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Craniofacial differences between Japanese and British Caucasian females with a skeletal Class III malocclusion

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SUMMARY The racial differences in the craniofacial structures of 28 Japanese and 24 British Caucasian females with Class III malocclusions associated with a severe skeletal pattern were examined using lateral cephalograms. The mean age of the Japanese and Caucasian patients was 19.6 ± 3.5 and 20.2 ± 3.8 years (±SD), respectively. The mean values of 14 linear and 13 angular cephalometric parameters were compared between the two groups.

The results showed that the Japanese females had a significantly reduced anterior cranial base ($P < 0.01$), a more retrusive midfacial component ($P < 0.05$), and a significantly increased lower anterior facial height ($P < 0.01$) associated with a more obtuse gonial angle ($P < 0.05$) compared with the Caucasians. Analysis of the dento-alveolar component in Japanese patients indicated more proclined upper incisors ($P < 0.01$) compared with those of Caucasian subjects.

The reduced anterior cranial base and midfacial component, and the high-angle facial pattern in the Japanese population, may be morphological features based on race, and these skeletal features seem to be less favourable for a skeletal Class III growth pattern compared with the Caucasian population.

Introduction

The prevalence of Class III malocclusions varies among races. In the Caucasian population, Haynes (1970) and Foster and Day (1974) screened British girls aged 11–12 years, and noted that 1.6 and 3.2 per cent, respectively, of this population had a Class III malocclusion. On the other hand, Endo (1971) reported that a reversed occlusion was more prevalent (7.81 per cent) in 11-year-old Japanese girls. Similarly, Susami *et al.* (1971) also reported that the frequency of a reversed occlusion in Japanese females aged between 3 and 19 years was 4.24 per cent. The high frequency in the Japanese population was also confirmed in other Asian populations; the prevalence of Class III malocclusions in Chinese and Korean individuals ranges from 9.4 to 19.0 per cent (Chan, 1974; Baik *et al.*, 2000).

Previous investigators have described the morphological differences between Japanese and Caucasians with respect to Class I (Masaki, 1980; Nezu *et al.*, 1982; Deguchi *et al.*, 1993; Miyajima *et al.*, 1996) and Class II (Ono *et al.*, 1986; Yamaki, 1987; Ishizuka *et al.*, 1989; Ishii *et al.*, 2002) malocclusions. Although the reported prevalence of Class III malocclusions is different among races, only a few studies have previously examined the morphological differences between Japanese and Caucasians with Class III malocclusions. Kishi (1991) and Uchiyama (1991), respectively, examined differences in the maxillary and mandibular skeletal features between Japanese and Caucasians with Class III malocclusions who required surgical correction using the same sample. Kishi (1991) reported that Japanese Class III malocclusion is characterized by a reduced cranial base and more posteriorly positioned maxilla compared with Caucasians, and these features are common in the Japanese population, including those with normal and other skeletal disharmonies. Uchiyama (1991) noted that Japanese patients with severe Class III malocclusions had an increased mandibular ramus and total

mandibular length associated with a more superiorly positioned glenoid fossa compared with Caucasians. Furthermore, that author reported that Japanese Class III patients had a relatively larger mandible to maxilla and thus a more severe skeletal maxillo-mandibular disharmony than Caucasians. However, Uchiyama (1991) did not fully compare the mandibular form and vertical development of the craniofacial structure between the races. Ngan *et al.* (1997) clarified the cephalometric differences between Chinese and Caucasian patients with severe skeletal Class III malocclusions. They found a reduced anterior cranial base, a larger posterior cranial base, a smaller gonial angle, and a larger mandible in the Chinese. Similar findings were reported by Singh *et al*. (1998), who examined Class III Korean and Caucasian patients. They noted that Korean Class III patients had a reduced anterior cranial base and midfacial dimensions, and a larger mandible with a smaller gonial angle.

