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A study of Steiner cephalometric norms for Chinese children

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We examined the facial characteristics of Chinese children with normal occlusion using Steiner analysis. Ninety boys and 90 girls who were selected from 5,417 students in a primary school in Taipei, Taiwan, were classified by Hellman's developmental stage (ⅢA, ⅢB and ⅢC) and chronological age stage Ⅳ (11 y 0 m–13 y 10 m). Angular and linear measurements were determined. In comparison with pre-existing measurement values for Japanese, the SNA angle, SNB angle, SND angle, interincisal angle, and SL values for the Chinese subjects were significantly larger for stages ⅢC and Ⅳ, while L1 to NB, ∠L1 to NB, occlusal plane to SN, GoGn to SN, and SE values were significantly smaller. Compared to measurement values for Caucasians, the mean of SNA angle, ANB angle, U1 to NA, ∠U1 to NA, L1 to NB, ∠L1 to NB, and occlusal plane to SN angle were larger among our subjects (stages ⅢC and Ⅳ) and the interincisal angle, SL and SE were smaller. These results demonstrate that Chinese have a more robust growth of the maxilla than Japanese and Caucasians.

We also found that although the skeletal Class Ⅱ tendency in Chinese was lower than in Japanese, it was higher than in Caucasians. Although the amount of growth of the mandible in Chinese was greater than in Japanese, it was less than in Caucasians. Although clockwise rotation was also less than in Japanese, it was greater than in Caucasians. Regarding dental structure, although anterior teeth in Chinese tended to have less bimaxillary protrusion than in Japanese, they had greater bimaxillary protrusion than in Caucasians. Although the occlusal plane was flatter than that of Japanese, it was steeper than that of Caucasians. The above findings suggest that when performing orthodontic treatments on Chinese, greater attention is needed when the features of malocclusion are similar to Caucasians. (J Osaka Dent Univ 2015 ; 49 : 237–244)

Key words : Cephalometric radiography ; Steiner analysis ; Chinese children

INTRODUCTION

Ever since Broadbent[1] introduced the basic techniques for radiographic cephalometry, this measurement method has been used in numerous studies of craniofacial growth, development, function, and ethnicity-related characteristics.[2–4] Currently, many measurement methods have been standardized for Caucasians and Japanese, and have been applied in the clinical field of orthodontics.[5–8] These methods have made it possible to assess the morphological features of the maxillofacial area, patterns of growth and development, and relationships between the teeth/dental arches and the jaws and face. In particular, the Steiner analysis[9] focuses on the relationships between the ANB angle and the U1-to-NA angle/L1-to-NB angle, and on the positions of the incisal edges of the maxillary and mandibular central incisors relative to the NA and NB lines.

Steiner analysis is a method that determines the occlusal relationships of the anterior teeth according to the individual's ANB angle to formulate goals for therapy. However, it is necessary to also consider age, sex, ethnicity, individual differences, and growth. To date, research on the relationships between the maxillofacial complex and dentition in Chinese has been inadequate ; in particular, there has been no systematic research on standard values in the healthy population from the mixed dentition stage to the permanent dentition stage. We analyzed the Steiner analysis measurement items (which have been widely used to establish treatment goals in orthodontics in Chinese children) to understand the morphological features of a normal occlusion group from the mixed dentition to the permanent dentition stage, and to establish guidelines for clinical orthodontic practice.

MATERIALS AND METHODS

Subjects

Three hundred individuals were selected from a group of 5,417 students undergoing oral examination at Taipei City municipal schools. Selected students met the following criteria to be included in the normal occlusion group : normal overbite/overjet, no observed abnormalities in the number of teeth or dental morphology, normal mesiodistal relationship of the maxilla and the mandible, a harmonious facial appearance, and no prior history of orthodontic treatment.

Thirty boys and 30 girls were selected from the normal occlusion group in each of Hellman's developmental stages ⅢA, ⅢB, and ⅢC for a total of 180 individuals.[10] Fifty-six individuals in chronological age stage Ⅳ (11 y 0 m–13 y 10 m) were also selected from the normal occlusion group.

