The Online ANGLE ORTHODONTIST
An International Journal of Orthodontics and Dentofacial Orthopedics
78th Anniversary 1930-2008

[Print Version]
[PubMed Citation] [Related Articles in PubMed]

TABLE OF CONTENTS

***The Angle Orthodontist:* Vol. 72, No. 1, pp. 28–35.**

Facial Asymmetry in Subjects with Skeletal Class III Deformity

Seiji Haraguchi, DDS;[a] Kenji Takada, DDS, PhD;[b] Yoshitaka Yasuda, DDS, PhD[c]

ABSTRACT

We investigated the frequency, site, amount, and direction of facial asymmetry in human adults with mandibular prognathism and examined if these characteristics were associated postnatally with cardinal clinical signs that may indicate a predisposition to facial asymmetry. Two hundred twenty young Japanese adults (69 men and 151 women) who exhibited skeletal Class III malocclusions were selected. The sample was divided into a Postnatal Factor Group and a Nonpostnatal Factor Group. The former group included those who had: (1) received orthodontic treatment using a chin cap; (2) exhibited clinical symptoms of temporomandibular joint (TMJ) disorder; (3) reported a history of maxillofacial trauma; or (4) radiographic abnormality of the condyles. Subjects with a deviation of more than 2 mm from the facial midline associated with any of the 4 landmarks (ANS, U1, L1 and Me) were classified as asymmetric and the asymmetry was measured on a postero-anterior (P-A) cephalogram. Radiographic facial asymmetry was found frequently (70%–85%, for Menton), and most obviously in the lower jaw ($P < .05$). Lateral displacement toward the left side of the face occurred more often than right-sided deviation ($P < .001$, for Menton). However, the Postnatal Factor Group showed a higher proportion of subjects with lateral deviation toward the right side ($P = .0031$) and a greater amount ($P < .0001$) of chin deviation. This was due to the fact that the subjects having TMJ problems as a postnatal factor showed no directional uniqueness in jaw deviation and exhibited a longer distance of deviation.

KEY WORDS: Face, Symmetry, Mandibular prognathism, Human.

Accepted: July 2001.

INTRODUCTION Return to TOC

The frequency, site and degree of facial laterality give important clues in our understanding of the etiology of facial asymmetry and improves our diagnosis and treatment plans for patients with dentofacial deformities who are in need of orthodontic treatment or orthognathic surgery. Asymmetry of the face is not rare; studies on laterality of the normal human skeletal face which employed relatively small sample sizes reported a dominance of the right side hemiface.[1–7] In regard to patients having skeletal deformities, previous reports using larger sample sizes have also documented proportions of facial asymmetry as 25%[8] and 34%[9] in the United States and 25%[10] in China. It is unfortunate, however, that the studies did not document in more detail their definitions and measuring methods for skeletal facial asymmetry.

Laterality is most common on the lower one-third of the face.[9,10] Severt and Proffit[9] reported that, in patients showing dentofacial deformity including jaw deviation, laterality toward the left side was present in more than 85% of their sample. From these findings, it can be hypothesized that there is a potential, inherent to humans, which induces dominant growth of the right side or hypo-growth on the left side of the face. However, a second hypothesis suggests environmental factors unilaterally interfere with jaw growth. Both hypothetical models may coexist. Congenital anomalies (such as cleft palates) and trauma to the face or the temporomandibular joint have been considered causal factors that may predispose to the development of facial asymmetry.[11–13] The dominance of left side laterality is seen in subjects without any discernible postnatal factor, which supports the first hypothesis. Quantitative measurement of magnitude and direction of laterality in the upper, middle, and lower thirds of the face in individuals with and without histories of trauma, congenital anomalies, or tempomandibular joint (TMJ) disorder is indispensable to our better understanding of human facial asymmetry.

The purpose of the present study was to investigate skeletal facial laterality and the difference in its frequency, site, amount, and direction between 2 groups of human adults with skeletal Class III deformity with and without history of postnatal cardinal clinical signs that may predispose to development of facial asymmetry.