Although there is a lack of information about differences in the vertical development of craniofacial structure between Japanese and Caucasians with a Class III skeletal pattern, most previous comparative studies of Japanese and Caucasians with normal and Class II skeletal patterns concluded that the former population had more excessive vertical development and high angle facial patterns (Masaki, 1980; Nezu *et al*., 1982; Ono *et al*., 1986; Yamaki, 1987; Ishizuka *et al*., 1989; Deguchi *et al*., 1993; Miyajima *et al*., 1996; Ishii *et al*., 2002). However, other Asian Class III patients have a low angle facial pattern associated with a smaller gonial angle compared with Caucasians (Ngan *et al*., 1997; Singh *et al*., 1998). These findings are conflicting, indicating that the craniofacial differences between Japanese and Caucasian patients with skeletal Class III malocclusions are still unclear, especially the racial differences in vertical development and mandibular form.

The purpose of the present study was to characterize the morphological features of the craniofacial structure of Japanese females with skeletal Class III malocclusions and to compare these features with those of Caucasians with a skeletal Class III malocclusion, with the aim of clarifying the differences in craniofacial morphology between the two races.

Material and methods

Subjects

The pre-treatment lateral cephalometric radiographs of 28 Japanese and 24 British Caucasian females diagnosed with skeletal Class III malocclusions and scheduled for orthognathic surgery were examined. Both groups were randomly selected from the Department of Orthodontics, Matsumoto Dental University, Japan, and Eastman Dental Hospital, UK. All Japanese and Caucasian female patients satisfied the following criteria: (1) treatment planned for orthognathic surgery; (2) negative A–N–B angle; (3) Angle Class III molar relationship; and (4) no previous history of any orthodontic treatment when the cephalograms were taken. The mean age was 19.6 ± 3.5 years (±SD, range 15.1–27.1) and 20.2 ± 3.8 years (±SD, range 15.3–27.4), for the Japanese and Caucasians, respectively.

Cephalometric analysis

All lateral cephalometric radiographs were taken using the same cephalostat system for each group. The image magnification of the cephalostat for the Japanese and Caucasian patients was 10 and 7 per cent, respectively, and all linear measurements reported in this study were adjusted accordingly. All lateral cephalograms of each subject were traced by the same investigator. The selected landmarks were digitized and converted to an *x–y* co-ordinate system (WinCeph, Rise Corporation, Sendai, Japan) (Figure 1). The 14 linear and 13 angular measurements represented the original parameters and those derived from the analyses of Steiner (1953) and Jarabak and Fizzell (1972).

Error of measurements

All 52 lateral cephalograms were re-traced and re-digitized a few weeks after the initial analysis. The error of the method was examined by the coefficient of reliability, calculated for each

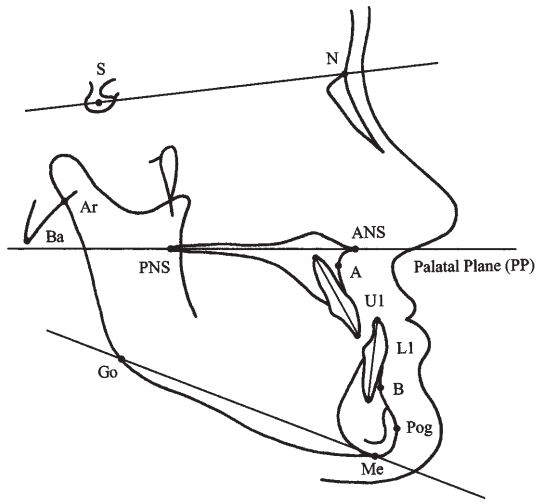

Figure 1 Cephalometric landmarks recorded in the present study. A, the deepest midline point on the premaxilla between the anterior nasal spine and prosthion. ANS, the most anterior point of the nasal floor; tip of the premaxilla on midsagittal plane. Ar, the point of intersection of the dorsal contour of the process articularis mandibulae and os temporale. B, the deepest midline point on the mandible between infradentale and pogonion. Ba, the most inferior point on the anterior margin of the foramen magnum in the midsagittal plane. Go, the most posterior inferior point at the angle of the mandible. L1, the axis of the lower central incisor. Me, the most inferior point on the symphysis of the mandible in the median plane. N, craniometric point where the midsagittal plane intersects the most anterior point of the nasofrontal suture. PNS, the most posterior point at the sagittal plane on the bony hard palate. Pog, the most anterior point on the symphysis of the mandible. S, the centre of the pituitary fossa. U1, the axis of the upper central incisor.

measurement as follows: coefficient of reliability = $1 - S_e^2/S_t^2$, where S_e^2 is the variance due to random error, and S_t^2 is the total variance of the measurements (Houston, 1983). The results are presented in Table 1.

