences between consecutive paired values.

Single point digitization. To assess the accuracy of both the operator and the reproducibility of the point placement procedure, a single point was traced and digitized 20 times by the same operator. The values for the x and y co-ordinates were obtained. Consecutive readings were paired into 10 groups and the means, SD and standard errors were then calculated.

Statistics

Descriptive statistics were generated for both the Singaporean girls and boys. The variance of the distribution was compared using tests of skewness and kurtosis.

Comparative statistics between the girls and boys were generated using independent t-tests.

Results

Descriptive statistics (Table 4)

Singaporean boys. It was found that the maxillary (s–n–ss) and mandibular (s–n–sm) protrusion relative to the anterior cranial base was 80.2 ± 3.7 and 78.1 ± 3.3 degrees, respectively, with a mean value for intermaxillary protrusion (ss–n–sm) of 2.5 ± 1.5 degrees. Wits analysis showed a mean value of –4.8 ± 2.0 mm.

The mandibular plane angles relative to the maxillary plane (NL/ML) and anterior cranial base (NSL/ML) were 25.4 ± 4.4 and 34.1 ± 4.6 degrees, respectively.

Upper and lower incisor proclination to the respective maxillary (U1–NL) and mandibular (L1–ML) bases was 116.8 ± 4.7 and 99.1 ± 3.1 degrees, respectively, and interincisal angle (U1–L1) was 119.3 ± 6.3 degrees.

Relative to the E line, upper (ls–E line) and lower (li–E line) lip prominence was 2.5 and 3.5 mm, respectively.

Singaporean girls. The mean values for maxillary (s–n–ss) and mandibular (s–n–sm) protrusion were 82.0 ± 3.3 and 80.5 ± 3.2 degrees, respectively. Intermaxillary protrusion (ss–n–sm) was 1.9 ± 1.4 degrees and Wits analysis –4.9 ± 3.0 mm.

Table 2 Hard and soft tissue reference lines.

Frankfort horizontal line (FH)	A line drawn from the superior point of the anatomic porion to the inferior point of the orbitale.
Functional occlusal plane (FOP)	A line of best intercuspation between the premolars and first molars.
Mandibular line (ML)	A line passing from gonion through gnathion on the mandible.
Nasal line (NL)	A line through the spinale and pterygomaxillare.
Nasion–sella line (NSL)	A line from sella to nasion, representing the anterior cranial base.
Soft tissue nose–chin line (NCL)	Also called the aesthetic line. Drawn from a tangent of the upper tangent of the nose to the lower tangent point on the chin.

Table 3 Hard and soft tissue variables.

Cranial base	
s–n	Anterior cranial base linear dimension.
s–ba	Posterior cranial base linear dimension.
n–s–ba	Nasion–sella–basion angle representing the cranial base angle.
Jaws (sagittal)	
sp–pm	Maxillary length.
co–pg	Mandibular length.
s–n–ss	Sella–nasion–subspinale angle, representing maxillary protrusion in relation to anterior cranial base.
s–n–sm	Sella–nasion–submentale angle, representing mandibular protrusion in relation to anterior cranial base.
pg–n perpen	Distance of the pogonion to a line from the nasion, perpendicular to the Frankfort horizontal, representing mandibular protrusion.
'Wits'	Distance between AO and BO points on the functional occlusal plane (FOP). AO formed from subspinale (point A) perpendicular to the FOP. BO formed from supramentale (point B) perpendicular to the FOP. Represents the relationship of upper and lower jaws to each other, independent of anterior cranial base.
Jaws (vertical)	
n–me	Total anterior face height.
n–sp	Upper anterior face height.
sp–me	Lower anterior face height.
s–go	Total posterior face height.
s–pm	Upper posterior face height.
co–go	Ramus length.
NSL–NL	Maxillary plane angle relative to anterior cranial base.
NSL–ML	Mandibular plane angle relative to anterior cranial base.
NL–ML	Maxillary–mandibular plane angle.
Dental	
IL(i)–ML	Lower incisor proclination relative to mandibular base.
IL(s)–NL	Upper incisor proclination relative to maxillary base.
IL(s)–IL(i)	Interincisal angle.
Soft tissue	
cm–sn–ls	Nasolabial angle.
Ls/NCL	Upper lip prominence.
Li/NCL	Lower lip prominence.
g–sn–pg'	Facial convexity.

