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A Morphological Study on the Relationship between Arch Form and Craniofacial Structures in Skeletal Class I and Class III Japanese Patient

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Summary

Available studies about differences among races, related to prevalence of malocclusion or morphology of head and dental arches, suggest a hypothesis that the high prevalence of skeletal Class III malocclusion in Asian ancestry populations could be correlated with a tendency toward a brachycephalic head form and larger arches widths.

The purpose of the present study was to evaluate anteroposterior relationship of upper and lower jaws associated to form of dental arches, maxilla, mandible, face and head.

Materials in this research consisted of pretreatment lateral and posteroanterior cephalometric radiographs and orthodontic models of Japanese females with skeletal Class I and Class III.

Strong correlations between head form and jaws anteroposterior relationship could not be found. However, results indicated that skeletal Class III have statistically significant smaller length of maxilla and greater length of mandible, than the skeletal Class I group. Moreover, basal arch length and width of mandible were significantly bigger in skeletal Class III group.

These results suggest that skeletal Class III, at least in this sample, might be associated to local malformation factors.

Introduction

It is important to consider the high prevalence of mandibular prognathism in patients of Asian ancestry, in contrast to its low prevalence in Caucasians.

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According to Lew et al[1]., among Chinese students, the prevalence of Class Ⅲ malocclusion is approximately 12%. Endo[2] and Susami et al.[3], in studies of frequencies of anterior crossbite and edge-to-edge incisal relationships in Japaneses reported ranges from 2.3% to 13% and 2.7% to 7.4% respectively. However, among patients submitted to orthodontic treatment, the prevalence of mandibular prognathism becomes 38% in males and 35% in females, being the most frequent malocclusion, according to Kawahara[4].

On the other hand, in Americans, Graber[5] reported that mandibular protrusion is rare, representing only 2–3% of the patients that undergo treatment, while the incidence of mandibular retrusion is high, representing about 2/3 of the patients.

Head form and occlusion could have some correlation. According to Enlow[6], in individuals with dolichocephalic head form, the forward basicranial rotation, and also, the horizontally longer anterior and middle segments of cranial floor, would result in a forward placement of the maxilla and backward placement of the mandibular corpus, positioning the molars in a tendency toward a Class Ⅱ position.

On the other hand, in individuals with brachycephalic head form, the horizontal length of the nasomaxillary complex is also relatively short and because the brachycephalized basicranium is wider but less elongated in the anteroposterior dimension, the middle and anterior cranial fossae are correspondingly foreshortened, resulting in a relative placement of the entire mandible, causing a greater tendency toward a prognathic profile and a Class Ⅲ relationship.

As observed by Graber[5], some correlation among the form of head, face and arches could exist. Dolichocephalic individuals trend to have long narrow faces and relatively narrow dental arches, while brachycephalic individuals trend to have very broad and relatively short faces and broad, round dental arches. Mesocephalic individuals would fit somewhere in between these two.

Those data suggest the hypothesis that the high prevalence of skeletal Class Ⅲ malocclusion in Asian ancestry populations could be correlated with a tendency toward a brachycephalic head form and larger arches widths.

Despite the several investigations in either head form[7-10] and arches dimensions[11-16], few data is found in Japanese individuals. Furthermore, most of them were undertaken on normal occlusion samples.

The present study was undertaken for evaluate the correlation between the anteroposterior position of upper and lower jaws, and the morphology of coronal and basal arches, maxilla, mandible, face and head, in Japanese females with skeletal Class Ⅰ and skeletal Class Ⅲ.

Materials and Methods

Materials

Sets of pretreatment recordings of 30 patients were selected from the clinics at Department of Orthodontics, Matsumoto Dental University. Each set consisted of lateral and anteroposterior cephalometric projections and orthodontic models.

Samples consisted of female individuals between ages of 12y0m and 16y11m (average age of 15y8m), which comprises the period after peak and before completion of growth. 15 individuals were skeletal Class Ⅰ (12y0–16y2m) patients and 15, skeletal Class Ⅲ (14y6–16y11m).