Methods

We measured the following 14 Steiner analysis items using cephalometric images obtained at each of these stages. 1) SNA angle, 2) SNB angle, 3) ANB angle, 4) 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 (shortest distance from edge of the maxillary central teeth to the NA line), 6) ∠U1 to NA (angle formed by the NA line and the axis of the maxillary central incisor), 7) L1 to NB (shortest distance from edge of the mandibular central incisor to the NB line), 8) ∠L1 to NB (angle formed by the NB line and the axis of the mandibular central incisor), 9) Po to NB (shortest distance from Po to the NB line), 10) Interincisal angle, 11) Occlusal plane to SN angle, 12) ∠GoGn to SN, 13) SL (distance from S to the point (L) of the intersection formed a line from the most anterior point of the mandible (Po) to the SN plane), 14)

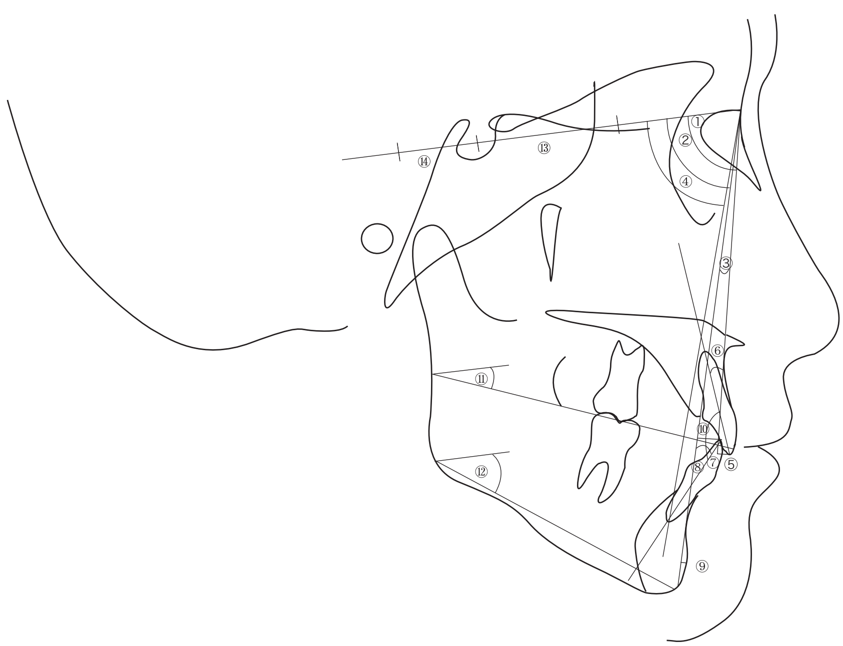

Fig. 1 Measurements on the lateral cephalogram.
① ∠SNA (°), ② ∠SNB (°), ③ ∠ANB (°), ④ ∠SND (°), ⑤ U1 to NA (mm), ⑥ ∠U1 to NA (°),
⑦ L1 to NB (mm), ⑧ ∠L1 to NB (°), ⑨ Pog to NB (mm), ⑩ ∠Interincisal (°), ⑪ ∠Occlusal to SN (°),
⑫ ∠GoGn to SN (°), ⑬ SL (mm), ⑭ SE (mm).

Table 1 Classification of the subjects in the present study

Subjects	Stage Ⅳ	ⅢA	ⅢB	ⅢC	Guo	Wang	Japanese
Number	56	60 (30 M, 30 F)	60 (30 M, 30 F)	60 (30 M, 30 F)	96 (50 M, 46 F)	69 (34 M, 35 F)	90 (40 M, 50 F)
Range of ages	11y0m–13y10m	7y6m–12y2m	7y8m–12y2m	9y11m–13y10m	11y0m–13y0m	12y0m–12y11m	7y11m–12y4m
Mean age	12y8m	8y10m	10y4m	11y5m	12y4m	12y6m	10y9m

SE (distance from S to the point (E) of the intersection formed a line from the most distal point of the head of the condyle perpendicular to the SN plane.

The Student's t-test was performed on each measurement value, and a comparative analysis was performed using pre-existing measurement values for Chinese,[11, 12] Japanese,[13] and Caucasians[9] (Fig. 1, Table 1).