MATERIALS AND METHODS Return to TOC

Subjects

Two hundred twenty Japanese orthodontic patients (69 men and 151 women, mean age 21y 11m; range 16y 0m to 38y 10m) who had visited the university dental hospital between the years 1989 and 1993 and had been diagnosed as having skeletal Class III malocclusions and in need of combined surgical orthodontic treatment were participants in this study. The selection was made consecutively from the patient database in order of their dates of registration at the hospital. None of the subjects had congenital craniofacial anomalies or missing teeth.

The sample was divided into 2 groups: the Postnatal Factor Group and the Nonpostnatal Factor Group. The Postnatal Factor Group included those who had: (1) received orthodontic treatment with a chin cap or a maxillary protraction headgear with a chin cap before they came to our hospital, (2) exhibited cardinal clinical symptoms of TMJ disorder such as pain or difficulty in jaw opening, or (3) reported a history of trauma to the face or jaws. Judgment of these conditions was made on the basis of recorded interviews with the patients and past medical records. Those who, when judged by visual inspection of panoramic and TMJ radiographs (Shüller method), showed a significant difference in size or shape (or both) of the condylar heads between the right and left sides were classified into the Postnatal Factor Group. Each patient was judged 3 separate times and only those who were judged as showing condylar malformation on either side or imbalance in size of the condyles at all 3 examinations were included into this group. The remaining subjects were assigned to the Nonpostnatal Factor Group.

METHODS Return to TOC

Postero-anterior cephalograms of each patient, taken with teeth in habitual maximum intercuspation and lips in repose with a magnification ratio of 1:1, were traced twice by one of the authors. Landmarks were identified with the methods recommended by Sassouni[14] and Ricketts[15] (Figure 1). Each of Lo and Lo' points was defined as a bilateral intersection of the oblique orbital line with the lateral contour of the right and left side orbits. Nc was the neck of crista galli, and ANS, U1, L1 and Me were defined as the anterior nasal spine, the mesial contact point of upper central incisors, the mesial contact points of lower incisors and the menton. The facial midline was defined as a line perpendicular to the line connecting Lo and Lo' through Nc.[14]

Perpendicular distances from the facial midline to the aforementioned landmarks were measured to an accuracy of 0.5 mm.[16] Any landmark deviating more than 2 mm from the facial midline was assumed to be asymmetric. When the landmark was located left of the midline, a positive value was assigned. Proportions of asymmetry were compared between the 2 groups for each landmark and between the landmarks in each group. Also, proportions and the distances of the left-sided deviation from each of the 4 landmarks to the facial midline were compared between the 2 subject groups and between the landmarks for each subject group.

Finally, conventional frontal facial photographs of all the patients, taken with the heads fixed by ear rods and the Frankfort horizontal plane parallel with the ground, were evaluated visually by a panel of 10 orthodontists each of whom had over 5 years of clinical experience. The photographs were taken with an SLR camera (Nikon FM2, Nikon Corporation, Tokyo) and a telescopic lens (Micro-Nikkor 105 mm, Nikon Corporation, Tokyo) with a magnification scale of 0.06 and a recording distance between the camera and the patient of 150 cm. The photographs (color slides, Kodak Ektachrome Dynaex100, ISO 100) were presented to the judges by projecting the photographs on a screen with a magnification scale of 300% and an average observation distance between the judges and the screen of 5 m. A total of 220 photos were divided into 5 data sets corresponding with the patients' registration numbers. The judges evaluated each photo sequentially for asymmetry with an interval of 10 seconds and a break for 2 minutes at the end of each session to reduce fatigue. The patient was assigned as having asymmetry only when the majority of judges agreed.

Statistical analyses

Age and sex distributions were compared between the 2 subject groups by an unpaired *t*-test and a chi-square test. Null hypotheses that proportions of deviation from landmarks are equal in each subject group and proportions of deviations for each landmark are equal between the 2 subject groups were tested.[17] The null hypothesis that the proportion of subjects in each group that showed left-sided deviation of the face, with respect to all subjects including those with asymmetry and no jaw deviation, is equal to those with the right-sided deviation was tested for each landmark. We also tested the null hypothesis that the proportion of subjects that showed chin deviation on the left side with respect to all subjects according to each postnatal factor is equal to the proportion of those with a deviating chin on the right side. In addition, we tested the null hypothesis that the proportions of subjects that showed deviation of landmarks toward the left or right side in each subject group are equal. Lastly, the null hypothesis that the proportion of subjects that showed deviation of landmarks toward the left side with respect to those having asymmetry are equal between the 2 subject groups was tested.