Classification of skeletal Ⅰ and Ⅲ was based on cephalometric analysis, considering ANB angle and Wits appraisal[17] cephalometric measurements.

Casts exhibiting severe crowding, missing or not fully erupted permanent teeth (second and third molars not included), evidence of tongue thrusting, teeth with obvious abnormality of size or shape, or ectopically erupted teeth were excluded from the sample.

Methods

Cephalometric linear measurements were taken from lateral and posteroanterior cephalogram tracings of the subjects as showed in Fig.1 and 2, respectively.

1 . Cephalometric analysis

1) Lateral cephalogram

Length of maxilla ‹A–Ptm (FH)› : distance from A to Ptm, parallel to Frankfurt Horizontal plane (FH).

Length of mandible ‹Pog–Ar (FH)› : distance from Pog to Ar, parallel to FH.

Facial length ‹S–Or (FH)› : distance from S to Or, parallel to FH.

Head length ‹G–Ba› : the linear distance from G to Ba. Usually, in cephalic index evaluation, linear distance from Ba to Op craniofacial surface landmarks is taken, but the limited size of available lateral cephalometric projection films did not permit visualization of Op point.

Anteroposterior displacement of jaws ‹A–B (FH)› : distance between A and B points, perpendicular to the Frankfort Plane.

2) Posteroanterior cephalogram (P–A)

Width of maxilla ‹Mxl–Mxr› : linear distance between Mx points of left and right sides.

Width of the mandible ‹Gol–Gor› : linear distance between Go points of left and right sides.

Facial width ‹Lol–Lor› : linear distance between intersection points of major wing of sphe-

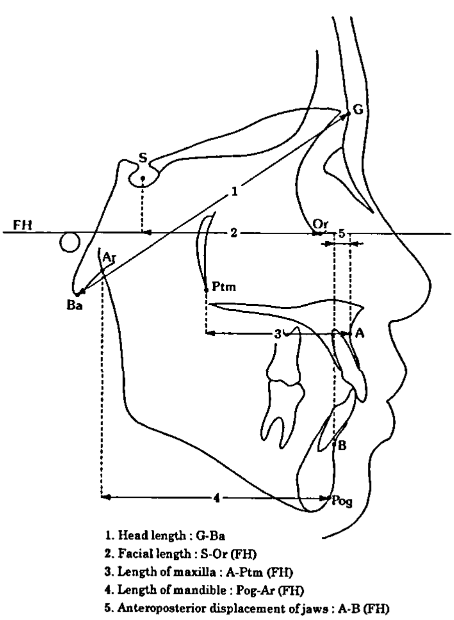

Fig.1 Measurement variables for lateral cephalogram

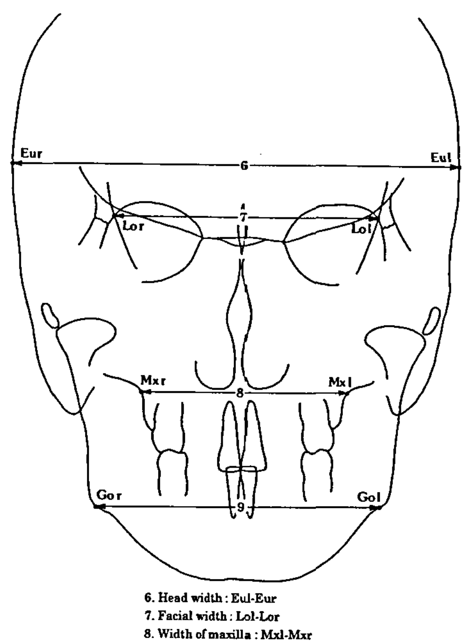

Fig.2 Measurement variables for posteroanterior cephalogram

noid bone and orbita contour, of left and right sides, named Lo point in Sassouni[18] analysis.