The angulation of the mandibular plane to the anterior cranial base (NSL/ML) was 33.9 ± 4.4 degrees and to the maxillary plane (NL/ML) 26.6 ± 4.1 degrees.

Upper and lower incisor proclination relative to the maxillary and mandibular planes was 119.2 ± 4.9 and 97.2 ± 4.8 degrees, respectively, and interincisal angle was 117.9 ± 8.6 degrees.

Upper (ls–E line) and lower (li–E line) lip prominence, relative to the E line, was 1.6 and 2.8 mm, respectively.

Gender comparison (Table 4)

Independent *t*-tests showed statistically significant differences in maxillary and mandibular protrusion (s–n–ss and s–n–sm), with girls showing greater maxillary and mandibular protrusion ($P = 0.027$ and $P = 0.002$, respectively). In addition, the girls showed statistically significant reduced facial convexity (g–sn–pg′; $P = 0.003$) and reduced upper lip prominence (ls–intct; $P = 0.008$). Measurements of intermaxillary protrusion (ss–n–sm) and Wits analysis showed that the girls had a tendency towards a Class III skeletal pattern, although these values were not statistically significant.

The pogonion to nasion perpendicular ($P = 0.006$) measurement was significant, with boys having a more retrusive chin point.

For the linear dimensions, boys had longer cranial lengths (s–n and s–ba; $P = 0.005$ and $P = 0.002$, respectively). Anterior (n–me, n–sp; $P = 0.01$ and $P = 0.001$, respectively) and posterior (s–go, co–go; $P = 0.005$ and $P = 0.002$, respectively) face height measurements were also significantly greater for the boys.

Statistically significant differences were noted for upper and lower incisor proclination to the maxillary and mandibular planes. Boys had greater upper incisor proclination ($P = 0.03$) but reduced lower incisor proclination ($P = 0.036$). The measurement of the upper lip to the E line was also greater for boys ($P = 0.008$).

Duplicate determination of landmarks (Table 5)

Statistically significant differences were detected in duplicate determination for anterior cranial base length (s–n; $P = 0.015$), mandibular length (co–pg; $P = 0.026$) and interincisal angle (U1/L1; $P = 0.003$).

Discussion

Sampling method

The subjects were selected from those individuals who had a lateral cephalometric radiograph taken for diagnostic purposes. This introduced sampling bias into the study.

The group was selected based on a Class I incisor relationship, as derived from the British Standards

Table 4 Descriptive statistics for craniofacial characteristics in Singaporean Chinese boys ($n = 31$) and girls ($n = 50$).

Variable	Mean (boys)	SD (boys)	Mean (girls)	SD (girls)	*P* value (gender difference)
s–n (mm)	63.6	2.8	61.9	3.5	0.020*
s–ba (mm)	45.8	2.7	44.4	3.0	0.043*
sp–pm (mm)	46.8	2.5	45.8	3.1	0.106
co–pg (mm)	100.7	5.1	100.2	5.8	0.642
n–me (mm)	113.0	6.4	109.2	6.2	0.010**
n–sp (mm)	52.0	3.7	49.4	3.2	0.001**
sp–me (mm)	62.6	4.1	61.2	4.3	0.153
s–go (mm)	72.4	5.5	68.7	5.7	0.005**
s–pm (mm)	46.6	2.9	45.7	3.3	0.242
co–go (mm)	48.2	4.4	45.1	4.3	0.002**
s–n–ss (°)	80.2	3.7	82.0	3.3	0.027*
s–n–sm (°)	78.1	3.3	80.5	3.2	0.002**
ss–n–sm (°)	2.5	1.5	1.9	1.4	0.053
NSL/NL (°)	8.7	2.9	7.3	3.3	0.054
NSL/ML (°)	34.1	4.6	33.9	4.4	0.882
NL/ML (°)	25.4	4.4	26.6	4.1	0.194
U1/NL (°)	116.8	4.7	119.2	4.9	0.036*
L1/ML (°)	99.1	3.1	97.2	4.8	0.030*
U1/L1 (°)	119.3	6.3	117.9	8.6	0.445
cm–sn–ls (°)	100.5	8.9	99.9	7.4	0.769
g–sn–pg' (°)	23.1	4.5	20.1	4.1	0.003**
ls–intct (mm)	2.5	1.9	1.6	1.1	0.008**
li–intct (mm)	3.5	2.1	2.8	1.7	0.118
Wits (mm)	–4.8	2.0	–4.9	3.0	0.868
pg–nasion ⊥ (mm)	–7.0	5.0	–3.9	4.7	0.006**

