

## Cephalometric analysis for Chinese adults with skeletal 1 craniofacial morphology

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**Using Steiner, Downs and Northwestern analysis and Tweed triangle's parameters, we examined the facial characteristics of 20 male and 23 female Chinese adults with skeletal 1 malocclusion selected from an orthodontic clinic at Guangdong Pharmaceutical University, in China. Angular and linear measurements were determined. In comparison with pre-existing measurement values of Chinese children with skeletal 1 craniofacial morphology, maxilla showed more protruded and mandible showed more retruded. Mandibular anterior teeth showed more lingual inclination. Lower facial height was shorter. Compared to Japanese adults with skeletal 1 craniofacial morphology, mandible showed more retruded. Maxillary anterior teeth showed more labial inclination. Lower facial height was shorter. Compared to Caucasian adults with skeletal 1, maxilla showed more protruded and mandible showed more retruded. Maxillary and mandibular anterior teeth showed more labial inclination. Lower facial height was shorter. These results demonstrate that Chinese adults with skeletal 1 malocclusion tend to have forwardly positioned maxilla, mandible, and smaller facial height than the Japanese and Caucasians. In addition, the occlusal plane was found to have less inclination in the Chinese than in the Japanese, suggesting that the orthodontic treatment of Japanese individuals with skeletal 1 malocclusion will be easier than that of the Chinese. (*J Osaka Dent Univ* 2022; 56: 71-77)**

**Key words: Cephalometric radiography; Steiner analysis; Chinese adults; Skeletal 1 craniofacial morphology**

### INTRODUCTION

Numerous studies have been conducted on craniofacial growth and development and ethnic characteristics, with the reference values being means and standard deviations obtained by cephalometric analysis of maxillofacial morphology with normal occlusion.<sup>1,2</sup> Measurement methods for Caucasians and Japanese have been standardized and applied clinically in the orthodontic field.<sup>3-5</sup> Numerous reports have been published on the differences between the craniofacial morphology of Japanese and Caucasian,<sup>6-9</sup> enabling comparison and evaluation of craniofacial morphological characteristics, growth and development patterns, and relationships between the dentition and dental arch and the cranio-

maxillofacial region. Steiner analysis, based on the principle that the position of the mandibular central incisors plays an important role in facial esthetics, focuses on the relationships of the  $\angle$  ANB with the maxillary and mandibular central incisor inclination and the positions of the incisal edges of the maxillary and mandibular central incisors. Thus, it can be used to establish the occlusal relationships of the anterior teeth based on each patient's  $\angle$  ANB, setting these as treatment targets.<sup>10</sup> In addition, when setting treatment targets, Steiner emphasized the need to take into consideration age, sex, ethnicity, growth rate, and individual differences.<sup>11</sup> However, with respect to ethnicity, insufficient research has been performed on the relationships between the craniofacial complex and the dental arch in Chi-

nese. Particularly, no systematic research has been performed in relation to the reference values for adults whose growth and development has completed.

In this study, we compared the parameters of Steiner's analysis that determine the craniofacial morphological characteristics of Chinese adults with skeletal 1 malocclusion with Chinese children, Japanese adults, Japanese American adults and Caucasians with skeletal 1 with craniofacial morphology.

## MATERIALS AND METHODS

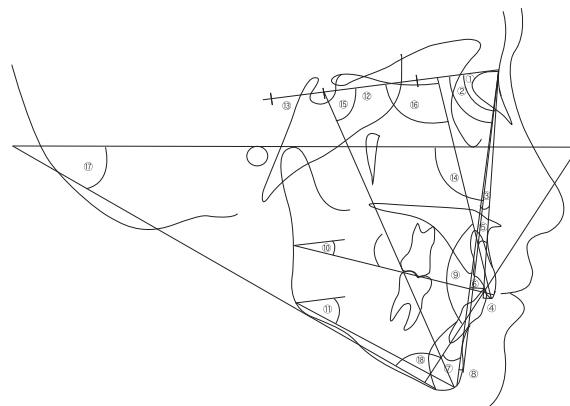
### Subjects

The subjects of this study, whose chief complaint were malocclusions with skeletal 1 craniofacial morphology, visited an orthodontic clinic at Guangdong Pharmaceutical University, in China. Among the adult patients who received orthodontic treatment, a total of 43 people were selected (20 males and 23 females, age range). The followings were inclusion criteria: an  $1.0^\circ \leq \angle ANB \leq 4.0^\circ$ , no abnormalities in the number of teeth except wisdom teeth, no morphological abnormalities in the region from the central incisors to the second molars, all tooth eruptions completed, correct interdigitation of the maxillary and mandibular teeth on both right and left sides, normal proximal centrifugal relationships of the maxillary and mandibular dental arches, and overbite and overjet within 1 to 3 mm (Table 1).