Head width ‹Eul–Eur› : linear distance between the outermost points in cranium skeleton contour, regarding midsaggital plane. Usually, to evaluate the cephalic index, it is used Eu–Eu craniofacial surface landmarks. Midsagittal plane was determined at crista galli.

2. Model analysis

Sagittal and transverse measurements in horizontal plane of coronal and basal arches were taken directly on casts as shown in Fig.3 and 4, respectively, using calipers readings at the nearest 0.5mm and Otsubo's sliding calipers[19].

1) Coronal arch measurements

Tooth material (TM) : sum of mesio–distal diameters of 12 teeth comprised between permanent first molars (incisors, cuspids, bicuspids and first molars).

Coronal arch length (CL) : distance between the midincisal edge (buccal side) of central incisors and the line tangent to the distal face of permanent first molars, measured parallel to palatal suture ; in case of a minimum central incisors crowding, it was used the middle point between their midincisal edges.

Coronal arch width (CW) : distance between summits of buccal cusps of first bicuspids.

2) Basal arch measurements

Basal arch length (BL) : distance from the innermost point at central incisors alveolus (point A in maxilla and point B in mandible) to the line tangent to the distal face of permanent first molars.

Basal arch width (BW) : distance between the mucogingival junctions below buccal cusp tips of first bicuspids.

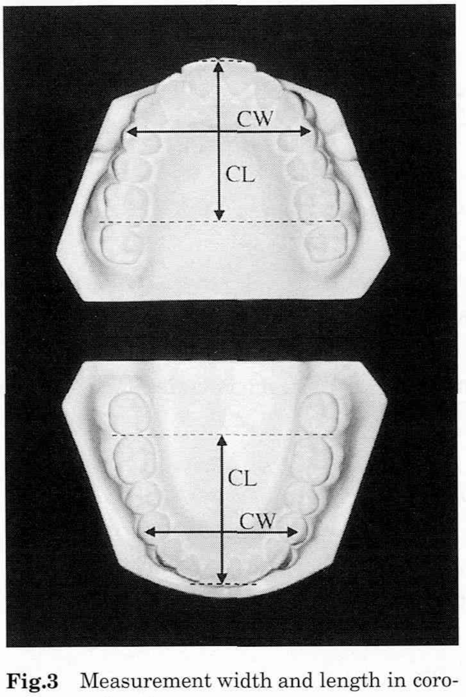

Fig.3 Measurement width and length in coronal archs

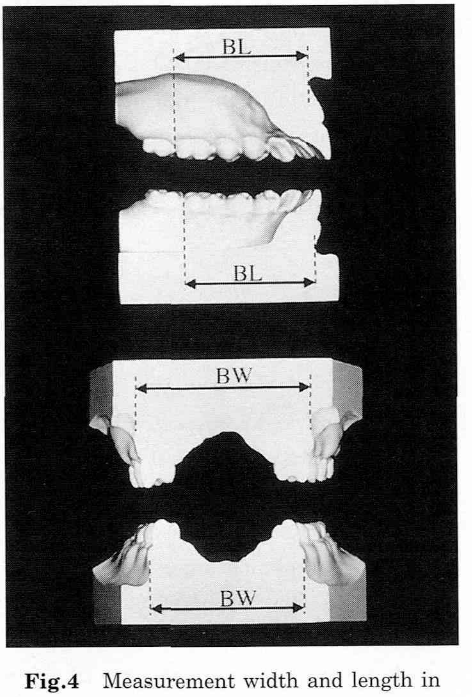

Fig.4 Measurement width and length in basal archs

3) Upper and lower coronal arches relationship

Mesial Step (MS) : the distance between the mesial faces of upper first molar and lower fist molars (Fig.5) ; it was used the mean of right and left sides measurements. It represents a form of evaluation of Angle malocclusion classification.

In cases with first molars mesio-distal asymmetric position, basal arch length and coronal arch length were determined as the mean of right and left sides measurements, parallel to palatal suture.

Ratios between length/width measurements were calculated as percentage.