Distances from the facial midline to each landmark between the 2 subject groups and distances from the facial midline to Me between the 3 factors were compared by an unpaired *t*-test. The null hypothesis that each of the 4 landmarks in each subject group has equal distances from the facial midline was tested by analysis of variance (ANOVA). Analyses were made with a statistical software program (StatView V, Abacus Concepts Inc, USA; Microsoft Excel 2000, Microsoft Corporation, USA) and a level of $P > .05$ was assumed to be insignificant.

RESULTS Return to TOC

The distributions of the subjects in the Postnatal Factor Group and the Nonpostnatal Factor Group by sex and age were found to be similar to each other (Table 1).

Table 2 gives the proportion of subjects in each of the 2 groups that showed deviation of landmarks toward the left side with respect to the total that exhibited asymmetry. An asymmetry showing a chin deviation toward the left side was present in 80.6% of the subjects that exhibited asymmetry in the Nonpostnatal Factor Group and 68.1% of subjects that exhibited asymmetry in the Postnatal Factor Group. The proportion of left-sided laterality in the Nonpostnatal Factor Group showed a higher proportion ($P = .0254$) than those in the Postnatal Factor Group. This indicates that patients with no discernible postnatal factors are more likely to have left-sided chin deviation than those having postnatal factors.

Figure 2A compares mean absolute distances from each landmark to the facial midline between the 2 subject groups. The Postnatal Factor Group showed significantly greater deviations for L1 and Me ($P < .0001$).

Table 3 shows the proportion of subjects with a deviation of anatomic landmarks from the facial midline relative to all subjects with asymmetry between landmarks for each of the Postnatal and the Nonpostnatal Factor Group. The more inferiorly located landmarks had more chance ($P < .05$) of deviation. Figure 2B compares mean absolute distances from each landmark to the facial midline for each subject group. A significant difference was not determined between the ANS and U1 in either group, but the more inferior the landmark location, the greater the deviation ($P < .0001$).

Figure 3 gives the proportion of subjects with deviation of landmarks toward the right or left side with respect to all subjects in each of the Postnatal Factor Group and the Nonpostnatal Factor Group, including asymmetry and no deviation. Proportional comparisons between the 2 groups for each of the left- and right-sided deviations, and those between the left- and right-sided deviations for each group are also provided. All landmarks in the Postnatal and Nonpostnatal Factor Groups showed significantly higher proportions of left-sided deviations ($P < .05$) except for ANS in the Postnatal Factor Group. Proportions of the left- or right-sided laterality between the 2 groups did not differ statistically, except for the right-sided chin deviation ($P = .0031$).

Figure 4 gives the proportion of subjects that showed bilateral deviation of the chin with respect to all subjects according to each factor calculated for the Postnatal Factor Group. The subjects who had histories of chin cap use or experienced injuries to the face, jaws, or both showed significantly higher proportions of left-sided chin deviation ($P < .0001$) than right-sided deviation. In contrast, those having TMJ problems did not show any difference between jaw deviations on the right or left side.

Figure 5 compares mean absolute distances from Me to the facial midline. The distance of chin deviation for the subjects with TMJ problems was significantly greater than those for subjects with histories of chin cap use ($P = .0008$) or injuries to the face, jaws, or both ($P = .0021$).

Visual inspection of photographs by the panel of orthodontic judges resulted in a mean frequency of 55.6% facial asymmetry for the present subjects. Proportions of patients that showed jaw asymmetry and symmetry in the distance of jaw deviation at Menton on the P-A cephalograms are shown in Figure 6. The critical distance of jaw deviation that separates facial asymmetry from symmetry was approximately 4 mm.

DISCUSSION Return to TOC

We employed 4 cephalometric landmarks on the basis of an assumption that each of them represents 4 anatomic components (ie, the maxilla, the upper incisors, the lower incisors, and the mandible). These landmarks were supposed to show less geometric or identification errors.[18] In a pilot study, the jaw deviation of Menton in 4 randomly selected patients was measured on P-A cephalograms and it was confirmed that the tracing errors did not exceed 0.5 mm. According to a criterion used previously, lateral deviation of 2 mm was employed as a critical value to separate asymmetry from symmetry.[9] The etiology of facial asymmetry is categorized into those of genetic origins and of environmental origins[12] and subjects were divided between those with obvious postnatal clinical signs and those with no such factors. Individuals with congenital craniofacial anomalies were not included.