### Methods

Using cephalograms of Chinese adult with skeletal 1 craniofacial morphology selected based on the above criteria, 14 parameters of Steiner's analysis, two parameters of Downs analysis, one parameters

of the Northwestern method, and three parameters of Tweed's triangle were conducted. Student's *t*-test was performed for each measured value and the values were then compared and evaluated against pre-existing Japanese adults,<sup>4</sup> Japanese American adults,<sup>12</sup> Caucasian adults,<sup>10</sup> and Chinese children measurements values<sup>13-15</sup> using SPSS statistics 26.0 (International Business Mechanics Corporation. Armonk, NY, USA). (Fig. 1).



**Fig. 1** Measurements on the lateral cephalogram. ①  $\angle$  SNA (angle), ②  $\angle$  SNB (angle), ③  $\angle$  ANB (angle), ④ U1 to NA (mm) (shortest distance from edge of the maxillary central incisor to the NA line), ⑤  $\angle$  U1 to NA (angle) (angle formed by the NA line and the axis of the maxillary central incisor), ⑥ L1 to NB (mm) (shortest distance from edge of the mandibular central incisor to the NB line), ⑦  $\angle$  L1 to NB (angle) (angle formed by the NB line and the axis of the mandibular central incisor), ⑧ Po to NB (mm), ⑨  $\angle$  Interincisal (angle), ⑩  $\angle$  Occlusal to SN (angle), ⑪  $\angle$  GoGn to SN (angle), ⑫ SL (mm) (distance from S to the point (L) of the intersection formed by a line from the most anterior point of the mandible (Po) to the SN plane), ⑬ SE (mm) (distance from S to the point (E) of the intersection formed by a line from the most distal point of the head of the condyle perpendicular to the SN plane), ⑭ Facial angle, ⑮ Y axis (angle), ⑯ U1 to SN (angle), ⑰ FMA, and ⑱ IMPA.

**Table 1** Subjects in the present study

Subjects	Chinese adults (Zhu)	Japanese-American children (Uesato)	Chinese children (Chen)	Chinese children (Guo)	Chinese children (Wang)	Japanese children (Miura)
Number	43 (20 M, 23 F)	100 (25 M, 25 F)	78 (40 M, 38 F)	96 (50 M, 46 F)	69 (34 M, 35 F)	90 (40 M, 50 F)
Range of ages	19 y 6 m – 34 y 2 m	11 y 6 m – 18 y 6 m	11 y 0 m – 13 y 10 m	11 y 0 m – 13 y 0 m	12 y 0 m – 12 y 11 m	7 y 11 m – 12 y 4 m
Mean age	23 y 9 m	14 y 6 m	11 y 11 m	12 y 4 m	12 y 6 m	10 y 9 m

## RESULTS

Comparison between males and females among Chinese adults with skeletal 1 malocclusion included in this study showed significant differences with respect to the following parameters of Steiner's analysis:  $\angle$  SNA,  $\angle$  SNB,  $\angle$  ANB, U1 to NA (mm), U1 to NA (angle), L1 to NB (mm),  $\angle$  Occl to SN,  $\angle$  GoGn to SN, and SL. Regarding the Downs and Northwestern methods, a significant difference was

found in the IMPA. When the means of each of the parameters in the Downs and Northwestern methods in Chinese adults with skeletal 1 malocclusion were compared with those of Japanese adults,<sup>4</sup> the former had greater Facial angle,  $\angle$  U1 to SN and IMPA, and smaller Y-axis and FMA among males and females (Tables 2, 3).

The  $\angle$  SNA,  $\angle$  SNB, U1 to NA (angle), Po to NB, and SL were significantly greater, and L1 to NB (angle), Interincisal angle, and  $\angle$  Occl to SN were

