Original Article

Asymmetry of the Face in Orthodontic Patients

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ABSTRACT

Objective: To investigate the laterality of the normal asymmetry of the human face, examining differences in laterality in relation to sex, growth stage, and skeletal classification.

Materials and Methods: A total of 1800 Japanese subjects (651 males and 1149 females; mean age, 15 years 3 months; range, 4 years 2 months to 59 years 11 months) were selected. Individuals in the sample were categorized according to sex, one of three growth stages, and one of three skeletal patterns. Differences in length between distances from the points at which ear rods were inserted to the facial midline and the perpendicular distance from the soft-tissue menton to the facial midline were measured on a frontal facial photograph. Subjects with a discrepancy of more than 3 standard deviations of the measurement error were categorized as having left- or right-sided laterality.

Results: Of subjects with facial asymmetry, 79.7% had a wider right hemiface, and 79.3% of those with chin deviation had left-sided laterality. These tendencies were independent of sex, age, or skeletal jaw relationships. In this regard, during pubertal growth, the proportion of subjects with wider right hemiface decreased ($P < .0001$), whereas the proportion of those with a wider left hemiface increased ($P < .01$), despite a consistent tendency for right-sided dominance.

Conclusion: These results suggest that laterality in the normal asymmetry of the face, which is consistently found in humans, is likely to be a hereditary rather than an acquired trait.

KEY WORDS: Laterality; Hemiface; Jaw deviation; Human

INTRODUCTION

Numerous factors such as cleft lip, hemifacial microsomia, and childhood fracture of the jaw have been reported to be associated with facial asymmetry. These conditions often result in severe and pathologic asymmetry of the face.[1,2] On the other hand, minor, nonpathologic facial asymmetry, which is defined as the difference in size between the left and right hemifaces, or normal asymmetry, is relatively common.[1,3,4] Most studies of normal asymmetry have reported that the right hemiface is usually wider than the left.[5–10] However, some reports have documented no significant difference between right and left hemiface size[11,12] or have found the left hemiface to be wider.[13,14] Causes of such facial laterality remain unknown. Similarly, a few studies have reported on the laterality of chin deviation, a subject that also remains controversial. A recent cephalometric study documented left-sided deviation of the menton from the midline in 60% to 80% of patients with skeletal Class III malocclusion who exhibited facial asymmetry.[15] In contrast, other studies have reported no such trait in patients with skeletal Class III malocclusion and long faces.[16]

The purposes of this study were (1) to investigate the laterality of the normal asymmetry of the human face with large numbers of Japanese subjects and (2) to investigate differences in laterality related to sex, growth stage, and skeletal classification to help elucidate the etiology of facial laterality and to provide useful information in diagnosing maxillofacial deformities.

MATERIALS AND METHODS

Subjects

A pooled sample of 2619 Japanese orthodontic patients who had received orthodontic clinical examina-

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tions at the university dental hospital between October 1996 and January 2005 participated in the study. Selection was made consecutively from the patient database. A group of 482 patients with congenital craniofacial anomalies or severe facial deformities including cleft lip and/or palate, severe malpositioning of the orbits or ears, and functional shift of the mandible were excluded. One hundred sixty-two patients who had received orthodontic treatment before attending the hospital were also excluded.

Conventional facial photos (frontal views in 35-mm color reversal films, Kodak Ektachrome DynaEX100, ISO 100; Eastman Kodak Co, Rochester, NY) were used. The photos had been taken with the head fixed using ear rods and the Frankfort horizontal plane parallel with the ground in maximum intercuspation. An SLR camera (Nikon FM2; Nikon Corporation, Tokyo, Japan) and a telescopic lens (Micro-Nikkor 105 mm; Nikon Corporation) were set perpendicular to the line connecting bilateral ear rods, calibrated using a grid sheet within errors of less than 0.001 mm. The recording distance between the camera and the patient was 150 cm. A ring strobe was employed as a light source. Photos that did not depict the patient looking straight at the camera or those in which the hair obscured the outline of the face or the pupils (a total of 175 records) were excluded. Finally, a total of 1800 patients (651 males and 1149 females; mean age, 15 years 3 months; range, 4 years 2 months to 59 years 11 months) were selected for subsequent analysis. Photographs were digitized with a film scanner (Coolscan III; Nikon Corporation, Tokyo, Japan) at a resolution of 300 dpi and 200% enlargement. Each photograph was analyzed with a software program (Photoshop 5.5J; Adobe, San Jose, Calif) by one of the authors (Dr Iguchi).

