

## Steiner cephalometric analysis for Chinese adults with maxillary protrusion

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**Using Steiner analysis we examined the facial characteristics of 35 male and 35 female Chinese adults with maxillary protrusion selected from a clinic in New Taipei City. Angular and linear measurements were determined. In comparison with pre-existing measurement values for Chinese children, the SNA angle, SNB angle, SND angle, L1 to NB (angle), Interincisal angle, and SL values for our subjects were significantly greater while the U1 to NA (mm), U1 to NA (angle), and SE values were significantly smaller. Compared to measurement values for Japanese, the SNA angle, ANB angle, U1 to NA (mm), U1 to NA (angle), Pog to NB, and SE were larger, and the SNB angle, SND angle, Interincisal angle, Occl to SN, and SL were smaller. These results demonstrate that there was excessive growth in Chinese adults with maxillary protrusion. The mandibles showed retrusion, and the degree of clockwise rotation was found to be less than in Japanese. In addition, with respect to the occlusal plane, the inclination in Chinese was less than in Japanese. Based on the above findings, it was suggested that maxillary protrusion in Chinese adults is easier to treat than in Japanese. (J Osaka Dent Univ 2022; 56: 1-6)**

**Key words: Cephalometric radiography; Steiner analysis; Chinese adults; Maxillary protrusion**

### INTRODUCTION

Since introduction of the basic technology of radiographic cephalometry, numerous studies have been performed on the growth, development, function, and ethnic characteristics of the head and face.<sup>1-3</sup> To date, numerous measurement methods have been standardized for Caucasians and Japanese, and have been applied clinically in orthodontics.<sup>4-6</sup> These methods enable evaluation of the morphological characteristics of the maxillofacial region, its pattern of growth and development, and its relationships with the teeth and dental arch. Among these methods, Steiner analysis<sup>7</sup> focuses on the relationships of the ANB angle with the U1 to NA angle, and the L1 to NB angle, and on the positions of the incisal edges of the maxillary and mandibular central incisors in relation to the NA and NB lines. It is known as an analysis method in which the occlusal

relationships of the anterior dental region are set, and the treatment method is defined, on the basis of each subject's ANB angle. However, it is also necessary to take age, sex, ethnicity, individual differences, and growth into consideration. In particular, the relationships among the maxillofacial complex and tooth alignment have not to date been sufficiently investigated in Chinese adults. Although there have been several reports about the standard values for children during growth spurts,<sup>8-10</sup> there have been very few systematic studies on mandibular morphology in adults with maxillary protrusion.

In order to determine the morphological characteristics of maxillary protrusion in Chinese adults, and as an aid for orthodontic clinical practice, we did a comparative investigation for each measured parameter in Steiner analysis, which is widely used for setting orthodontic treatment targets.

## MATERIALS AND METHODS

### Subjects

From adults who had the primary diagnosis of maxillary protrusion at an orthodontic clinic in New Taipei City, we selected 70 patients (35 males and 35 females) who had an overjet of at least 4 mm, an ANB angle greater than  $4^\circ$ , no abnormalities in the number or morphology of the teeth, and no history of orthodontic treatment. Their age and gender distribution is shown in Table 1.

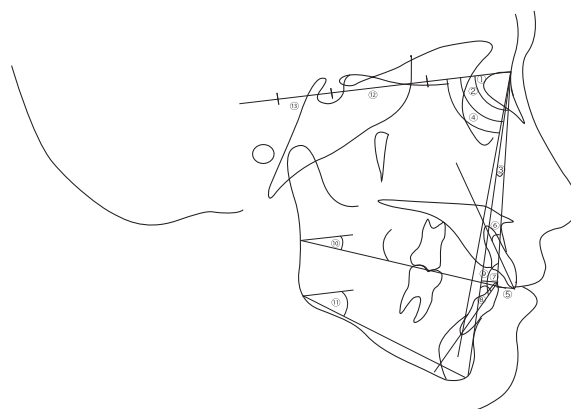
### Methods

We measured the 13 Steiner analysis items shown in Fig. 1 using cephalometric images of the 70 adult subjects. The Student's *t*-test was performed on each measurement value, and a comparative analysis was done using pre-existing measurement values for Chinese,<sup>8-11</sup> Japanese,<sup>12</sup> and Caucasians.<sup>13</sup>