The postnatal factors included trauma and infection or inflammation in the TMJ.[12] Fractures of the mandibular condyles in children are difficult to notice until growth disturbances become obvious.[19] Such 'masked' trauma, hypertrophy, or hypotrophy of the condyle and ankylosis of the condyle produced by infection or inflammation, are likely to cause deformities or abnormality in size of the condylar head on the affected side. These were diagnosed visually on the radiographs. Subjects with skeletal Class III malocclusion often exhibit posterior cross bites. It is difficult to diagnose properly whether a posterior crossbite is a consequence of constriction of the maxilla in the lateral direction or merely the result of lower jaw deviation. We chose the asymmetry of the condylar shape that was visually determined on radiographs as one of the postnatal factors because the posterior crossbite with jaw deviation is often accompanied by an asymmetry of the shape of the TMJ bilaterally.[20] The past use of the chin cap appliance also was considered as a postnatal factor because we assumed that the application of an external force to the lower jaw for a certain period of time may cause directional change in mandibular growth in the transverse direction. It should be noted, however, that these factors were chosen not because their etiologic roles had been proven to be true, but rather to eliminate any 'suspicious' individuals with possible postnatal risk factors.

The present study revealed the following 4 major findings:

1. Facial asymmetry was seen frequently and not by chance.
2. The lower jaw showed more asymmetry than the upper jaw.
3. Left-sided facial laterality occurred more often than the right-sided deviation.
4. Subjects with TMJ problems showed equal chances for the lower jaw to deviate toward the left and right sides.

Facial asymmetry was seen frequently and not by chance

According to Severt and Proffit,[9] asymmetry of the face is found in 40% of patients with Class III deformity. A previous study reported facial asymmetry in a Japanese sample as 11–25%,[21,22] but neither of the reports described the skeletal types, the method of judgment, or the decision criteria for facial asymmetry. About 80% of the subjects in the present sample showed skeletal asymmetry of the face. This was higher than the previous report[9] that used a Caucasian sample. In contrast to the higher frequency (80%) of the patients that exhibited skeletal asymmetry (2 mm or more), only 56% showed soft tissue asymmetry.

The results of the panel of 10 orthodontists who assessed soft tissue asymmetry suggest that faces having skeletal chin deviation of more than 4 mm are likely to be judged also with soft tissue facial asymmetry. In other words, humans are sensitive to about 4 mm in their visual judgment of clinically significant asymmetry. Therefore, observed differences in proportions of facial asymmetry may be due to the differences in methods and measurement sensitivity between studies. It should be noted that the P-A cephalograms were exposed while the patient was in habitual maximum intercuspation. If the films had been exposed while the patient was in first dental contact, centric relation would have eliminated some patients with functional shifts from the skeletal asymmetry group.

The lower jaw showed more asymmetry than the upper jaw

Facial laterality was seen more frequently in the more inferiorly placed landmarks of both groups. Proffit et al,[8] in their patient database survey (n = 1193, Caucasian 75%, Afro-American 21%, native American 4%), found asymmetry of the middle face in 8% of the sample studied and of the lower face in one-fourth of the total sample. In a 1997 report, his group documented frequencies of laterality of 5%, 36% and 74% in the upper, middle, and lower thirds of the face, respectively.[9] The present study determined a general tendency of the inferior landmarks to deviate more frequently and at greater distances than the more superiorly located landmarks because: (1) the mandible grows longer than the maxilla and thus is likely to show more deviation given that the amount of jaw growth per unit period is consistent for both jaws, and (2) the mandible is a mobile apparatus whereas the maxilla is connected rigidly to its adjacent skeletal structures with sutures and synchondroses. Because the growth of the mandible is largely seen at the condylar regions,[23] the mandible is likely to show gradual deviation during growth period, as if it swings with a condylar head on the affected side as its center of rotation.