RESULTS

Comparisons between the genders at each stage showed that boys had a significantly increased U1 to NA in stages ⅢA and ⅢB, and a significantly increased L1 to NB and SE in stages ⅢB and ⅢC. Girls had a significantly increased U1 to NA, ∠U1 to NA, SL, and SE, and a significantly decreased ANB angle and occlusal plane to SN in stages ⅢB and ⅢC (Tables 2 and 3).

When we combined the measurement values for boys and girls, no significant differences were observed in any item between stages ⅢA and ⅢB; however, between stages ⅢB and ⅢC, there were significant increases in the SNB angle, U1 to NA, ∠U1 to NA, L1 to NB, interincisal angle, SL and SE, and a significant decrease in occlusal plane to SN. There were significant increases in the SNB angle, SND angle, U1 to NA, ∠U1 to NA, L1 to NB, Po to NB, SL and SE, and significant decreases in ANB angle and occlusal plane to SN between stages ⅢA and ⅢC as well (Table 4).

The measurement values for the 30 boys and 30 girls from the stage ⅢC group were subsequently compared with pre-existing measurement values for Chinese. Compared with the findings of Guo,[11] our values for SNA, SNB, SND, ∠L1 to NB, and SL were significantly larger, while the ANB angle, L1 to NB, and occlusal plane to SN were significantly smaller. Compared with the findings of Wang,[12] our measurement values were significantly larger for SNA, SNB, U1 to NA, ∠U1 to NA, L1 to NB, and ∠L1 to NB, and

Table 2 Comparison of measurements among ⅢA, ⅢB, and ⅢC for males

Parameter	ⅢA (M)	ⅢB (M)	ⅢC (M)	t-test (ⅢA and ⅢB)	t-test (ⅢB and ⅢC)	t-test (ⅢA and ⅢC)
∠SNA (°)	83.01 ± 2.68	82.45 ± 2.41	83.54 ± 4.25	NS	NS	NS
∠SNB (°)	78.97 ± 2.74	79.05 ± 2.79	80.25 ± 3.87	NS	NS	NS
∠ANB (°)	4.04 ± 1.28	3.40 ± 1.24	3.29 ± 1.79	NS	NS	NS
∠SND (°)	75.45 ± 2.44	75.70 ± 2.64	76.54 ± 3.66	NS	NS	NS
U1 to NA (mm)	4.31 ± 1.83	5.35 ± 1.76	6.14 ± 2.01*	NS	**	**
U1 to NA (°)	22.69 ± 5.50	23.34 ± 4.47	24.55 ± 5.34	NS	NS	NS
L1 to NB (mm)	5.98 ± 1.57	6.24 ± 1.53	7.26 ± 1.49	NS	*	**
L1 to NB (°)	29.64 ± 4.66	29.11 ± 4.43	30.28 ± 5.16	NS	NS	NS
Po to NB (mm)	0.56 ± 0.99	0.08 ± 1.07	0.00 ± 1.26	NS	NS	NS
Interincisal (°)	123.64 ± 8.57	124.14 ± 7.13	121.87 ± 7.61	NS	NS	NS
Occl to SN (°)	18.03 ± 2.93	18.36 ± 3.20	16.59 ± 4.51	NS	NS	NS
GoGn to SN (°)	31.39 ± 3.88	32.91 ± 3.98	31.80 ± 4.93	NS	NS	NS
SL (mm)	46.79 ± 5.01	46.11 ± 6.58	48.65 ± 8.37	NS	NS	NS
SE (mm)	18.26 ± 2.45	18.66 ± 2.82	20.75 ± 3.45	NS	*	**

Mean ± SD, NS : Not significant, ** $p < 0.01$, * $p < 0.05$, $n = 30$.