Statistical analysis

The mean and standard deviation of each parameter were calculated. D'Agostino–Pearson's test was used to determine the distribution of cephalometric variables prior to using parametric tests. Equality of variance was tested between each group by the F-test. The unpaired Student's and Welch's *t*-tests were applied to each parameter to test the significance of differences between groups; the former was applied to parameters that had equal variances, while the latter was applied to those that had unequal variances at the F-test.

Results

The coefficient of reliability for all cephalometric parameters satisfied the level of confidence above 0.90 (Houston, 1983). The results of the comparison between cephalometric measurements of Japanese and Caucasian females with skeletal Class III malocclusion are presented in Table 1 and Figure 2.

Cranial base relationships

The mean anterior cranial base (S–N) was significantly reduced in Japanese patients compared with Caucasians ($P < 0.01$). However, the other cranial base parameters, posterior cranial base length (S–Ar), total cranial base length (N–Ar), saddle angle (the N–S–Ar angle) and the cranial base angle (the N–S–Ba angle), were not significantly different between the two groups.

Maxillary skeletal relationships

The anteroposterior position of the maxilla was evaluated by measuring S–A, Ar–A, and the S–N–A angle. Only Ar–A was significantly reduced in the Japanese females compared with the Caucasians ($P < 0.05$). S–A and S–N–A angle were not significantly different between the groups. Based on the parameters of vertical development, N–ANS and PP/S–N angle were not significantly different between the groups.

Mandibular skeletal relationships

The anteroposterior position of the mandible was evaluated by measuring S–B and the S–N–B angle. Although the linear parameter was significantly increased in the Japanese females compared with the Caucasian group ($P < 0.05$), there was no significant difference in the angular parameter between the two groups. The

Table 1 Comparison of various cephalometric parameters between Japanese and Caucasian females with skeletal Class III malocclusions.

			Japanese $n = 28$			Caucasian $n = 24$			Significance
			Coefficient of reliability	Mean	SD	Coefficient of reliability	Mean	SD	
Cranial base relationships									
	S–N	(mm)	0.992	62.5	3.1	0.994	65.0	3.2	**
	S–Ar	(mm)	0.950	31.4	3.4	0.977	30.3	2.6	NS
	N–Ar	(mm)	0.956	84.1	4.1	0.981	85.8	4.0	NS
	N–S–Ar	(°)	0.974	123.8	5.5	0.969	124.4	5.6	NS
	N–S–Ba	(°)	0.973	131.6	4.8	0.966	131.2	5.5	NS
Maxillary skeletal relationships									
Anteroposterior	S–A	(mm)	0.990	76.8	4.0	0.986	78.7	3.5	NS
	Ar–A	(mm)	0.983	76.3	3.6	0.993	78.7	3.7	*
	S–N–A	(°)	0.987	80.1	4.2	0.986	80.2	4.3	NS
Vertical	N–ANS	(mm)	0.967	51.4	2.6	0.983	50.8	3.9	NS
	PP/S–N	(°)	0.949	10.0	3.5	0.944	9.4	3.3	NS
Mandibular skeletal relationships									
Anteroposterior	S–B	(mm)	0.989	112.2	5.3	0.984	108.9	4.8	*
	S–N–B	(°)	0.991	84.3	4.7	0.991	84.1	5.0	NS
	S–Pog	(mm)	0.996	125.8	6.4	0.993	122.8	5.0	NS
	S–N–Pog	(°)	0.990	84.3	4.8	0.993	84.7	5.3	NS
Vertical	N–Me	(mm)	0.999	120.3	7.5	0.996	114.6	8.0	*
	S–Go	(mm)	0.945	72.3	4.8	0.991	70.6	4.8	NS
	S–N/Go–Me	(°)	0.996	40.9	6.1	0.996	36.8	7.5	*
	S–Ar–Go	(°)	0.944	139.2	7.3	0.966	138.5	7.0	NS
Mandible	Ar–Go	(mm)	0.939	45.7	4.1	0.986	45.2	5.0	NS
	Go–Pog	(mm)	0.968	76.8	4.8	0.980	77.5	4.8	NS
	Ar–Pog	(mm)	0.996	112.4	5.6	0.992	111.2	4.6	NS
	Ar–Go–Me	(°)	0.968	137.9	7.1	0.972	133.9	6.3	*
Inter-maxillary relationships									
Anteroposterior	A–N–B	(°)	0.993	–4.2	2.4	0.996	–4.0	2.3	NS
Vertical	ANS–Me	(mm)	0.996	69.2	6.5	0.989	64.1	5.3	**
	PP/Go–Me	(°)	0.989	30.8	6.4	0.989	27.4	7.0	NS
Dento-alveolar relationships									
	U1/S–N	(°)	0.997	110.3	6.6	0.995	105.6	5.9	**
	L1/Go–Me	(°)	0.999	75.0	7.4	0.996	78.5	5.0	NS