Points er_r and er_l were defined as points on the patient's right and left sides where a line connecting the centers of the ear rods intersects the outer contour of the face (Figure 1). The facial midline was defined as the perpendicular bisector of the line between the centers of the right and the left pupils (*p*). The differences in the distance between er_r to the facial midline and from er_l to the facial midline were defined as dFW. Soft-tissue menton, *me*, was defined as the lowest point of the outer contour of the face on the standardized facial photographs. The horizontal distance between *me* and the facial midline was defined as dME.

To estimate measurement error, 100 subjects were selected randomly from the database of 1800 patients for a pilot study, and each was measured 10 times. Standard deviations of the measurement errors were 0.34 mm for dFW and 0.49 mm for dME. A value of dFW within 0 mm $\pm$ 3 SD of the measurement error (ie, -1.03 mm $<$ dFW $<$ 1.03 mm) was defined as having no laterality. A value of dFW smaller than 0 minus 3 SD was taken to indicate a wider right hemiface, whereas a dFW exceeding 0 plus 3 SD was considered to represent a wider left hemiface. In a similar manner, if the dME fell within 0 mm $\pm$ 3 SD of the measurement error (ie, -1.48 mm $<$ dME $<$ 1.48 mm), the chin was considered to have no deviation. A dME of less than 0 minus 3 SD was defined as right-sided deviation, whereas a dME exceeding zero plus 3 SD was defined as a left-sided deviation. Patients were categorized by sex (male or female), age (prepubertal, pubertal, or postpubertal), and skeletal pattern (skeletal Class I, II, or III). Patients younger than 11 years 9 months for males and 10 years 3 months for females were subclassified as prepubertal, while males older than 15 years 8 months and females older than 14 years 2 months were assigned to the postpubertal stage groups. The remaining patients were classified as pubertal.[17] Skeletal classifications were made based on the ANB angle, as described in previous reports.[18]

Statistical Analyses

A χ^2 test was used for comparisons of proportions of right-sided and left-sided laterality in each group. Ryan's multiple comparison tests were used for comparisons of proportions between the components of the same categorized group for three directional sides. Analyses were conducted using a software program (R 1.9.1, R Foundation for Statistical Computing). *P* values $>.01$ were considered not significant.

RESULTS

Values of dFW for subjects with asymmetry (n $=$ 1430), excluding those with no discernable laterality (n $=$ 370), are shown in Figure 2. Data were sorted consecutively in the numeric sequence of the patients' database. The horizontal axis of the bar chart shows the differences between the left and the right midfacial widths in millimeters. A minus value indicates that the right midfacial width was greater than the left midfacial width. The proportion of subjects with a wider right hemiface at the middle face level was significantly higher than the proportion with a wider left hemiface ($P < .00001$).

Values of dME for subjects with asymmetry (n $=$ 1135) are shown in Figure 3. A positive value indicates that the soft-tissue menton was in a left-sided position with respect to the facial midline. The proportion of subjects with a left-sided chin deviation was significantly higher than the proportion with a right-sided deviation ($P < .00001$).

Table 1 shows the proportions of subjects (n $=$ 1800) with greater left or right hemiface dimensions as

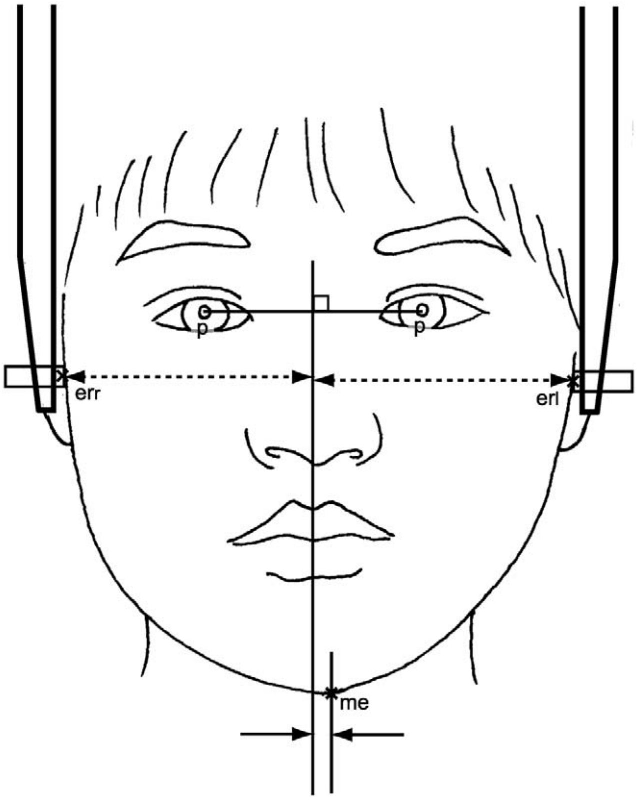

Figure 1. Schematic illustration of reference points and linear measurements used on frontal facial photographs.