Left-sided facial laterality had more chances to occur than right-sided deviation

A third important finding was the dominance of facial laterality toward the left side in all groups except the ANS in the Postnatal Factor Group. The 68.1% of those who showed laterality in the Postnatal Factor Group and 80.6% of those with facial asymmetry in the

Nonpostnatal Factor Group exhibited left-sided deviation. In the University of North Carolina sample[9], 85% of subjects who had chin deviation exhibited the deviation toward the left side. It is then reasonable to accept the statement: Human faces have a tendency towards left-sided laterality. The Nonpostnatal Factor Group exhibited a higher proportion of left-sided facial asymmetry (P = .0254) than the Postnatal Factor Group. In contrast, the proportion of right-sided deviations from Me in the total sample that included those subjects showing symmetry and asymmetry of the face was found to be significantly higher (P = .0031) in the Postnatal Factor Group than that in the Nonpostnatal Factor Group (Figure 2). This indicates that postnatal factors do not increase chances of chin deviation toward the left side, but rather, may act to mask the tendency toward left-sided deviation that was obvious in the Nonpostnatal Factor Group. In short, the left-sided facial laterality consistently found in humans may likely be induced by prenatal rather than postnatal factors.

The more frequent left-sided laterality of the skeletal face may be ascribed to the dominant growth potential of the jaw's right side. Previous studies[1–7] have documented the dominance of the right side hemiface in subjects with no pathologic problems. According to Woo,[24] the internal length of the skull was larger on the right side than the left side, which possibly influences the laterality in anatomic size of the cranium and the brain towards the right hemiface.[2,25] Vertebrates exhibit numerous left and right asymmetries, such as the positioning of the heart and spleen on the left side of the body. Key genes like nodal, lefty-1, and lefty-2, which contribute to the establishment of L-R polarity, have been identified in mice.[32,33] Accordingly, there is no reason to reject the possibility of an L-R axis ‘ pathway’ formation which induces morphological asymmetry in the craniofacial region.

Another possible innate mechanism causing facial laterality may be attributed to the disruption of neural crest cell development. Neural crest cells represent a vulnerable population as they leave the neuroectoderm and are often targeted by teratogens.[26] A time lag between the development of the left and right sides of the craniofacial structures may cause asymmetry[28] and may explain the dominant inheritance of left-sided facial hypoplasia.[27] Cleft lip is now regarded as a result of disturbances in neural crest migration[29] and cleft lips are two-thirds more likely to occur on the left side.[30,31] Hence, it can be speculated that neural crest migrations are more likely to be delayed on the left side, and preceded on the right side.[29] Given that the migration process terminates simultaneously on both sides, the initial subtle difference in migration commencement timing is likely to lead to an eventually obvious dominance on the right-side of the face.

Subjects with TMJ problems had equal chances for the lower jaw to deviate toward the left and right sides

Subjects who had worn chin caps or sustained injuries to the face or jaws showed significantly higher proportions of left-sided chin deviation (P < .0001) than of right-sided deviation. This is not difficult to understand if we accept the assumption that humans are innately prone to show facial and chin deviation toward the left side as previously determined, and that TMJ problems are found on the right and left sides equally.[34,35] In a similar context, it was assumed that the subjects having TMJ problems would show higher proportions of left-sided chin deviation. However, this was not the case. This may be explained as follows: The Postnatal Factor Group, including the subjects with TMJ problems, showed significantly greater amount of chin deviations (P < .0001) than the Nonpostnatal Factor Group subjects. Also, the subjects who had TMJ problems exhibited a significantly greater distance (P < .0001) of chin deviation than those with other postnatal risk factors. This indicates that the amount of chin deviation related to TMJ problems is greater than that derived prenatally. Accordingly, the higher innate tendency toward the left-sided jaw deviation is likely masked by the TMJ problems that occur postnatally and can result in longer deviations.