## RESULTS

When males and females were compared for Chinese adults with maxillary protrusion, significant differences were found in the SNB angle, SND angle, U1 to NA (angle), L1 to NB (mm), Interincisal angle, and SE. These measurements were then compared with previous measurements for Chinese. When compared with the measurements made by Guo<sup>8</sup> for Chinese at developmental stage IIIC with skeletal 1, the SNA angle, ANB angle,  $\angle$  GoGn to SN, and SL were significantly greater than in Guo's measurements, and the U1 to NA (angle) was significantly smaller. When compared with measurements made by Wang<sup>9</sup> for Chinese at developmental stage IIIC and skeletal 1, the SNA angle, ANB

angle, L1 to NB (mm), L1 to NB (angle), and  $\angle$  GoGn to SN were significantly greater than in Wang's measurements, and the Interincisal angle,  $\angle$  Occl to SN, and SL were significantly smaller. When compared with measurements made by Chen<sup>10</sup> for Chinese at developmental stage IIIC with skeletal 1, the ANB angle, L1 to NB (mm), L1 to NB angle, and  $\angle$  GoGn to SN were significantly greater than in Chen's measurements, and the SNB angle, U1 to NA (angle), and SL were significantly smaller.



**Fig. 1** Measurements on the lateral cephalogram. ①  $\angle$  SNA (angle), ②  $\angle$  SNB (angle), ③  $\angle$  ANB (angle), ④  $\angle$  SND (angle) (angle formed by the SN plane and the line through the point (D) of the center of the mass of cross-section of the body of the symphysis and S), ⑤ U1 to NA (mm) (shortest distance from edge of the maxillary central teeth to the NA line), ⑥  $\angle$  U1 to NA (angle) (angle formed by the NA line and the axis of the maxillary central incisor), ⑦ L1 to NB (mm) (shortest distance from edge of the mandibular central incisor to the NB line), ⑧  $\angle$  L1 to NB (angle) (angle formed by the NB line and the axis of the mandibular central incisor), 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), and 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).

**Table 1** Subjects in different studies

Subjects	Chen YC	Guo	Wang	Gon	Chen YW	Japanese
Number	70 (35 M, 35 F)	96 (50 M, 46 F)	69 (34 M, 35 F)	100 (50 M, 50 F)	60 (30 M, 30 F)	90 (40 M, 50 F)
Range of ages	19 y 0 m–53 y 0 m	11 y 0 m–13 y 0 m	12 y 0 m–12 y 11 m	10 y 9 m–15 y 1 m	9 y 11 m–13 y 10 m	7 y 11 m–12 y 4 m
Mean age	23 y 5 m	12 y 4 m	12 y 6 m	12 y 3 m	11 y 5 m	10 y 9 m

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

Parameter	Chen YC (M) n=35	Chen YC (F) n=35	Chen YC (M and F) n=70	t-test (M and F)
∠SNA (angle)	85.64±3.08	84.43±3.28	84.71±3.34	NS
∠SNB (angle)	79.50±3.19	77.88±3.68	78.28±3.70	*
∠ANB (angle)	6.14±1.33	6.55±1.64	6.43±1.60	NS
∠SND (angle)	76.81±3.27	75.05±3.63	75.45±3.70	*
U1 to NA (mm)	6.13±3.18	5.26±2.45	5.40±2.66	NS
U1 to NA (angle)	24.27±6.17	20.60±8.07	21.21±7.93	*
L1 to NB (mm)	9.54±3.00	8.33±2.92	8.46±2.97	*
L1 to NB (angle)	33.50±3.94	32.92±6.44	32.91±6.08	NS
Interincisal (angle)	116.88±8.98	120.60±12.53	120.18±12.05	*
Occl to SN (angle)	16.74±2.90	17.89±5.19	17.64±4.90	NS
GoGn to SN (angle)	34.80±4.44	36.16±7.05	35.87±6.74	NS
SL (mm)	43.89±5.23	43.14±5.84	45.33±5.80	NS
SE (mm)	21.09±1.69	19.24±2.74	19.62±2.71	*