Table 3 Comparison of measurements among ⅢA, ⅢB, and ⅢC for females

Parameter	ⅢA (F)	ⅢB (F)	ⅢC (F)	t-test (ⅢA and ⅢB)	t-test (ⅢB and ⅢC)	t-test (ⅢA and ⅢC)
∠SNA (°)	81.70 ± 3.01	82.99 ± 2.65	83.50 ± 2.93	NS	NS	*
∠SNB (°)	78.23 ± 2.81	79.15 ± 2.65	80.50 ± 2.89	NS	NS	**
∠ANB (°)	3.47 ± 1.26	3.83 ± 1.33	3.00 ± 1.17	NS	*	NS
∠SND (°)	74.53 ± 3.12	75.49 ± 2.90	76.79 ± 2.84	NS	NS	**
U1 to NA (mm)	4.76 ± 1.47	4.69 ± 1.71	6.01 ± 1.33	NS	**	**
U1 to NA (°)	22.30 ± 3.57	21.95 ± 3.79	25.88 ± 3.68	NS	**	**
L1 to NB (mm)	5.82 ± 1.46	6.30 ± 1.58	6.52 ± 1.41	NS	NS	NS
L1 to NB (°)	29.48 ± 4.56	28.66 ± 3.62	28.70 ± 3.92	NS	NS	NS
Po to NB (mm)	–0.18 ± 1.31	–0.46 ± 1.62	0.17 ± 1.00	NS	NS	NS
Interincisal (°)	124.75 ± 5.73	125.57 ± 6.01	122.41 ± 6.06	NS	NS	NS
Occl to SN (°)	20.33 ± 3.08	19.25 ± 3.37	16.58 ± 2.82	NS	**	**
GoGn to SN (°)	34.11 ± 4.38	34.15 ± 4.08	32.53 ± 4.27	NS	NS	NS
SL (mm)	42.85 ± 5.48	44.50 ± 6.03	48.58 ± 6.02	NS	*	**
SE (mm)	17.47 ± 2.66	17.82 ± 2.37	19.51 ± 2.76	NS	*	**

Table 4 Comparison of measurements among ⅢA, ⅢB, and ⅢC for males and females

Parameter	ⅢA (M + F)	ⅢB (M + F)	ⅢC (M + F)	t-test (ⅢA and ⅢB)	t-test (ⅢB and ⅢC)	t-test (ⅢA and ⅢC)
∠SNA (°)	83.36 ± 2.90	83.72 ± 2.53	83.52 ± 3.62	NS	NS	NS
∠SNB (°)	78.60 ± 2.78	79.10 ± 2.70	80.38 ± 3.39	**	*	**
∠ANB (°)	3.76 ± 1.29	3.62 ± 1.30	3.15 ± 1.51	**	NS	*
∠SND (°)	74.99 ± 2.82	75.60 ± 2.75	76.66 ± 3.25	**	NS	**
U1 to NA (mm)	4.54 ± 1.66	5.02 ± 1.75	6.08 ± 1.70	NS	**	**
U1 to NA (°)	22.49 ± 4.60	22.64 ± 4.17	25.22 ± 4.59	NS	**	**
L1 to NB (mm)	5.90 ± 1.51	6.27 ± 1.54	6.89 ± 1.48	**	*	**
L1 to NB (°)	29.56 ± 4.57	28.89 ± 4.02	29.49 ± 4.61	*	NS	NS
Po to NB (mm)	0.19 ± 1.21	–0.19 ± 1.39	0.09 ± 1.13	NS	NS	NS
Interincisal (°)	124.20 ± 7.25	124.85 ± 6.58	122.14 ± 6.83	NS	*	NS
Occl to SN (°)	19.18 ± 3.20	18.81 ± 3.29	16.58 ± 3.73	**	**	**
GoGn to SN (°)	32.75 ± 4.33	33.53 ± 4.04	32.17 ± 4.59	NS	NS	NS
SL (mm)	44.82 ± 5.57	45.31 ± 6.31	48.62 ± 7.22	**	**	**
SE (mm)	17.87 ± 2.57	18.24 ± 2.62	20.13 ± 3.16	NS	**	**

n = 60

Table 5 Comparison of our measurements in stage ⅢC with pre-existing measurement values for Chinese and Japanese