**Table 2** Comparison of measurements for males and females

Parameter	Chinese male adults (M) n = 20	Chinese female adults (F) n = 23	t - test (M and F)
$\angle$ SNA (angle)	83.75 $\pm$ 3.91	81.25 $\pm$ 4.42	*
$\angle$ SNB (angle)	80.91 $\pm$ 4.86	77.89 $\pm$ 4.23	*
$\angle$ ANB (angle)	2.84 $\pm$ 1.82	3.36 $\pm$ 1.82	*
U1 to NA (mm)	6.87 $\pm$ 3.52	5.20 $\pm$ 2.95	*
U1 to NA (angle)	30.11 $\pm$ 8.16	28.32 $\pm$ 8.29	*
L1 to NB (mm)	7.36 $\pm$ 3.01	5.69 $\pm$ 2.81	*
L1 to NB (angle)	28.83 $\pm$ 6.48	28.32 $\pm$ 8.29	NS
Po to NB (mm)	1.20 $\pm$ 1.00	1.56 $\pm$ 1.06	NS
Interincisal (angle)	118.20 $\pm$ 8.58	120.56 $\pm$ 12.11	NS
Occl to SN (angle)	15.54 $\pm$ 7.30	18.05 $\pm$ 6.46	*
GoGn to SN (angle)	31.04 $\pm$ 7.04	32.14 $\pm$ 5.50	NS
SL (mm)	40.08 $\pm$ 5.17	37.11 $\pm$ 12.13	*
SE (mm)	19.72 $\pm$ 1.98	19.04 $\pm$ 6.27	NS
Facial angle (angle)	85.84 $\pm$ 3.08	86.24 $\pm$ 4.34	NS
Y axis (angle)	63.41 $\pm$ 2.80	63.48 $\pm$ 4.84	NS
UI-SN (angle)	111.00 $\pm$ 8.58	109.57 $\pm$ 10.35	NS
FMA	25.44 $\pm$ 5.45	25.37 $\pm$ 6.78	NS
IMPA	95.61 $\pm$ 9.63	96.80 $\pm$ 9.29	*

Mean  $\pm$  SD, NS: Not significant, \*p < 0.05.

**Table 3** Comparison of measurements for Chinese and Japanese adults

Parameter	Chinese male adults (Zhu) n = 20	Chinese female adults (Zhu) n = 23	Japanese male adults (Iizuka) n = 50	Japanese female adults (Iizuka) n = 50
Facial angle (angle)	85.84 $\pm$ 3.08	86.24 $\pm$ 4.34	85.07 $\pm$ 5.76	84.83 $\pm$ 3.05
Y-axis (angle)	63.41 $\pm$ 2.80	63.48 $\pm$ 4.84	65.71 $\pm$ 3.27	65.38 $\pm$ 5.63
UI-SN (angle)	111.00 $\pm$ 8.58	109.57 $\pm$ 10.35	108.94 $\pm$ 5.53	104.54 $\pm$ 5.55
FMA	25.44 $\pm$ 5.45	25.37 $\pm$ 6.78	26.25 $\pm$ 6.34	28.81 $\pm$ 5.23
IMPA	95.61 $\pm$ 9.63	96.80 $\pm$ 9.29	94.67 $\pm$ 7.21	96.33 $\pm$ 5.78

**Table 4** Comparison of pre-existing measurement values for Chinese

Parameter	Chinese adults (Zhu)	Chinese children (Chen)	Chinese children (Guo)	Chinese children (Wang)	t-test (Zhu and Chen)	t-test (Zhu and Guo)	t-test (Zhu and Wang)
∠SNA (angle)	82.41 ± 4.37	83.52 ± 3.62	81.5 ± 3.5	82.21 ± 3.24	*	*	NS
∠SNB (angle)	79.29 ± 4.78	80.38 ± 3.39	77.7 ± 3.2	79.15 ± 2.92	*	*	NS
∠ANB (angle)	3.12 ± 21.53	3.15 ± 1.51	4.0 ± 1.8	3.07 ± 1.54	NS	*	NS
U1 to NA (mm)	5.98 ± 3.48	6.08 ± 1.70	6.1 ± 2.0	4.17 ± 1.82	NS	NS	*
U1 to NA (angle)	29.15 ± 8.28	25.22 ± 4.59	24.2 ± 5.4	22.49 ± 4.25	*	*	*
L1 to NB (mm)	6.46 ± 3.02	6.89 ± 1.48	7.8 ± 2.0	4.76 ± 2.14	NS	*	*
L1 to NB (angle)	28.30 ± 6.81	29.49 ± 4.61	31.6 ± 5.5	27.09 ± 6.54	*	*	*
Po to NB (mm)	1.40 ± 1.05	0.09 ± 1.13	0.3 ± 1.4	-0.11 ± 1.14	*	*	*
Interincisal (angle)	119.46 ± 12.16	122.14 ± 6.83	119.9 ± 8.5	127.35 ± 7.93	*	NS	*
Occl to SN (angle)	16.89 ± 6.97	16.58 ± 3.73	18.8 ± 3.8	19.70 ± 3.77	NS	*	*
GoGn to SN (angle)	31.63 ± 6.38	32.17 ± 4.59	33.0 ± 4.4	32.79 ± 4.19	*	*	*
SL (mm)	49.22 ± 10.22	48.62 ± 7.22	42.9 ± 6.7	48.39 ± 5.49	*	*	*
SE (mm)	20.88 ± 6.11	20.13 ± 3.16	20.0 ± 2.9	20.82 ± 2.91	NS	NS	NS