*$P < 0.05$; **$P < 0.01$.
SD, standard deviation.

Institute (1983). Previous studies have used differing selection criteria. Some were randomly collected and unselected, but most based their selection on occlusal evaluation, facial aesthetics, or both.

Chan (1972) and Lin (1985) selected subjects with clinically excellent occlusions where the molars were Class I with good intercuspation and, in addition, there was a pleasing facial profile. Similarly, Chang (1964) and Foo (1986) derived their samples based on acceptable occlusions and pleasing facial profiles. Lew (1992), in his soft tissue study using Chinese adults, selected his sample based on a pleasing profile and intact dentition, but with no exclusion of those with a history of orthodontic treatment.

Sampling based on 'pleasing aesthetics' is subjective and introduces the biases of the judges and is thus not a randomized representation of the Chinese population. The selection of subjects may also be influenced by other factors, such as hair style and colour.

There have been very few cephalometric investigations using random samples. Johnson (1958) used a random sample but it was based on data from one school only. Cooke and Wei (1988) obtained a sample of Chinese children in Hong Kong where schools were selected randomly and the children selected using random number tables.

True cephalometric norms are difficult to establish due to the difficulty in defining the selection criteria. Assessments based on 'pleasing profiles' and 'satisfactory occlusions' are subjective. However, random samples are difficult to obtain due to ethical reasons and radiological restrictions.

In this study, statistically significant differences were detected in duplicate determinations of s–n, co–pg and U1/L1, as shown in Table 5. Poor landmark identification of incisor inferius and superius, apex inferius and superius, or a combination of the two, may have affected interincisor angulation, U1/L1. Similar findings were noted in a cephalometric study by Midtgård *et al.* (1974), where the apices of the upper and lower incisors were associated with large error measurements.

The findings from this study are also in agreement with Cooke and Wei (1991), who found poor reproducibility for gonion and the incisor long axes.

Results

Previous studies of Singapore Chinese subjects have used adults (Lew, 1992, 1994) and only one investigated Singaporean children (Johnson, 1958). However, this study used a handmade cephalostat, which could affect the reproducibility of the measurements. It is impossible to compare the results of the present study with other investigations based on adults because of hard and soft tissue changes with growth.

Table 5 Duplicate determination of 15 pairs of cephalometric radiographs.