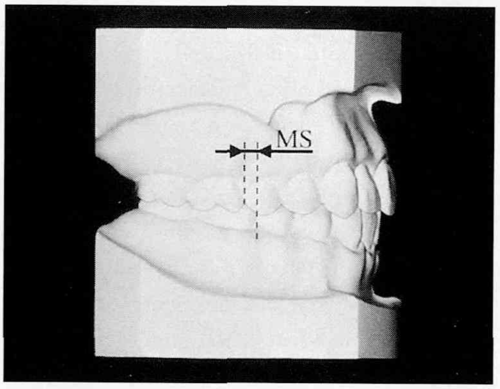

Fig.5 Measurement in upper and lower coronal archs relationship

Measurements analysis were carried out into two parts :

A sequential analysis of anteroposterior displacement of jaws, using A-B (FH) measurement as parameter ;

A comparison between mean values of Class I and Class III groups.

Decrease of the A-B (FH) reading means a increasing tendency toward a skeletal Class III malocclusion, while increased readings represents a increasing tendency toward a skeletal Class II malocclusion. A-B (FH) measurement was selected as a parameter due to its larger range of variation, compared with ANB angle, for example. Furthermore, ANB angle can be severely affected by position variation of point N[20,21].

3 . Statistical analysis

Statistic analysis was conducted as follows :

A two-sided test of significance (t test) was used to compare means of cephalometric and model measurements in skeletal Class I and Class III groups.

Using a Pearson's correlation coefficient at a significance level of 95%, data were evaluated in a sequential anteroposterior positional change of maxilla and mandible, using A-B (FH) measurement as parameter.

Results

Results of descriptive statistics for the measurements obtained from cephalograms and models are shown in Table 1 and 2, respectively.

1 . Class I × Class III groups (t test)

Relevant findings of two-sided t test are summarized below.

1) Cephalometric analysis

A. Lateral cephalogram measurements

Skeletal Class III individuals had smaller length of maxilla (A-Ptm measurement), with significance at the 1% level.

B. Posteroanterior cephalogram (P. A.) measurements

Significant differences could not be found.

Table 1 Cephalometric measurements of skeletal Class I and Class Ⅲ groups

Measurement	Class I group (n=15)		Class Ⅲ group (n=15)		t value	r value
	mean	S. D.	mean	S. D.		
Lateral Cephalogram						
A–Ptm (FH)	48.1	2.1	45.4	1.9	**	0.398
Pog-Ar (FH)	77.0	5.4	79.9	5.8	–	–0.491
S-Or (FH)	56.3	5.1	54.7	2.8	–	–0.009
G-Ba	121.2	5.5	121.4	4.8	–	0.044
A-B (FH)	5.3	3.0	–2.0	4.4	–	–
P. A. Cephalogram						
Eu-Eu	162.7	6.7	161.9	6.3	–	0.211
Lo-Lo	93.1	4.6	92.8	1.8	–	–0.123
Mx-Mx	69.7	3.5	69.1	3.3	–	0.125
Go-Go	100.4	5.9	102.5	6.6	–	–0.259
Lateral/P. A.						
A-Ptm (FH)/Mx-Mx	69.2	4.1	66.0	5.4	–	0.178
Pog-Ar (FH)/Go-Go	76.8	5.8	78.3	8.5	–	–0.233
S-Or (FH)/Lo-Lo	60.6	5.9	58.9	3.4	–	0.062
G-Ba (FH)/Eu-Eu	74.6	5.1	75.1	4.9	–	–0.104