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

**Table 3** Comparison of pre-existing measurement values for Chinese and Japanese

Parameter	Chen YC n=70	Chinese (Guo) n=96	Chinese (Wang) n=69	Chinese (Gon) n=100	Chinese (Chen YW) n=60	Japanese n=90	t-test (Chen YC and Guo)	t-test (Chen YC and Wang)	t-test (Chen YC and Gon)	t-test (Chen YC and Chen YW)	t-test (Chen YC and Japanese)
∠SNA (angle)	84.71±3.34	81.5±3.5	82.21±3.24	81.24±2.84	83.52±3.62	81.3±3.2	*	*	*	NS	*
∠SNB (angle)	78.28±3.70	77.7±3.2	79.15±2.92	75.46±2.84	80.38±3.39	76.8±3.0	NS	NS	*	*	*
∠ANB (angle)	6.43±1.60	4.0±1.8	3.07±1.54	5.78±0.97	3.15±1.51	4.5±1.7	*	*	NS	*	*
∠SND (angle)	75.45±3.70	74.2±3.1	75.83±2.86	72.94±3.54	76.66±3.25	73.4±3.1	NS	NS	*	NS	NS
U1 to NA (mm)	5.40±2.66	6.1±2.0	4.17±1.82	7.15±3.20	6.08±1.70	5.9±1.8	NS	NS	*	NS	NS
U1 to NA (angle)	21.21±7.93	24.2±5.4	22.49±4.25	29.98±7.15	25.22±4.59	24.1±4.9	*	NS	*	*	*
L1 to NB (mm)	8.46±2.97	7.8±2.0	4.76±2.14	7.49±2.72	6.89±1.48	7.8±2.1	NS	*	NS	*	NS
L1 to NB (angle)	32.91±6.08	31.6±5.5	27.09±6.54	30.20±6.39	29.49±4.61	31.2±5.6	NS	*	*	*	NS
Interincisal (angle)	120.18±12.05	119.9±8.5	127.35±7.93	114.15±8.42	122.14±6.83	120.3±8.5	NS	*	*	NS	NS
Occl to SN (angle)	17.64±4.90	18.8±3.8	19.70±3.77	17.90±4.71	16.58±3.73	20.0±3.7	NS	*	NS	NS	*
GoGn to SN (angle)	35.87±6.74	33.0±4.4	32.79±4.19	35.50±3.08	32.17±4.59	36.2±4.5	*	*	NS	*	NS
SL (mm)	45.33±5.80	42.9±6.7	48.39±5.49	36.54±6.69	48.62±7.22	41.1±5.9	*	*	*	*	*
SE (mm)	19.62±2.71	20.0±2.9	20.82±2.91	23.73±9.70	20.13±3.16	21.0±3.0	NS	NS	*	NS	*

When compared with measurements made by Gon<sup>11</sup> for Chinese maxillary protrusion patients at developmental stage IIIC, the SNA angle, SNB angle, SND angle, L1 to NB (angle), Interincisal angle, and SL were significantly greater in our group, and the U1 to NA (mm), U1 to NA (angle), and SE were significantly smaller. When compared with measurements made by Miura<sup>12</sup> for Japanese at developmental stage IIIC with skeletal 1, the SNA angle, SNB angle, ANB angle, U1 to NA (mm), and SL were significantly greater in our group, and the ∠Occl to SN and SE were significantly smaller. When compared with previous measurements for Caucasians,<sup>13</sup> the mean SNA angle, ANB angle, U1

**Table 4** Comparison of Chen's values with pre-existing values for Caucasians

Parameter	High angle Chinese adults	Caucasian
∠SNA (angle)	84.71±3.34	82
∠SNB (angle)	78.28±3.70	80
∠ANB (angle)	6.43±1.60	2
∠SND (angle)	75.45±3.70	76
U1 to NA (mm)	5.40±2.66	4
U1 to NA (angle)	21.21±7.93	22
L1 to NB (mm)	8.46±2.97	4
L1 to NB (angle)	32.91±6.08	25
Interincisal (angle)	120.18±12.05	131
Occl to SN (angle)	17.64±4.90	14
GoGn to SN (angle)	35.87±6.74	32
SL (mm)	45.33±5.80	51
SE (mm)	19.62±2.71	22

to NA (mm), L1 to NB (mm), L1 to NB (angle), and  $\angle$  Occl to SN were significantly greater in our group, and the Interincisal angle, SL, and SE were significantly smaller (Tables 2-4).