Variable	Mean	Two-tailed significance	Dahlberg's method error [$\sqrt{(\Sigma d^2/2n)}$]
s–n	69.6		
	69.3	0.015*	0.068
s–ba	49.0		
	48.6	0.501	0.066
sp–pm	49.4		
	50.1	0.243	0.133
co–pg	109.0		
	110.7	0.026*	0.303
n–me	120.2		
	120.0	0.705	0.040
n–sp	55.2		
	55.1	0.860	0.022
sp–me	66.1		
	66.3	0.562	0.027
s–go	76.7		
	76.1	0.436	0.099
s–pm	50.5		
	50.9	0.131	0.077
co–go	50.9		
	50.8	0.875	0.031
s–n–ss	80.5		
	81.2	0.184	0.133
s–n–sm	79.2		
	79.9	0.169	0.122
ss–n–sm	1.7		
	1.7	0.946	0.002
NSL/NL	8.0		
	7.5	0.575	0.082
NSL/ML	33.7		
	33.5	0.861	0.024
NL/ML	25.7		
	26.0	0.502	0.058
L1/ML	95.6		
	96.6	0.069	0.210
U1/NL	118.1		
	119.3	0.205	0.188
U1/L1	122.1		
	118.9	0.003**	0.588
ls–intct	2.4		
	2.4	0.800	0.005
li–intct	3.4		
	3.4	0.833	0.004
cm–sn–ls	100.9		
	101.4	0.820	0.095
g–sn–pg'	20.9		
	20.7	0.505	0.031
Wits	–5.8		
	–6.0	0.571	0.040
pg–nasion ⊥	–5.3		
	–5.8	0.551	0.075

$*P < 0.05$; $**P < 0.01$.

Singaporean boys

Previous studies by Wei (1968), Lin (1985) and Foo (1986) used adult Chinese samples. It would be expected that the adult measurements would be larger than those of the present study. However, Foo (1986) found smaller anterior face height measurements in her sample of adults even when compared with the present 12-year-old sample. This could be due to the differences in the method of measuring anterior face height. The present study measured directly from point to point and it is possible that other investigations measured from a specific point to a reference line.

The Singaporean boys had an ANB angle of 2.5 degrees, much lower than the 5 degrees found by Johnson (1958). He stated that his findings were due to the shortcomings of using ANB angle, which may be affected by the posterior positioning of nasion, thus exaggerating the true ANB difference.

The value for the Wits analysis was –4.8 mm, close to that of –4.9 mm found by So *et al.* (1990) in their study of southern Chinese boys.

The mandibular plane angle was found to be 25.4 degrees, which is in contrast to the higher value of 32 degrees in the Johnson *et al.* (1978) study of Singaporean children.

Upper and lower lip protrusion was assessed with reference to Ricketts' E line and measured 2.5 and 3.5 mm, respectively. This suggests more lip protrusion than in Malaysian Chinese where the values were –0.34 and 1.24 mm (Foo, 1986), but less than the Hong Kong Chinese with values of 3.1 and 4.3 mm (Cooke and Wei, 1988). When comparing the present study with that of Foo (1986), it is likely that the differences are age related, where there are soft tissue changes with growth and the lips consequently become less protrusive.

Singaporean girls

The ANB angle found in this study was 2.5 degrees. This is close to the value of 2.4 degrees found by Lew (1994) in his sample of Singaporean Chinese adult females. The values for SNA (82.0 degrees) and SNB (80.5 degrees) were slightly lower than those reported by Lew (1994) of 84.6 and 81.0 degrees, respectively. The Wits measurement of –4.9 mm was close to the –4.5 mm reported by So *et al.* (1990) in their study of southern Chinese girls.

The facial convexity angle for the girls in this study was 20.1 degrees, which contrasts with the much smaller angle of 10.5 degrees reported by Lew (1992). The girls in the present study also had a mean nasolabial angle of 99.9 degrees, slightly higher than the 95 degrees found by Lew (1994). These differences may be due to the soft tissue changes that occur with age, as Lew (1994) had an older sample ranging from 18 to 24 years of age.

Gender differences

The results of the present study revealed a statistically significant difference in maxillary and mandibular prognathism between boys and girls, with girls showing greater maxillary and mandibular protrusion ($P = 0.027$ and $P = 0.002$, respectively). Measurements of pogonion to nasion perpendicular also showed statistically significant differences, with the girls showing greater mandibular prognathism. In addition, measurements of intermaxillary protrusion (ss–n–sm) and Wits analysis showed a trend towards a Class III skeletal pattern for the girls, although these values were not statistically significant.