unit : mm t test : **p<0.01 ; *p<0.05

Table 2 Model measurements of skeletal Class I and Class Ⅲ groups

Measurement	Class I group (n=15)		Class Ⅲ group (n=15)		t value	r value
	mean	S. D.	mean	S. D.		
Coronal Arch						
Maxilla						
CL	37.8	1.9	36.9	2.0	–	0.285
CW	42.3	2.5	42.9	2.3	–	–0.085
CL/CW	89.7	5.5	86.0	4.0	*	0.352
TM	89.9	4.0	89.7	3.7	–	–0.002
CL/TM	42.1	1.6	41.2	2.9	–	0.262
CW/TM	47.1	2.6	47.9	3.1	–	–0.086
Mandible						
CL	33.6	1.5	32.5	1.3	*	0.254
CW	34.4	1.6	34.8	2.0	–	0.012
CL/CW	97.9	4.6	93.7	6.5	*	0.166
TM	82.2	2.8	82.3	3.5	–	–0.028
CL/TM	41.0	2.1	39.5	1.8	*	0.253
CW/TM	41.9	2.2	42.3	2.7	–	0.029
Basal Arch						
Maxilla						
BL	33.0	1.1	31.7	1.9	*	0.564
BW	44.5	3.2	44.9	2.1	–	–0.076
BL/BW	74.3	5.4	70.6	4.2	*	0.513
BL/TM	36.7	2.0	35.4	2.6	–	0.329
BW/TM	49.6	3.9	50.1	3.4	–	–0.063
Mandible						
BL	31.5	1.6	33.3	1.2	**	–0.495
BW	39.8	1.6	42.0	1.4	**	–0.526
BL/BW	79.2	3.0	79.4	2.4	–	–0.044
BL/TM	38.4	2.0	40.5	1.4	**	–0.470
BW/TM	48.5	2.2	51.1	2.5	*	–0.430
Mesial Step						
1M–1M	2.78	0.96	5.59	2.11	**	–0.792

unit : mm t test : **p<0.01 ; *p<0.05

C. Lateral / P. A. measurements ratio

Significant differences could not be found.

2) Model analysis

A. Coronal arch measurements

a) Maxilla

Coronal length/coronal width ratio was greater for skeletal Class Ⅲ group, with significance at the 5% level.

b) Mandible

Coronal length and coronal length/tooth material ratio measurements were smaller in skeletal Class Ⅲ, at the 5% level.

Coronal length/Coronal width ratio was bigger in skeletal Class Ⅲ, significant at the 5% level.

B. Basal arch measurements

a) Maxilla

In skeletal Class Ⅲ individuals, basal length measurement was smaller, while basal length/basal width ratio was bigger, with significance at the 5% level.

b) Mandible

Basal length measurement ($p<0.01$), basal length/tooth material ratio ($p<0.01$), basal width measurement ($p<0.01$) and basal width/tooth material ratio ($p<0.05$) showed significantly bigger values in skeletal Class Ⅲ individuals.

C. Mesial step measurement

The distance between mesial surfaces of upper and lower first molars was greater in skeletal Class Ⅲ individuals, with significance at the 1% level.

2 . Evaluation according to A–B (FH)–(Pearson's correlation coefficient)

Following, relevant findings of Pearson's correlation analysis are summarized (Figs. 6–10).

1) Cephalometric study

A. Lateral cephalogram measurements

a) Maxilla

Length of maxilla (A–Ptm (FH) measurement) and A–B (FH) showed correlation ($r=0.398$). This means some tendency to become smaller with increasing of Class Ⅲ severity.

b) Mandible

Length of mandible (Pog–Ar (FH) measurement) and A–B (FH) showed correlation ($r=0.491$). This means tended to become bigger as severity of Class Ⅲ.

B. Posteroanterior cephalogram (P–A) measurements

Significant correlation coefficients could not be found.

C. Lateral / P. A. measurements ratio

Significant correlation coefficients could not be found.

2) Model study

A. Coronal arch measurements

a) Maxilla

Coronal length/coronal width ratio and A–B (FH) showed correlation ($r=0.352$). This means tendency to become smaller with increasing of Class Ⅲ severity.

b) Mandible

Significant correlation coefficients could not be found.