Parameter	ⅢC (M + F) n = 60	Chinese (Guo) n = 96	Chinese (Wang) n = 69	Japanese n = 90	t-test (ⅢC and Guo)	t-test (ⅢC and Wang)	t-test (ⅢC and Japanese)
∠SNA (°)	83.52 ± 3.62	81.5 ± 3.5	82.21 ± 3.24	81.3 ± 3.2	**	*	**
∠SNB (°)	80.38 ± 3.39	77.7 ± 3.2	79.15 ± 2.92	76.8 ± 3.0	**	*	**
∠ANB (°)	3.15 ± 1.51	4.0 ± 1.8	3.07 ± 1.54	4.5 ± 1.7	**	NS	**
∠SND (°)	76.66 ± 3.25	74.2 ± 3.1	75.83 ± 2.86	73.4 ± 3.1	**	NS	**
U1 to NA (mm)	6.08 ± 1.70	6.1 ± 2.0	4.17 ± 1.82	5.9 ± 1.8	NS	**	NS
U1 to NA (°)	25.22 ± 4.59	24.2 ± 5.4	22.49 ± 4.25	24.1 ± 4.9	NS	**	NS
L1 to NB (mm)	6.89 ± 1.48	7.8 ± 2.0	4.76 ± 2.14	7.8 ± 2.1	**	**	**
L1 to NB (°)	29.49 ± 4.61	31.6 ± 5.5	27.09 ± 6.54	31.2 ± 5.6	*	*	NS
Po to NB (mm)	0.09 ± 1.13	0.3 ± 1.4	–0.11 ± 1.14	0.4 ± 1.3	NS	NS	NS
Interincisal (°)	122.14 ± 6.83	119.9 ± 8.5	127.35 ± 7.93	120.3 ± 8.5	NS	**	NS
Occl to SN (°)	16.58 ± 3.73	18.8 ± 3.8	19.70 ± 3.77	20.0 ± 3.7	**	**	**
GoGn to SN (°)	32.17 ± 4.59	33.0 ± 4.4	32.79 ± 4.19	36.2 ± 4.5	NS	NS	**
SL (mm)	48.62 ± 7.22	42.9 ± 6.7	48.39 ± 5.49	41.1 ± 5.9	**	NS	**
SE (mm)	20.13 ± 3.16	20.0 ± 2.9	20.82 ± 2.91	21.0 ± 3.0	NS	NS	NS

Table 6 Comparison of measurements in stages ⅢA+ⅢB+ⅢC with Stage Ⅳ and pre-existing measurement for Japanese

Parameter	ⅢA + ⅢB + ⅢC n = 180	Stage Ⅳ n = 56	Japanese n = 90	t-test (ⅢA + ⅢB + ⅢC and Stage Ⅳ)	t-test (ⅢA + ⅢB + ⅢC and Japanese)
∠SNA (°)	82.87 ± 3.07	83.55 ± 3.67	81.3 ± 3.2	NS	**
∠SNB (°)	79.36 ± 3.05	80.26 ± 3.48	76.8 ± 3.0	NS	**
∠ANB (°)	3.51 ± 1.38	3.29 ± 1.51	4.5 ± 1.7	NS	**
∠SND (°)	75.75 ± 3.01	76.76 ± 3.33	73.4 ± 3.1	NS	**
U1 to NA (mm)	5.21 ± 1.81	5.75 ± 1.76	5.9 ± 1.8	*	**
U1 to NA (°)	23.45 ± 4.60	23.39 ± 4.45	24.1 ± 4.9	*	NS
L1 to NB (mm)	6.35 ± 1.56	6.67 ± 1.59	7.8 ± 2.1	NS	**
L1 to NB (°)	29.31 ± 4.40	29.42 ± 4.73	31.2 ± 5.6	NS	**
Po to NB (mm)	0.03 ± 1.25	0.37 ± 1.11	0.4 ± 1.3	NS	NS
Interincisal (°)	123.73 ± 6.95	122.89 ± 7.11	120.3 ± 8.5	NS	**
Occl to SN (°)	18.19 ± 3.58	16.69 ± 4.03	20.0 ± 3.7	*	**
GoGn to SN (°)	32.81 ± 4.34	31.95 ± 4.67	36.2 ± 4.5	NS	**
SL (mm)	46.25 ± 6.59	48.65 ± 7.29	41.1 ± 5.9	*	**
SE (mm)	18.74 ± 2.95	19.75 ± 3.22	21.0 ± 3.0	*	**