## DISCUSSION

### Materials

We investigated the characteristics of maxillary protrusion in Chinese adults. With respect to the skeletal characteristics of Japanese, because Iizuka *et al.*<sup>5,6</sup> and Miura *et al.*<sup>12</sup> reported standard values based on cephalometric analyses for each generation, comparisons with Japanese can readily be made. In the case of Chinese, however, although values for children during growth spurts have been reported,<sup>8-11</sup> no standard values based on cephalometric analysis have been reported for adults. We studied changes in each value from the growth spurt to maturity based on Iizuka's analysis, and compared these with changes in each value from the growth spurt to maturity in Chinese. We also investigated the skeletal characteristics of Chinese adults.

### Maxillary protrusion

The progression of malocclusion with age has also been elucidated in a study by Susami *et al.*<sup>14</sup> According to that report, maxillary protrusion in Japanese malocclusion is very slight during the primary dentition stage, and increases somewhat on initiation of eruption of the permanent central incisors and first molars. In addition, maxillary protrusion at completion of eruption of the central incisors and first molars is approximately three times that at initiation of eruption, and although it further increases slightly at the time of replacement of the lateral incisors, there are no subsequent major changes in the frequency of maxillary protrusion. With maxillary protrusion, consideration must be given to the situation where tooth protrusion is reported, including bimaxillary protrusion. However, a feeling of tooth protrusion is not only reported when there is a large overjet, but also when the anterior teeth have a small overjet. This is also connected with the overbite; the greater the overbite, the more marked

the feeling of protrusion. However, cephalometric analysis landmarks have been put forward as elements for defining the feeling of tooth protrusion, in addition to the size of the overjet and overbite. In addition, there are various other important elements, including the mean distance and vertical spatial relationship between points A and B, mandibular symphysis morphology, the spatial relationship between the upper and lower lips, and the relative spatial relationships of the pronasale, subnasale, supramentale, pogonion, and other measurements.

In general, maxillary protrusion is divided broadly into the skeletal and the denture types, which are restricted to the teeth and alveolar region, and the functional type, which is caused by abnormal jaw movement. Otani *et al.*<sup>15</sup> developed a more detailed classification system, in which U1 to SN (angle), L1 to SN (angle), the SNA angle, the SNB angle, A-Ptm and Go-Me are measured as parameters for classification of maxillary protrusion, with priority given to the skeletal classification into the following six categories: Although the maxillary anterior teeth show labial inclination, there are no abnormalities in the sizes or positions of the maxilla or mandible; Although the mandibular anterior teeth show labial inclination, there are no abnormalities in the sizes or positions of the maxilla or mandible; Although the maxilla is protruded, it is not abnormal in size; The maxilla is protruded and unusually large; The mandible is retruded, and is unusually small; Although the mandible is retruded, it is not abnormal in size. In addition to these classifications, in terms of denture pattern, a merged type involving the first and second categories may occur. In terms of the skeletal pattern, a merged type involving either the third or fourth category and the fifth or sixth category may occur. Steiner analysis, as used in the present study, includes the SNA and SNB angles among the parameters identified by Otani *et al.* It is thought that  $\angle$  U1-SN can be evaluated on the basis of U1 to NA (mm) and the U1 to NA angle;  $\angle$  L1-SN can be evaluated on the basis of L1 to NA (mm) and the L1 to NA (angle); and Go-Me can be evaluated on the basis of SL.

The principal aim of this study was to determine the morphological characteristics of maxillary protrusion in Chinese adults. We made orthodontic diagnosis with data collected previously, using different criteria, and carried out treatment. In future orthodontic treatment of Chinese, it will be necessary to determine the morphological characteristics of their maxillary protrusion, using consistent analysis methods, and to define feasible therapeutic targets acceptable to them by determining the normal values. When we compared our finding on maxillary protrusion in Chinese adults with the measurements in Chinese in developmental stage IIIC by Gon,<sup>11</sup> we found that the SNA angle, SNB angle, SND angle, L1 to NB (angle), Interincisal angle, and SL were significantly greater, and that U1 to NA (mm), U1 to NA (angle), and SE were significantly smaller. Gon made comparative investigations of measurements in Chinese in developmental stage IIIC with maxillary protrusion and skeletal type 1, and reported that, in comparison with the measurements made by Guo,<sup>8</sup> the ANB angle, U1 to NA (mm), U1 to NA (angle), Po to NB,  $\angle$ GoGn to SN, and SE were significantly greater, and the SNB angle, SND angle, L1 to NB (mm), Interincisal angle,  $\angle$ Occl to SN, and SL were significantly smaller. In addition, Gon reported that, in comparison with Wang's findings,<sup>9</sup> the ANB angle, U1 to NA (mm), U1 to NA (angle), L1 to NB (mm), L1 to NB (angle), Po to NB, and  $\angle$ GoGn to SN were significantly greater, and the SNB angle, SND angle, Interincisal angle,  $\angle$ Occl to SN, and SL were significantly smaller.