NS = not significant, *$P < 0.05$, **$P < 0.01$.

anteroposterior position of the chin evaluated by S–Pog and the S–N–Pog angle did not show a significant difference between the Japanese and Caucasian groups. The vertical position of the mandible was evaluated by measuring N–Me, S–Go, S–N/Go–Me angle, and S–Ar–Go angle. The total anterior facial height (N–Me) and the mandibular plane angle (S–N/Go–Me angle) in the Japanese group were significantly increased compared with the Caucasians ($P < 0.05$), but the posterior facial height (S–Go) and the saddle angle (S–Ar–Go angle) were not significantly different. The form of the mandible was examined by Ar–Go, Go–Pog, Ar–Pog, and the Ar–Go–Me angle. All linear measurements of the mandible indicated no significant difference between the two groups, but the Japanese females had a significantly more obtuse gonial angle (Ar–Go–Me angle) compared with the Caucasian patients ($P < 0.05$).

Inter-maxillary relationships

The anteroposterior relationship between the maxilla and mandible was evaluated by the A–N–B angle. There was no significant difference

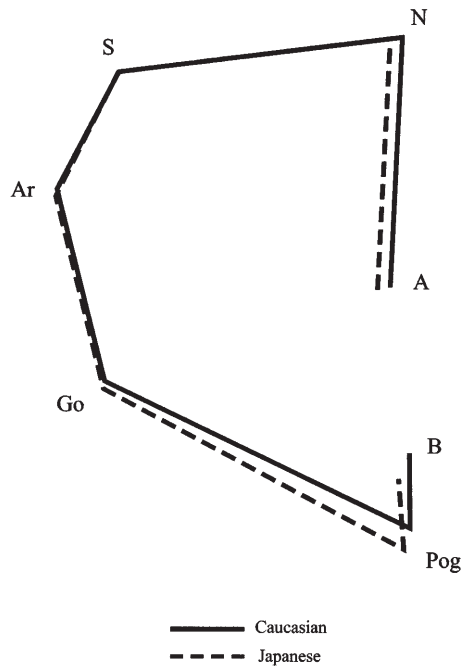

Figure 2 Comparison between representative landmarks of Japanese and Caucasian with severe Class III malocclusions.

between the groups. The vertical distance between the palatal and mandibular planes was examined by ANS–Me and the PP/Go–Me angle. The linear parameter showed a significantly increased lower anterior facial height in the Japanese patients ($P < 0.01$), but the angular parameter did not show a significant difference between the two groups.

Dento-alveolar relationships

The Japanese females had significantly more proclined upper incisors compared with the Caucasians ($P < 0.01$), but the inclination of the lower incisors was similar between the groups.