One reason could be due to the differences in timing of the pubertal and mandibular growth spurts. It is known that girls experience an earlier pubertal growth spurt than boys. Marshall and Tanner (1986) reported the mean ages of the somatic pubertal growth spurt to be 14.1 years for boys and 12.1 years for girls. However, there is still controversy with regard to the existence of a craniofacial growth spurt. Mitani (1973) concluded that both boys and girls experience growth spurts in the linear dimensions of the cranial base, maxilla and mandible. Lewis *et al.* (1985) also found that pubertal growth spurts were common in both the cranial base and the mandible.

In contrast, recent studies have not been able to conclusively demonstrate a craniofacial growth spurt. Bishara (1981) examined the changes in mandibular dimensions and the relationship to standing height between 8 and 17 years of age and found that mandibular growth proceeded at a relatively constant rate. Similarly, Moore *et al.* (1990) also concluded that the craniofacial growth spurt could not be consistently observed on an individual basis.

In addition, the sequence of events of the somatic pubertal and craniofacial growth spurts has also been debated. Hunter (1966) reported that the peak height velocity and pubertal peaks for facial dimensions are coincident. He found this to be at 14.1 years for boys and 11.8 years for girls. However, other investigators, such as Baughan *et al.* (1979), found that maximum facial growth lags behind peak height velocity.

In this study, the patients had a mean age of 12.5 years for girls and 12.7 years for boys. It is postulated that the girls had experienced a mandibular growth spurt whereas the boys had not. This may explain the trend towards a Skeletal III pattern for the girls when compared with the boys.

Wei (1968) found that the maxillary angles of basal and alveolar prognathism (s–n–ss and s–n–sp) were slightly greater in females than in males, although not statistically significant. However, he found that the mandibular prognathic angles were almost identical for both sexes. It appears from his study, that females had a tendency to maxillary prognathism, which was described as a secondary sexual characteristic by Martin (1957) and Abbie (1947).

Wei (1969) found no significant gender differences in angular measurements, and concluded that there was a close resemblance of craniofacial shape in male and female Chinese subjects, as in other population groups. However, almost all linear measurements were significantly greater in males than females.

Cooke and Wei (1988) also reported similarities when comparing Chinese boys and girls using radiographic superimpositioning. The male profile was larger by approximately 1–2 per cent in overall linear dimensions, with total face height 1.4 per cent greater. Most angular measurements showed no significant gender differences.

Foo (1986), in comparing Malaysian males and females, found no significant differences in angular measurements, but the linear measurements were smaller for females than males. In the present study, anterior and posterior cranial base lengths (n–s and s–ba) were significantly larger for boys. The linear face height measurements (n–sp, n–me, s–go and co–go) were also significantly greater for boys. All other linear measurements, though not statistically significant, showed a tendency towards larger measurements for boys.

The lower incisors were less protrusive in boys relative to the mandibular plane. This is in contrast to Cooke and Wei (1988), who found less protrusive lower incisors in girls. The current study also showed that the upper incisors to maxillary plane angle was lower in girls compared with boys, although none of the previous studies has reported significant differences for this particular measurement.

In terms of soft tissue measurements, there was significantly greater protrusion of the upper and lower lips in boys. This agrees with the findings of Cooke and Wei (1988), although Foo (1986) found the lips to be more protrusive in Chinese females.

Conclusions

The results give a description of the craniofacial morphology of Singaporean children based on a Class I incisor classification.

Gender comparisons using intermaxillary angle, Wits analysis, pogonion to nasion perpendicular and facial convexity revealed a trend towards a Class III skeletal pattern for girls, although the values were not statistically significant for intermaxillary angle or Wits measurements. In addition, the girls had greater maxillary and mandibular protrusion. With regard to the soft tissues, the girls had reduced upper lip protrusion and a reduced facial convexity.

For the linear dimensions, the boys showed longer cranial base lengths as well as greater anterior and posterior face heights. Other linear dimensions also showed a trend towards greater values for the boys.

In conclusion, the results showed both linear and angular differences in craniofacial morphology between boys and girls. The data provide useful reference cephalometric values for Singaporean Chinese children.

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