Although certain differences were found from the previous measurements with Chinese that were used in this study, these are thought due to differences in the age of the patients when the data were collected. It has been reported that developmental stage IIIC with maxillary protrusion in Chinese does not involve excessive maxillary growth, in terms of skeletal-type classification, and that the mandible does not show morphological characteristics such as retrusion or clockwise rotation. It has also been reported, with respect to denture pattern classification, that the maxillary anterior teeth

showed marked labial inclination, whereas the mandibular anterior teeth showed no labial inclination, and that the occlusal plane was more level than it was with the standard values. It has also been reported that when the measurements of developmental stage IIIC maxillary protrusion in Chinese by Gon<sup>11</sup> were compared with the measurements of developmental stage IIIC skeletal 1 in Japanese by Miura, that the SNA angle, ANB angle, U1 to NA (mm), U1 to NA (angle), and SE were significantly greater in the former group, whereas the SNB angle, SND angle, Interincisal angle,  $\angle$ Occl to SN, and SL were significantly smaller.

According to Iizuka,<sup>5</sup> comparison of Japanese adults with normal occlusion with measurements at developmental stage IIIC showed increases in the SNA angle, SNB angle,  $\angle$ U1 to SN, and Go-Me, and decreases in the ANB angle. In addition, comparison of the measurements of maxillary protrusion in Chinese adults in the present study with measurements of skeletal 1 in Japanese adults by Iizuka showed that the SNA angle and ANB angle were larger in the former, and the Interincisal angle was smaller. Furthermore, comparison with previous measurements in Caucasians showed the mean SNA angle, ANB angle, U1 to NA (mm), L1 to NB (mm), L1 to NB (angle), and  $\angle$ Occl to SN to be greater, and the mean Interincisal angle, SL, and SE to be smaller. The above results show that in terms of skeletal type there was excessive growth in Chinese adults with maxillary protrusion. In addition, there was mandibular retrusion, and the degree of clockwise rotation was less than in Japanese, but greater than in Caucasians. In terms of dentition type, labial inclination of the anterior teeth was more marked than in Japanese and Caucasians. In addition, the inclination of the occlusal plane in Chinese was less than in Japanese, but greater than in Caucasians.

On the basis of the above, it can be seen that, for orthodontic treatment of maxillary protrusion in Chinese adults, a therapeutic approach is required, such as one involving counter-clockwise mandibular rotation. In addition, their maxillary and mandibular anterior teeth show marked labial inclination, sug-

gesting the need for orthodontic treatment in combination with bimaxillary extractions. Furthermore, the mandibular plane angle and occlusal plane angle are steeper than in Caucasians, but not as steep as in Japanese, suggesting that orthodontic treatment of maxillary protrusion will be less difficult in Chinese than in Japanese.

## CONCLUSION

The most important aspect of orthodontic practice is diagnosis. In order to reach a rational diagnosis, it is important to know the standard values. In addition, since there are known to be numerous ethnic differences in skeletal and dentition types, knowledge of the standard values for each ethnicity are essential for accurate analysis. There have previously been numerous reports connecting standard orthognathic values in Chinese. There are a large number of ethnic differences. We compared the measurements we made with those previously reported in relation to ethnic differences, and attempted to define the standard values. We collected samples on the basis of standards different from those set previously, used the samples in this study, and investigated the characteristics of maxillary protrusion in Chinese adults.

We concluded that when evaluating of the data obtained, it is essential to compare them with data for other ethnicities, rather than focusing on a single ethnicity. In this study, we found that maxillary protrusion in Chinese adults involved excessive growth of the maxilla and retrusion of the mandible, and that although clockwise mandibular rotation is more marked in Chinese than in Caucasians, it is less than in Japanese. This seems to imply that it will be easier to treat maxillary protrusion in Chinese than in Japanese.

This study was provided de-identified and anonymized data.

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