Table 7 Comparison of measurements in stage Ⅳ, stage Ⅲ and pre-existing values for Chinese

Parameter	Stage Ⅳ n = 56	Chinese (Guo) n = 96	Chinese (Wang) n = 69	ⅢC (M + F) n = 60	t-test (SⅣ and Guo)	t-test (SⅣ and Wang)	t-test (SⅣ and ⅢC)
∠SNA (°)	83.55 ± 3.67	81.5 ± 3.5	82.21 ± 3.24	83.52 ± 3.62	**	*	NS
∠SNB (°)	80.26 ± 3.48	77.7 ± 3.2	79.15 ± 2.92	80.38 ± 3.39	**	NS	NS
∠ANB (°)	3.29 ± 1.51	4.0 ± 1.8	3.07 ± 1.54	3.15 ± 1.51	*	NS	NS
∠SND (°)	76.76 ± 3.33	74.2 ± 3.1	75.83 ± 2.86	76.66 ± 3.25	**	NS	NS
U1 to NA (mm)	5.75 ± 1.76	6.1 ± 2.0	4.17 ± 1.82	6.08 ± 1.70	NS	**	NS
U1 to NA (°)	23.39 ± 4.45	24.2 ± 5.4	22.49 ± 4.25	25.22 ± 4.59	NS	*	NS
L1 to NB (mm)	6.67 ± 1.59	7.8 ± 2.0	4.76 ± 2.14	6.89 ± 1.48	**	**	NS
L1 to NB (°)	29.42 ± 4.73	31.6 ± 5.5	27.09 ± 6.54	29.49 ± 4.61	*	*	NS
Po to NB (mm)	0.37 ± 1.11	0.3 ± 1.4	−0.11 ± 1.14	0.09 ± 1.13	NS	*	NS
Interincisal (°)	122.89 ± 7.11	119.9 ± 8.5	127.35 ± 7.93	122.14 ± 6.83	*	*	NS
Occl to SN (°)	16.69 ± 4.03	18.8 ± 3.8	19.70 ± 3.77	16.58 ± 3.73	**	**	NS
GoGn to SN (°)	31.95 ± 4.67	33.0 ± 4.4	32.79 ± 4.19	32.17 ± 4.59	NS	NS	NS
SL (mm)	48.65 ± 7.29	42.9 ± 6.7	48.39 ± 5.49	48.62 ± 7.22	**	NS	NS
SE (mm)	19.75 ± 3.22	20.0 ± 2.9	20.82 ± 2.91	20.13 ± 3.16	NS	NS	NS

Table 8 Values for stage Ⅳ, ⅢC and pre-existing values for Caucasians

Parameter	Stage Ⅳ n = 56	ⅢC (M + F) n = 60	Caucasian
∠SNA (°)	83.55 ± 3.67	83.52 ± 3.62	82
∠SNB (°)	80.26 ± 3.48	80.38 ± 3.39	80
∠ANB (°)	3.29 ± 1.51	3.15 ± 1.51	2
∠SND (°)	76.76 ± 3.33	76.66 ± 3.25	76
U1 to NA (mm)	5.75 ± 1.76	6.08 ± 1.70	4
U1 to NA (°)	23.39 ± 4.45	25.22 ± 4.59	22
L1 to NB (mm)	6.67 ± 1.59	6.89 ± 1.48	4
L1 to NB (°)	29.42 ± 4.73	29.49 ± 4.61	25
Po to NB (mm)	0.37 ± 1.11	0.09 ± 1.13	0
Interincisal (°)	122.89 ± 7.11	122.14 ± 6.83	131
Occl to SN (°)	16.69 ± 4.03	16.58 ± 3.73	14
GoGn to SN (°)	31.95 ± 4.67	32.17 ± 4.59	32
SL (mm)	48.65 ± 7.29	48.62 ± 7.22	51
SE (mm)	19.75 ± 3.22	20.13 ± 3.16	22

significantly smaller for the interincisal angle and occlusal plane to SN. Compared with the measurement values for Japanese by Miura,[13] SNA, SNB, SND, U1 to NA, interincisal angle, and SL were significantly larger, while L1 to NB, ∠L1 to NB, occlusal plane to SN, GoGn to SN, and SE were significantly smaller (Table 5).