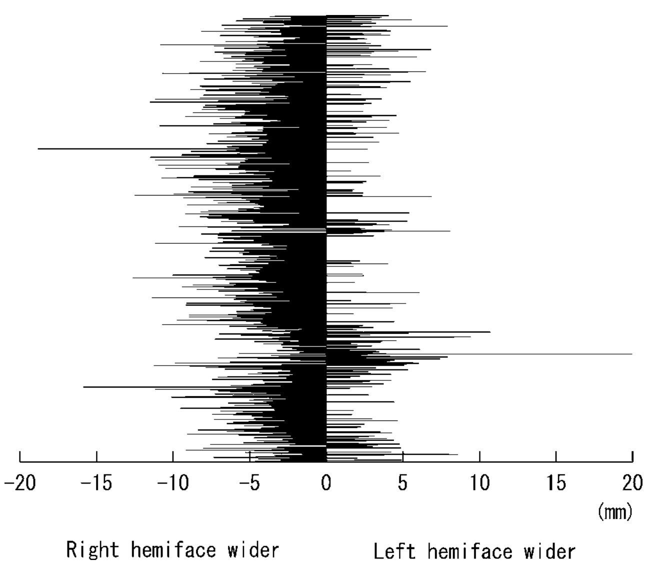

Figure 2. Bar graph showing values of dFW for subjects with asymmetry (n = 1430), excluding those with no laterality (n = 370). Data were sorted consecutively in the numeric sequence of the patient database. The horizontal axis of the bar chart shows the differences between the left and the right midfacial width in millimeters. The number of subjects with a wider right hemiface (n = 1139) was significantly larger than the number with a wider left hemiface (n = 291; $P < .00001$).

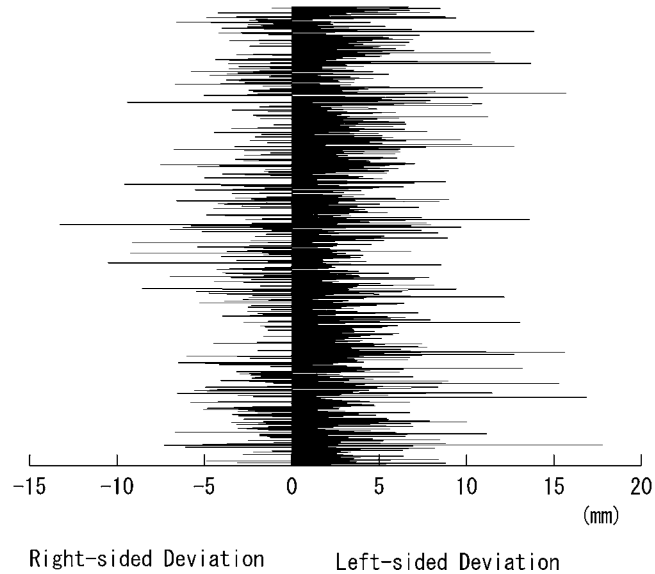

Figure 3. Bar graph showing values of dME for patients with asymmetry (n = 1135), excluding those with no jaw deviation (n = 665). Data were sorted consecutively in numeric sequence of the patient database. The horizontal axis of the bar charts shows the differences between the left and the right chin deviation in millimeters. The number of subjects who had a left-sided chin deviation (n = 901) was significantly larger than those with a right-sided deviation (n = 234; $P < .00001$).

well as no laterality divided by sex, growth stage, and skeletal pattern. The proportion of subjects with a wider right hemiface was significantly higher than that of those with a wider left hemiface for each category ($P < .00001$). The proportion of subjects with a wider right hemiface in the prepubertal stage was significantly higher than that of those in the postpubertal stage ($P < .0001$). On the other hand, the proportion of subjects with a wider left hemiface in the postpubertal stage was greater than for those in the prepubertal stage ($P < .01$).

Table 2 displays the proportions of subjects who showed left- or right-sided chin deviations from the facial midline or no deviation (n = 1800) for each category by sex, growth stage, and skeletal pattern. For each category, the proportion of subjects who showed a left-sided deviation of the soft-tissue menton was significantly greater than the proportion with right-sided deviation ($P < .00001$). The proportion of subjects in the postpubertal stage who showed a left-sided chin deviation was significantly greater than those in the prepubertal stage ($P < .0001$). The proportions of subjects in the postpubertal stage who showed no deviation at menton were lower than both those in the prepubertal stage ($P < .0001$) and those in the pubertal stage ($P < .01$).