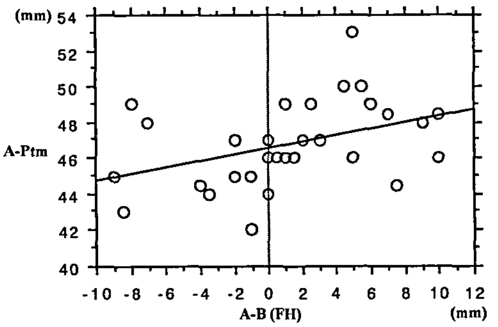

Fig. 6 Length of Maxilla : correlation analysis between A–Ptm and A–B (FH)

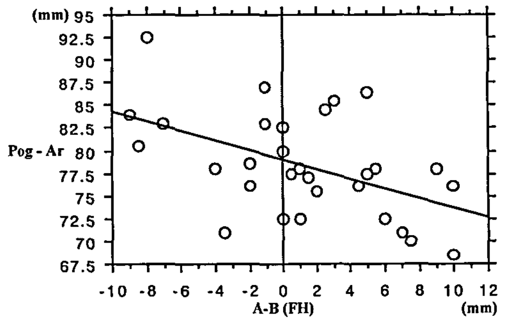

Fig. 7 Length of Mandible : correlation analysis between Pog–Ar and A–B (FH)

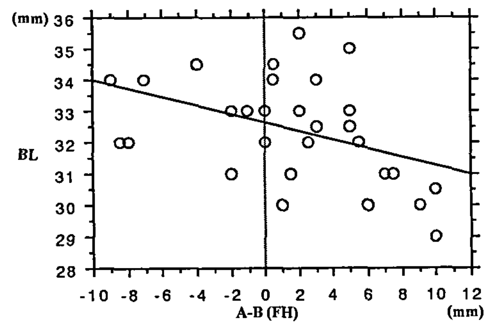

Fig. 8 Length of Mandibular basal arch length : correlation analysis between BL and A–B (FH)

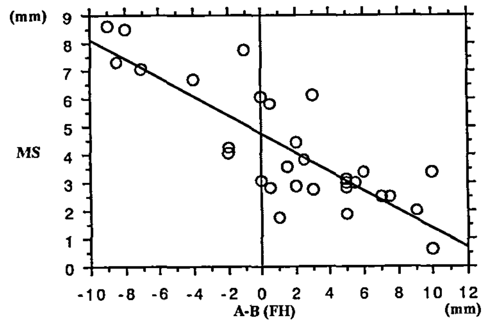

Fig. 9 Mandibular basal arch width : correlation analysis between MS and A–B (FH)

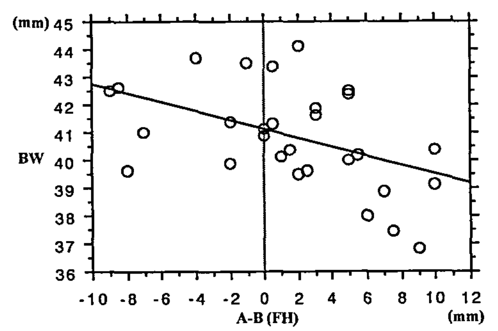

Fig. 10 Mesial step : correlation analysis between BW and A–B (FH)

B. Basal arch measurements

a) Maxilla

Basal length measurement (r=0.564), basal length/basal width ratio (r=0.513) and A–B (FH) showed strong correlation. This means a tendency to become smaller with increasing of ClassⅢ severity.

b) Mandible

Basal length measurement (r=0.495), basal length/tooth material ratio (r=0.470), basal width (r=0.526), basal width/tooth material ratio (r=0.430), and A–B (FH) showed correlation. In this measurement, basal width showed strong correlation. This means tendency to become bigger with increasing of Class Ⅲ severity.

C. Mesial step measurement

The distance between mesial surfaces of upper and lower first molars and A–B (FH) showed strong correlation ($r=0.792$). This means tended to become bigger as severity of Class Ⅲ increased.