Discussion

The major finding of the present study was the reduced anterior cranial base in Japanese females with skeletal Class III malocclusions compared with their Caucasian counterparts. In general, the majority of previous investigations that compared the craniofacial morphology between Asians and Caucasians reported that Asians had a reduced anterior cranial base not only in those with a Class I occlusion (Masaki, 1980; Nezu *et al*., 1982; Cooke and Wei, 1989; Deguchi *et al*., 1993; Miyajima *et al*., 1996), but also in subjects with Class II (Ono *et al*., 1986; Yamaki, 1987; Ishizuka *et al*., 1989; Ishii *et al*., 2002) and Class III (Kishi, 1991; Ngan *et al.*, 1997; Singh *et al*., 1998) malocclusions. Fukui *et al.* (1992) examined the morphological features of the maxilla and cranial base in Taiwanese with a pseudo anterior crossbite, and compared their findings with those of Japanese and American whites. The maxilla and dento-alveolar components of the Taiwanese were slightly different from those of the Japanese, but the form of the cranial base was similar in both races. They stated that the development of the maxilla and the dento-alveolar component might be influenced by their oral functions, but the form of the cranial base could directly reflect the genetic characteristics. The present study characterized the typical racial differences in craniofacial morphology among Asian and Caucasian populations.

With respect to the mandibular dimensions, there was no significant difference between the Japanese and Caucasian groups; the mandible was similar in size in both groups. However, the cranial base and midfacial component of the Japanese patients were more reduced compared with the Caucasian group; a reduced midfacial dimension was found in previous studies of Class III patients (Kishi, 1991; Ngan *et al.*, 1997; Singh *et al*., 1998). These results indicate that Asian skeletal Class III patients have a relatively larger mandible to the cranial base and maxilla. Uchiyama (1991) reported similar findings, and concluded that these more severe skeletal abnormalities were less favourable with regard to orthodontic and orthognathic treatment of Japanese and other Asian populations.

A steeper mandibular plane angle (S–N/Go–Me angle) associated with a more obtuse gonial angle (Ar–Go–Me angle) was also found in the Japanese females with skeletal Class III malocclusions compared with Caucasians in the present study. These results are in conflict with the findings of Ngan *et al*. (1997) and Singh *et al*. (1998), respectively, who compared skeletal

Class III Chinese and Koreans with Caucasians; both investigators reported that Chinese/Korean had a smaller mandibular plane angle and gonial angle. From this point of view, the morphological features of the craniofacial structure of Japanese Class III patients seems to be different from the Chinese and Korean patients, although all three races are categorized into Mongoloid. The results of Chui and Kawamoto (1990) could support this assumption. They compared Chinese children with a Class III malocclusion with Japanese subjects. They stated that both races had similar skeletal features, but Chinese subjects had a significantly smaller mandibular plane angle compared with the Japanese. Thus, Japanese Class III patients have more excessive vertical development associated with a larger mandibular plane angle and gonial angle compared with Caucasian Class III patients, and this racial feature is supported by the comparative studies between Japanese and Caucasian Class I (Masaki, 1980; Nezu *et al*., 1982; Deguchi *et al*., 1993; Miyajima *et al*., 1996) and Class II (Ono *et al*., 1986; Yamaki, 1987; Ishizuka *et al*., 1989; Ishii *et al*., 2002) subjects.

The Japanese females in the present study had a reduced anterior cranial base, more retrusive midfacial component, and a high-angle facial pattern with a steeper mandibular plane compared with the Caucasians. In general, these differences between Japanese and Caucasians with surgical Class III were not specific to the skeletal Class III growth pattern; they might be common racial differences. However, these common racial features in the Japanese would not be favourable for the Class III skeletal pattern, as the retrusive midfacial component indicated a more posteriorly positioned maxilla, whilst a steeper mandibular plane resulted in the effective mandibular length being increased. In other words, Japanese individuals tend to have a retrognathic maxilla and prognathic mandible compared with Caucasians. These common skeletal features based on racial differences might be less favourable for correction of a Class III skeletal pattern, and consequently, severe skeletal Class III abnormalities are more likely to occur among the Japanese population compared with Caucasians.

Conclusions

The results of this study showed that the major craniofacial differences between Japanese and Caucasian females with skeletal Class III malocclusion were as follows. Japanese females had: (1) a significantly reduced anterior cranial base; (2) a significantly more obtuse gonial angle; (3) a high angle facial pattern with a significantly increased lower anterior face height; and (4) significantly more proclined upper incisors. These differences in subjects with a skeletal Class III malocclusion might represent common differences in skeletal features between the two racial groups, but the reduced midfacial component and high angle facial pattern in the Japanese population would be less favourable for correction of a Class III skeletal pattern compared with Caucasians.

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