**Table 5** Comparing Zhu's results with pre-existing values for Japanese—Americans and Caucasians

Parameter	Chinese (Zhu)	Japanese—Americans (Uesato)	Caucasian (Steiner)
∠SNA (angle)	82.41 ± 4.37	79.8	82
∠SNB (angle)	79.29 ± 4.78	77	80
∠ANB (angle)	3.12 ± 21.53	2.8	2
U1 to NA (mm)	5.98 ± 3.48	4.1	4
U1 to NA (angle)	29.15 ± 8.28	22.2	22
L1 to NB (mm)	6.46 ± 3.02	4.7	4
L1 to NB (angle)	28.30 ± 6.81	25.5	25
Po to NB (mm)	1.40 ± 1.05	2.4	—
Interincisal (angle)	119.46 ± 12.16	128.3	131
Occl to SN (angle)	16.89 ± 6.97	18.3	14
GoGn to SN (angle)	31.63 ± 6.38	34.4	32
SL (mm)	49.22 ± 10.22	46.8	51
SE (mm)	20.88 ± 6.11	21.5	22

significantly smaller in Chinese adults with skeletal 1 malocclusion than in Chinese children on many paragraphs (Table 4). The ∠SNA, ∠ANB, U1 to NA (mm), U1 to NA (angle), L1 to NB (mm), L1 to NB (angle), and SL were greater and Po to NB, Interincisal angle, ∠Occl to SN, and ∠GoGn to SN, were smaller in Chinese adults with skeletal 1 malocclusion than in Japanese Americans. The ∠ANB, U1 to NA (mm), U1 to NA (angle), L1 to NB (mm), L1 to NB (angle), and ∠Occl to SN, and SE were greater and Interincisal angle and SL were smaller in Chinese adults with skeletal 1 malocclusion than

in Caucasian adults (Table 5).

## DISCUSSION

### Materials

In this study, the maxillofacial morphological characteristics of Chinese adults with skeletal 1 malocclusion were investigated by Steiner's analysis. Reference values based on cephalometric analysis have been reported for Japanese of various age groups by Iizuka *et al.*,<sup>4</sup> Nagaoka *et al.*,<sup>16</sup> and Miura *et al.*,<sup>17</sup> thus, comparison with the Japanese was not difficult. However, in the case of the Chinese,

although there have been reports on Chinese children,<sup>13-15</sup> there were no previous reports of reference values obtained by cephalometric analysis in adults. In the current study, analysis results were compared between Chinese adults with skeletal 1 malocclusion and Chinese children with skeletal 1 malocclusion, and the growth and development characteristics of Chinese were thus investigated.

### Growth and development

No longitudinal data were obtained on growth and development; thus, the investigation was based on comparison with pre-existing data for Chinese children. Regarding skeletal pattern in relation to the growth and development of the nasomaxillary complex, Coben<sup>18, 19</sup> reported that there are links between the growth of the cranial suture regions and alveolar bone formation associated with tooth eruption. Ono<sup>20</sup> and Fukuizumi<sup>21</sup> showed that the maxillary growth pattern is stable in relation to the cranial base. In the present study, in Chinese adults,  $\angle$  SNA tended to increase with increasing age, which confirmed the previous findings of maxillary growth and development in Japanese. With respect to mandibular growth and development, the  $\angle$  SNB tended to decrease with increasing age. Iizuka<sup>22</sup> reported that the Facial angle, indicating mandibular growth, increases with age, whereas Coben<sup>18, 19</sup> reported that it decreases with age. In the present study,  $\angle$  SNB increased or decreased with age; thus, our findings support those of Iizuka and Coben. However, SL increased with age, suggesting that the differences in forward growth of the cranial base were similar to those reported by previous authors. With respect to the growth and development of facial height, Iizuka reported that Downs analysis showed an increase in FMA, and Coben reported that Steiner's analysis showed a decrease in mandibular plane angle ( $\angle$  GoGn to SN). In the present study,  $\angle$  GoGn to SN decreased with age, indicating that the mandibles of Chinese with skeletal 1 malocclusion showed growth and development associated with counterclockwise rotation. This was consistent with Coben's report, suggesting that differences in growth and development were because of ethnic differences.