Discussion

Difference among races seems to be relevant also in head and arches form. As studied by Farkas[22] in a cephalic index analysis, Caucasians have a trend toward mesocephalism, Chineses toward brachycephalism, while Africans have a dolichocephalism tendency. In a model measurements study on normal occlusion samples, Aoki et al.[23] reported that arch width is larger in Japaneses than in Americans.

The purpose of the present study was to evaluate anteroposterior relationship of upper and lower jaws associated to the morphology of dental arches and craniofacial structures. Measurements were taken on pretreatment cephalograms and plaster models from Japanese females with skeletal Class Ⅰ and Class Ⅲ.

This study was carried out into two parts :

A sequential analysis of anteroposterior displacement of jaws, using A–B (FH) measurement as parameter ;

A comparison between means of Class Ⅰ and Class Ⅲ groups.

Differences between the two ways of analyze might be explained by Järvinen[24]'s study, that reported that ANB angle and A–B (FH) are not always directly comparable. However, in statistical results of this study, great differences were not found.

In this study, no significant difference on tooth material measurements between Class Ⅰ and Class Ⅲ groups was found, but values for both groups were greater than those found by Otsubo[16] on normal occlusion samples. These results confirm that tooth size is related to malocclusion.

Results of the present study are in according to findings of Braun et al.[25], which reports that Class Ⅲ individuals have smaller arch length and greater arch width of mandibular coronal arches than Class Ⅰ subjects. Maxillary coronal arch widths were similar in both groups.

Significant differences were found for basal arch measurements but not for coronal arch. It might be correlated to dental compensations, such as accentuated Spee Curve, dental crowding or tipping. Results of this study agree with findings of Richardson et al.[26], which observed lack of correlation between the size of the apical base, the alveolar arch and the dental arch.

Although strong correlation between head form and anteroposterior relationship of upper and lower jaws was not found, results indicated that there were significant correlations in lengths of maxillary and mandibular bones, and in basal arches measurements.

Skeletal Class Ⅲ group, compared to Class Ⅰ, have significantly smaller length of maxilla and greater length of mandible, and those tendencies increase with severity of Class Ⅲ malocclusion.

Moreover, basal arch length and width of mandible were bigger in skeletal Class Ⅲ group, and these measurements trend to become greater with increase of Class Ⅲ severity.

These results suggest that skeletal Class Ⅲ, at least in this sample, might be associated to local malformation, considering two factors : the expression of size discrepancy between maxilla and mandible, apart of growth of other craniofacial structures ; the anteroposterior alignment and rotation of maxilla and mandible, contributing to create a ClassⅢ malocclusion.

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抄録：日本人 skeletal Ⅰ，skeletalⅢ症例の歯列弓と顎顔面頭蓋における形態学的関係に関する研究

成沢ロベルタ美世江[1]，簑島保宏[1]，影山　徹[1]，出口敏雄[1,2]，栗原三郎[1]
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民族間の相違について，形態学における不正咬合，もしくは歯列弓の優位性に関連した研究で，アジアの先祖人民の骨格的特徴は，短頭型の頭蓋形態を示す傾向があり，大きい歯列弓幅径との相関に優位性が高く，不正咬合者は，skeletalⅢ症例が多い，という仮説が報告されている．

本研究の目的は，歯列弓，上下顎骨の長径，幅径，の形態的特徴および，前後的な関係を評価することを目的とする．

研究の試料は，日本人女性で，skeletal Ⅰ症例，skeletalⅢ症例を対象とし，治療前の側貌および正貌の頭部Ｘ線規格写真と矯正診断用口腔模型を試料とした．

頭蓋形態と上下顎の前後的な関連において，強い相互関係は，認められなかった．しかし，skeletal Ⅲ群は統計学的に skeletal Ⅰ群より上顎骨長径は短く，下顎骨長径は長い結果を示し，相関に有意差が認められた．さらに，下顎歯槽基底弓長径は長く，幅径は広い結果を示し，skeletalⅢグループにおいて相関関係が認められた．

これらの結果から，skeletalⅢは少なくともこの試料において，局所的な形態異常の要因に関連していることが示唆された．