When we compared the 180 people in the present study and the 56 people who were at chronological age stage Ⅳ, the measurement values for the 180 children were significantly larger for occlusal plane to SN and significantly smaller for U1 to NA, ∠U1 to NA, SL and SE. When we compared the 180 children and the measurement values for Japanese according to Miura, the SNB angle, SND angle, interincisal angle, and SL were significantly larger, while SNA, ANB, U1 to NA, L1 to NB, ∠L1 to NB, occlusal plane to SN, GoGn to SN, and SE were significantly smaller (Table 6).

When the measurement values for the 56 children who were at chronological age stage Ⅳ were compared with pre-existing measurement values, SNA, SNB, SND, interincisal angle, and SL were significantly larger compared with the measured values for Chinese from Guo, while the ANB angle, L1 to NB, ∠L1 to NB, and occlusal plane to SN were significantly smaller. When the measurement values for the 56 children were compared with measurement values for Chinese according to Wang, the SNA, U1 to NA, ∠U1 to NA, L1 to NB, and ∠L1 to NB of the 56 children were significantly larger and the interincisal angle and occlusal plane to SN were significantly smaller. A comparison of these 56 children in chronological age stage Ⅳ with the 30 boys and 30 girls in the ⅢC group showed no significant differences for any of the parameters (Table 7).

Compared with the pre-existing measurement values for Caucasian the Chinese had larger mean values for SNA, ANB, U1 to NA, ∠U1 to NA, L1 to NB, ∠L1 to NB, and occlusal plane to SN, while the values for the interincisal angle, SL and SE were smaller (Table 8).

DISCUSSION

Materials

Craniofacial growth is closely related to the timing of tooth eruption. Growth and development research classifications have typically used Hellman's developmental stages,[10] which are based on physiological age. In terms of pre-existing age categories for Chinese people that can be used for comparison, Guo used 11 y 0 m to 13 y 0 m, while Wang used 12 y 0 m to 12 y 11 m. The ages for ⅢC used in the present study were 10 y 2 m to 13 y 10 m (mean 11 y 8 m) for boys, and 9 y 11 m to 12 y 3 m (mean 11 y 1 m) for girls. The combined mean for boys and girls was 11 y 5 m. This was regarded as appropriate for age comparisons. The ages for chronological age stage Ⅳ were 11 y 0 m to 13 y 10 m (mean 11 y 10 m) for boys and 11 y 0 m to 13 y 10 m (mean 11 y 5 m) for girls, similar to the combined mean age for boys and girls in ⅢC.

Since no significant differences were observed in any of the values for ⅢC and stage Ⅳ, we consider the values for ⅢC and stage Ⅳ as standard in our Steiner analysis of Chinese in the present study.

Growth and development

Growth and development of the nasomaxillary complex, according to Coben,[14, 15] involves the growth of the bone suture line and formation of the alveolar bone in association with eruption of the teeth. Ono[16] and Fukuizumi[17] showed that the growth pattern of the maxilla is stable against the base of the skull. We also found that although the SNA angle in boys and girls increases with age, no significant differences were found among the ⅢA, ⅢB and ⅢC groups.

The SNB angle increased with age ; in particular, there was a significant increase between stages ⅢB and ⅢC. Iizuka[7] reported that an increase in facial angle was indicative of mandibular growth, while Coben[14, 15] reported the reverse, that a decrease in the facial angle indicated growth of the mandible. Our results are consistent with Iizuka's view. Also, we did not find any significant change in GoGn to SN, which was consistent neither with Iizuka's report, which showed an increase in the mandibular plane angle due to growth and development, nor with Coben's report, which described a decrease.