CONCLUSIONS Return to TOC

A total of 220 Japanese adults having skeletal Class III deformities were divided into 2 groups, the Postnatal Factor Group and the Nonpostnatal Factor Group. Postero-anterior cephalograms of each subject were traced to measure the deviation from the midline of 4 landmarks: ANS, U1, L1 and Me. Proportions of asymmetry for each landmark and between the landmarks, with a particular focus on the direction of laterality, were compared between the 2 groups. There was an obvious tendency towards left-sided facial laterality in subjects having skeletal Class III deformity (P < .001, for Menton), which was more obvious in the lower part of the face (P < .05) and in the Nonpostnatal Factor Group. A similar tendency was also found in the soft tissue faces. The Postnatal Factor Group showed a higher proportion of subjects exhibiting right-sided (P = .0031) and greater amounts (P < .0001) of chin deviation at Me when compared with the Nonpostnatal Factor Group. This was due to the fact that the subjects having TMJ problems as a postnatal factor showed no directional uniqueness in jaw deviation and exhibited longer distance of deviation.

ACKNOWLEDGMENTS

Authors are greatly indebted to Dr W.R. Proffit of the University of North Carolina at Chapel Hill for his productive advice and encouraging discussions during manuscript preparation. We also thank Ms Katie MacEntee for grammatical correction of the manuscript.

REFERENCES Return to TOC

1. Burke PH. Stereophotogrammetric measurement of normal facial asymmetry in children. *Hum Biol.* 1971; 43:536–548. [PubMed Citation]

2. Burke PH. Growth of the soft tissues of middle third of the face between 9 and 16 years. *Eur J Orthod.* 1979; 1:1–13. [PubMed Citation]

3. Shah SM, Joshi MR. An assessment of asymmetry in the normal craniofacial complex. *Angle Orthod.* 1978; 48:141–148. [PubMed Citation]

4. Koff E, Borod JC, White B. Asymmetries for hemiface size and mobility. *Neuropsychologia.* 1981; 19:825–830. [PubMed Citation]

5. Koff E, Borod J, Strauss E. Development of hemiface size asymmetry. *Cortex.* 1985; 21:153–156. [PubMed Citation]

6. Farkas LG, Cheung G. Facial asymmetry in healthy North American Caucasians. An anthropometrical study. *Angle Orthod.* 1981; 51:70–77. [PubMed Citation]

7. Peck S, Peck L, Kataja M. Skeletal asymmetry in esthetically pleasing faces. *Angle Orthod.* 1990; 61:43–48.

8. Proffit WR, Phillips C, Dann C 4th. Who seeks surgical-orthodontic treatment?. *Int J Adult Orthodon Orthognath Surg.* 1990; 5:153–160. [PubMed Citation]

9. Severt TR, Proffit WR. The prevalence of facial asymmetry in the dentofacial deformities population at the University of North Carolina. *Int J Adult Orthodon Orthognath Surg.* 1997; 12:171–176. [PubMed Citation]

10. Samman N, Tong AC, Cheung DL, Tideman H. Analysis of 300 dentofacial deformities in Hong Kong. *Int J Adult Orthodon Orthognath Surg.* 1992; 7:181–185. [PubMed Citation]

11. Proffit WR, White RP. *Surgical-orthodontic Treatment*. St Louis, Mo: Mosby Year Book; 1991:24–70.

12. Bishara SE, Burkey PS, Kharouf JG. Dental and facial asymmetries: a review. *Angle Orthod.* 1994; 64:89–98. [PubMed Citation]

13. Pirttiniemi PM. Associations of mandibular and facial asymmetries: a review. *Am J Orthod Dentofacial Orthop.* 1994; 106:191–200. [PubMed Citation]

14. Sassouni V. Position of the maxillary first permanent molar in the cephalofacial complex. *Am J Orthod.* 1957; 43:477–510.

15. Ricketts RM, Bench RW, Gugino CF, Hilgers JJ, Schulhof RJ. *Bioprogressive Therapy*. Denver, Col: Rocky Mountain Orthodontics; 1979.

16. Baumrind S, Frantz RC. The reliability of head film measurements. 2. Conventional angular and linear measures. *Am J Orthod.* 1971; 60:505–517. [PubMed Citation]

17. Walpole RE, Myers RH. *Probability and Statistics for Engineers and Scientists*. 2nd ed. New York, NY: Macmillan Publishing; 1978:260–265.