With respect to denture pattern, U1 to NA (angle) was greater and L1 to NB (angle), Interincisal angle,  $\angle$  Occl to SN and  $\angle$  GoGn to SN were smaller in the Chinese adults than in the Chinese children. For maxillary and mandibular anterior teeth, Iizuka *et al.*<sup>22</sup> reported an increase in  $\angle$  U1 to SN and L1 to mandibular plane angle and a decrease in Interincisal angle and  $\angle$  Occl to SN with age. Furthermore, in the present study, the labial inclination of the maxillary anterior teeth increased with age, supporting the findings of Iizuka *et al.* In addition, U1 to NA (angle) increased and U1 to NA (mm) decreased, suggesting a correlation with differences in forward growth at point A.

### Comparison with pre-existing measurements

The primary objective of this study was to determine the maxillofacial morphological characteristics of Chinese adults with skeletal 1 malocclusion and to clarify the treatment targets for orthodontic patients. In connection with the present authors' provision of orthodontic treatment, by comparing measurements from this study with existing reference data, patients' craniofacial morphological characteristics were determined, and the reference values for skeletal 1 craniofacial morphology were investigated, which can be used in the orthodontic management of the Chinese.

When the parameters of the Japanese were compared by Iizuka *et al.*,<sup>4</sup> based on the Downs method, Northwestern method, and Tweed's triangle, we observed in skeletal pattern, the Facial angle in the Chinese was greater, and the mandible was forwardly positioned. In addition, Y-axis and FMA were smaller in the Chinese, showing that the mandibular facial height was shorter, with low angle craniofacial morphology. Regarding the denture pattern,  $\angle$  U1 to SN was greater; thus, the maxillary anterior tooth labial inclination was greater. Comparison with the parameters of Japanese Americans showed that in skeletal pattern,  $\angle$  SNA,  $\angle$  SNB, and SL were greater in the Chinese, and the maxilla and mandible were positioned forward. In addition,  $\angle$  GoGn to SN was smaller, showing that Chinese adults with skeletal 1 malocclusion have low angle craniofacial morphology than Japanese

Americans. Furthermore, Po to NB was smaller, clearly showing differences in symphysis morphology. Regarding the denture pattern, U1 to NA (mm), U1 to NA (angle), L1 to NB (mm), and L1 to NB (angle) were greater and Interincisal angle and  $\angle$  Occl to SN were smaller in the Chinese, indicating that the labial inclination of the maxillary and mandibular teeth was greater. Compared with Caucasians in the skeletal pattern,  $\angle$  GoGn to SN was smaller. This indicated that the Chinese had a low angle craniofacial morphology than Caucasians. With respect to the denture pattern, U1 to NA (mm), U1 to NA (angle), L1 to NB (mm), and L1 to NB (angle) were greater in the Chinese and the Interincisal angle was smaller, showing that the labial inclination of the maxillary and mandibular teeth was greater.

The above results show that, with respect to the skeletal pattern, Chinese adults with skeletal 1 malocclusion have forwardly positioned maxilla and mandible compared with Japanese / Japanese Americans. In addition, with respect to the facial type, they have low angle craniofacial morphology than Japanese / Japanese Americans and Caucasians. Regarding the denture pattern in terms of mandibular and maxillary anterior teeth, inclination of the mandibular and maxillary teeth was greater in the Chinese than in the Japanese / Japanese Americans and Caucasians. Finally, with respect to the occlusal plane, the inclination was smaller in the Chinese than in the Japanese Americans, but greater than that in the Caucasians.

## CONCLUSIONS

The most important issues for orthodontic treatment are accurate diagnosis and formulation of treatment plan. Availability of the reference values is important for rational diagnosis. In addition, although numerous ethnic differences in skeletal pattern and denture pattern are known, it is essential to take into consideration the ethnic differences in the reference values for accurate analysis. Several studies have reported the reference values for Chinese, but variable analysis methods were used. Furthermore, numerous methods are currently in use for

measurement at the same loci. The objective of the present study was to perform a comparative investigation between the measurements used in the present study and the pre existing data, to establish reference values. The present authors collected data based on the standards different from those used previously and used these in the present study. Furthermore, we determined the craniofacial morphological characteristics of Chinese adults with skeletal 1 malocclusion.

It is essential to compare data from different ethnic groups, rather than focusing on a single group. In terms of craniofacial morphology, Chinese adults with skeletal 1 malocclusion tend to have forwardly positioned maxilla and mandible and smaller facial height than the Japanese, Japanese Americans, and Caucasians. In addition, the occlusal plane was found to have less mandibular inclination in the Chinese than in the Japanese, suggesting that the orthodontic treatment of Japanese individuals with skeletal 1 malocclusion will be easier than that of the Chinese.

This study was conducted with the approval of the Ethics Committee of Osaka Dental University (Approval No. 111186-0).

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