Table 3 shows the proportions of all subjects (n = 1800) in each of the three skeletal categories who

Table 1. Proportions of Subjects Who Showed Left- or Right-Sided Lateralities of the Midfacial Width or No Laterality (N = 1800) Subdivided by Sex, Growth Stage, and Skeletal Pattern

	Right Hemiface Greater, %	No Laterality, %	Left Hemiface Greater, %	Sample Size	Right vs Left χ^{2a}
Sex					
Female	63.5	21.1	15.4	1149	248.60
Male	62.8	19.5	17.7	651	120.75
Growth stage					
Prepubertal	68.0†	18.8	12.9*	663	184.23
Pubertal	63.6	20.6	16.0	388	81.02
Postpubertal	58.8†	22.0	19.3*	749	110.17
Skeletal pattern					
Class 1	65.2	20.0	14.8	874	205.42
Class 2	60.2	21.9	17.9	379	63.67
Class 3	62.3	20.3	17.4	547	101.88

[a] All χ^2 values were significant at the $P < .00001$ level with one degree of freedom.
* $P < .01$; † $P < .0001$.

Table 2. Proportions of Subjects Who Showed Left- or Right-Sided or No Chin Deviation From the Facial Midline (N = 1800) Subdivided by Sex, Growth Stage, and Skeletal Pattern

	Right-Sided Deviation, %	No Deviation, %	Left-Sided Deviation, %	Sample Size	Right vs Left χ^{2a}
Sex					
Female	13.0	37.8	49.2	1149	187.27
Male	13.7	34.9	51.4	651	109.90
Growth stage					
Prepubertal	12.1	42.9†	45.1†	663	100.07
Pubertal	12.6	38.8*	48.6	388	63.65
Postpubertal	13.5	30.5*†	56.0†	749	148.63
Skeletal pattern					
Class 1	12.8	36.9	50.3	874	150.60
Class 2	10.8	41.4	47.8	379	69.71
Class 3	13.9	33.6	52.5	547	94.06

[a] All χ^2 values were significant at the $P < .00001$ level with one degree of freedom.
* $P < .01$; † $P < .0001$.

Table 3. Proportion of Subjects Who Exhibited Skeletal Class I, Skeletal Class II, or Skeletal Class III Malocclusion With Left- or Right-Sided or No Chin Deviation (N = 1800) Further Divided Into Three Growth Stages

	Right-Sided Deviation, %	No Deviation, %	Left-Sided Deviation, %	Sample Size	Right vs Left χ^{2a}
Skeletal Class 1					
Prepubertal	13.5	43.7†	42.8†	348	41.97
Pubertal	13.8	37.9	48.2*	224	33.12
Postpubertal	11.3	28.0†	60.7*†	302	77.83
Skeletal Class II					
Prepubertal	11.1	41.3	47.6	126	22.55
Pubertal	12.0	37.3	50.6	83	15.33
Postpubertal	10.0	43.5	46.5	170	31.87
Skeletal Class III					
Prepubertal	10.0	42.4*	47.9	190	33.35
Pubertal	10.0	42.5*	47.5	80	15.53
Postpubertal	18.0	25.2*	56.8	277	41.64

[a] All χ^2 values were significant at the $P < .00001$ level with one degree of freedom.
* $P < .01$; † $P < .0001$.

showed a left- and right-sided chin deviation from the facial midline or no deviation. Each skeletal category was further divided into three growth stages. The proportion of subjects in the postpubertal stage with skeletal Class I jaw relationships had higher left-sided chin deviation than those with skeletal Class I relationships in the prepubertal stage ($P < .0001$) and the pubertal stage ($P < .01$). The proportion of subjects in the postpubertal stage with skeletal Class I jaw relationships and no deviation at menton was lower than for those who exhibited a skeletal Class I relationship in the prepubertal stage ($P < .0001$). The proportion of postpubertal stage subjects with skeletal Class III jaw relationships and no deviation at menton was lower than those with Class III in the prepubertal stage ($P < .01$) and the pubertal stage ($P < .01$).

DISCUSSION

The laterality of the human face has been investigated using methods involving frontal facial photographs, posteroanterior cephalograms, and stereophotogrammetry.[5–16] The key to evaluating facial asymmetry with any of these methods is defining the criteria for determining the facial midline. Because there is no absolute facial midline, we employed the centers of the pupils of the eyes as landmarks for defining the facial midline, as well as defined the area of the head forward of the ears as the face. We assumed that proper visual recognition of an object in space on binocular vision is achieved according to a perpendicular bisector to a line connecting bilateral pupils. This bisector coincides with the direction of gravity and was defined as the facial midline.[19]

Previous reports have suggested that facial asymmetry is likely to exhibit laterality.[5–10,13–16] The present study examined facial laterality from two perspectives: (1) which side of the hemiface is most likely to be wider and (2) to which side does the chin tend to deviate. The results indicated that 79.7% of subjects with facial asymmetry had a wider right hemiface and, concomitantly, that 79.3% of subjects with chin deviation showed left-sided laterality.