Regarding the maxillary anterior teeth, we found that U1 to NA, ∠U1 to NA, L1 to NB, and ∠L1 to NB increased between each of the groups, and that aging was associated with a labial tendency. In particular, there was a significant increase between ⅢB and ⅢC. These results are consistent with Iizuka's report, which showed an increase in the U1 to SN angle and L1 to mandibular plane angle between the same groups. The interincisal angle and occlusal plane to SN also showed decreases, consistent with Iizuka's report.

Comparison with pre-existing measurement values

The main purpose of the present study was to clarify the treatment goals for Chinese orthodontic patients, whom we have thus far failed to understand properly. The most important observation is that we have used different criteria for the resulting data. Thus, we feel it is important to take not only normal occlusion into consideration, but also the harmony of the facial profile. For these reasons, we determined standards that can be accepted for Chinese.

In the present study, for comparison with pre-existing measurement values, we used values obtained in Hellman's developmental stage ⅢC and chronological age stage Ⅳ, because of the similarity of the age groups for the data collected. In comparison with pre-existing measurement values for Chinese according to reports by Guo[11] and Wang,[12] our values for stage ⅢC were significantly greater for SNA, SNB and ∠L1 to NB, while they were significantly smaller for occlusal plane to SN. When we compared our measurement values for chronological age stage Ⅳ with those from the reports by Guo and Wang, we found a significantly greater SNA angle while our occlusal plane to SN value was significantly smaller. The differences that were noted for these items and other measurement values were thought to result from differences in the ages and number of subjects for the data collected.

Compared with pre-existing measurement values for Japanese, our subjects had significantly larger values for SNA, SNB, SND, the interincisal angle, and SL for stages ⅢC and Ⅳ, while L1 to NB, ∠L1 to NB, occlusal plane to SN, GoGn to SN, and SE were significantly smaller. Compared to measurement values for Caucasians, our subjects had larger values for the mean SNA, ANB angle, U1 to NA, ∠U1 to NA, L1 to NB, ∠L1 to NB, and occlusal plane to SN (stages ⅢC and Ⅳ), as well as a smaller interincisal angle, SL, and SE. These results demonstrate that Chinese have a more robust growth of the maxilla than Japanese or Caucasians.

We also found that although the skeletal Class Ⅱ tendency in Chinese was lower than that in Japanese, it was greater than that in Caucasians. Although the amount of growth of the mandible in Chinese was greater than that in Japanese, it was less than that in Caucasians. Although clockwise rotation was also less than that in Japanese, it was greater than that in Caucasians. The anterior teeth in Chinese tended to have less bimaxillary protrusion than in Japanese, but more than in Caucasians. The occlusal plane was flatter than that of Japanese, but steeper than that of Caucasians. The above findings suggest that when performing orthodontic treatments on Chinese, greater attention is needed when the malocclusion is similar to that in Caucasians.

CONCLUSION

The most important consideration in orthodontic treatment is the method of diagnosis. To make a logical diagnosis, it is important to know the standard values. Among the many methods of analysis in orthodontic clinical practice, the Steiner analysis is one of the most common and widely used. It is well known that many differences exist in the skeletal and denture patterns of ethnic groups. If we are to use the analytical techniques properly, we must have standards specific to each ethnic group. There are considerable differences among the many standard values that have been reported for Chinese. This has led to confusion and misunderstanding.

The purpose of this study was to compare the differences between measured values that we collected for Chinese and previously published values, to attempt to clarify these differences, and to define standard values. For this study, we collected samples using criteria different from those used previously. In addition to normal occlusion, our criteria included a harmonious facial profile, allowing us to determine ideal values for Chinese. As a result, it was possible to define not only ideal values, but also broad standards. As orthodontists, we have a duty to do our best when completing a treatment. The point at which we want to finish the treatment must not necessarily serve as what we consider an allowable range. We have been conducting research against the backdrop of these concepts and ideals.

We concluded that while selecting ideal samples, we should not just focus on patients with normal occlusion, but also consider a good facial profile. We found that there are fewer Class Ⅱ skeletal patterns in Chinese than in Japanese. Also, compared with Caucasians, Chinese tend to have a more prominent maxilla and a shorter mandible base, their mandible also grows in a clockwise direction, and they tend to have more marked bimaxillary protrusion.

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