Most previous studies examining differences in hemiface size have used relatively small samples of 100 or fewer. The lack of consistent agreement among the results of previous studies may reflect the inadequacy of these relatively small samples in detecting subtle differences in size between the left and the right hemiface. We found a consistent tendency for dominance of the right hemiface. As the growth stage proceeds, however, right-sided dominance becomes less frequent, whereas left-side dominance becomes more frequent. Mobility of facial expression also exhibits facedness.[20,21] Most studies suggest that the left side of the face is more expressive of emotions.[22–24] Such a functional asymmetry in facial expression may have some relationship to the dimensional balance between the left and the right hemiface.

While the proportion of subjects who exhibited no deviation at the menton decreased with age, the proportion of those having the left-sided deviation increased accordingly. In terms of skeletal pattern, no deviation at the menton was more frequently seen in subjects with the skeletal Class III malocclusion than in those with skeletal Class II malocclusion. Specifically, the proportions of the no-deviation, right-sided, and left-sided groups in the skeletal Class II subjects were consistent for all pubertal growth periods. In the skeletal Class I group, however, the proportion of subjects with no significant jaw deviation decreased with age, whereas the proportion of those with left-sided jaw deviation increased. In this group, the proportion of the subjects exhibiting right-sided jaw deviation was similar between different growth stages. In the skeletal Class III group, the proportion of subjects without chin deviation also decreased throughout the pubertal growth period, and the proportions of both those with left-sided deviation and those with right-sided deviation tended to increase.

These findings suggest that, overall, the proportion of subjects with jaw deviation at the menton remains unchanged during the pubertal growth period because those with skeletal Class II jaw relationship are likely to show relatively less growth of the mandible, even during the pubertal growth period. In contrast, skeletal Class III patients generally exhibit greater growth and also may be more likely to be affected by postnatal, environmental influences because of the relatively longer jaw growth period. Previous studies[5,6,25,26] have discussed possible causes of facial laterality. Most have concluded that environmental influences were the most likely cause. Habitual chewing on one side has been reported to lead to increased skeletal development on the ipsilateral side.[5] Others have also discussed the possibility that such laterality is simply a response of functional adaptation to asymmetrical masticatory activity.[13]

On the other hand, other studies[27] that have investigated facial asymmetry have emphasized the innate functional and structural differences between the cerebral hemispheres, suggesting that it would not be surprising if the normal asymmetry of the human face primarily originated from brain and skull base asymmetry.[27] According to a recent report,[15] lateral displacement of the cephalometric menton toward the left side of the face is found more frequently than right-sided deviation. The study also documented, however, that subjects who had received chin cup treatment or had exhibited TMJ symptoms and/or reported a history of maxillofacial injury showed a higher proportion of right-sided chin deviation at menton when compared with those who had not experienced those factors. It was therefore suggested that these postnatal factors are not the causes of directional uniqueness in menton deviation. Given the possibility that the right-side hemiface grows wider than its counterpart because of postnatal factors, such as more use of a habitually preferred chewing side, it would be reasonable to assume that the proportion of individuals who show facial laterality toward the right side increases during the pubertal growth period. The results of the present study, however, suggest that the proportion of subjects with right-sided laterality decreases with age while the proportion of those with left-sided laterality increases.

It can be speculated that the laterality in normal asymmetry consistently found in human faces may likely be induced by prenatal rather than postnatal factors, such as a functional bias induced by facedness or lateral preference in mastication. Finally, the results of the present study may help to explain why photographic frontal views of the human face that are artificially manipulated to reflect complete symmetry appear so strange to the viewer's eyes. The perfectly symmetric face differs sharply from the normal asymmetric face that is so familiar to us and thus may seem unnatural.

CONCLUSIONS

- The results showed that 79.7% of subjects with facial asymmetry had a wider right hemiface and that 79.3% of the subjects with chin deviation showed left-sided laterality. Laterality in the normal asymmetry of the face is consistently found in Japanese orthodontic patients.
- The right-sided dominance of the face was independent of sex, age, and skeletal jaw relationships. In this regard, the proportion of subjects with a wider right hemiface was larger at earlier ages than at later ages, while the proportion of subjects with a wider left hemiface was larger at later ages than earlier.

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