18. Pirttiniemi P, Miettinen J, Kantomaa T. Combined effects of errors in frontal-view asymmetry diagnosis. *Eur J Orthod.* 1996; 18:629–636. [PubMed Citation]

19. Proffit WR, Vig KW, Turvey TA. Early fracture of the mandibular condyles: frequently an unsuspected cause of growth disturbances. *Am J Orthod.* 1980; 78:1–24. [PubMed Citation]

20. Pirttiniemi P, Kantomaa T, Rönning O. Relation of the glenoid fossa to craniofacial morphology, studied on dry human skulls. *Acta Odontol Scand.* 1990; 48:359–364. [PubMed Citation]

21. Minami K, Sugahara T, Mori Y, Miyajima T, Yamada T, Kyomoto H, Shimizu H, Sakuda M. Clinico-statistical study of orthognathic surgery [in Japanese]. *J Jpn Stmatol Soc.* 1997; 46:165–170.

22. Yunoki H, Nakajima M, Hayashi H. et al. Clinicostatistical study on orthognathic surgery for 11 years at second department of oral and maxillofacial surgery, Osaka dental university [in Japanese]. *Jpn J Jaw Deform.* 1999; 9:51–56.

23. Enlow DH. *Facial Growth*. 3rd ed. Philadelphia, Penn: WB Saunders; 1990:58–163.

24. Woo TL. On the asymmetry of the human skull. *Biometrika.* 1931; 22:324–341.

25. Lundström A. Some asymmetries of the dental arches, jaws and skull, and their etiological significance. *Am J Orthod.* 1961; 47:81–106.

26. Sadler TW, Langman J. *Langman's Medical Embryology*. 7th ed. Baltimore, Md: Lippincott Williams and Wilkins; 1995.

27. Aase JM, Smith DW. Facial asymmetry and abnormalities of palms and ears: a dominantly inherited developmental syndrome. *J*

Pediatr. 1970; 76:928–930. [PubMed Citation]

28. Jacobsson C, Granström G. Clinical appearance of spontaneous and induced first and second branchial arch syndromes. *Scand J Plast Reconstr Hand Surg.* 1997; 31:125–136. [PubMed Citation]

29. Geschwind N, Galaburda AM. Cerebral lateralization. Biological mechanisms, associations, and pathology: II. A hypothesis and a program for research. *Arch Neurol.* 1985; 42:521–552. [PubMed Citation]

30. Ingalls TH, Taube JE, Klingberg MA. Cleft lip and cleft palate: epidemiologic considerations. *Plast Reconstr Surg.* 1964; 34:1

31. Fraser FC. The genetics of cleft lip and cleft palate. *Am J Hum Genet.* 1970; 22:336–352. [PubMed Citation]

32. Saijoh Y, Adachi H, Mochida K, Ohishi S, Hirao A, Hamada H. Distinct transcriptional regulatory mechanisms underlie left-right asymmetric expression of lefty-1 and lefty-2. *Genes Dev.* 1999; 13:259–269. [PubMed Citation]

33. Adachi H, Saijoh Y, Mochida K, Ohishi S, Hashiguchi H, Hirao A, Hamada H. Determination of left/right asymmetric expression of nodal by a left side-specific enhancer with sequence similarity to a lefty-2 enhancer. *Genes Dev.* 1999; 13:1589–1600. [PubMed Citation]

34. Hodges DC. Temporomandibular joint osteoarthritis in a British skeletal population. *Am J Phys Anthropol.* 1991; 85:367–377. [PubMed Citation]

35. List T, Dworkin SF. Comparing TMD diagnoses and clinical findings at Swedish and US TMD Centers using research diagnostic criteria for temporomandibular disorders. *J Orofac Pain.* 1996; 10:240–253. [PubMed Citation]

TABLES Return to TOC

TABLE 1. Sample Distributions by Sex and Age

Group	Sample Size	Male	Female	Mean Age	Age Range
Postnatal	82	25	57	22y 1 m	16y 0m–29y 4m
Nonpostnatal	138	44	94	21 y 9m	16y 2m–38y 10m

TABLE 2. Percent of Subjects With Landmarks Deviated Toward the Left Side Relative to Those With Deviation Toward Either Side in the Postnatal Factor Group and Non-postnatal Factor Group, and Comparison Between the Two Groups for the Left-Sided Deviation[a]

Landmark	Postnatal Factor Group (n = 82)	Nonpostnatal Factor Group (n = 138)	Significance of Difference (*P*-value)
ANS	58.8 (10/17)	76.7 (23/30)	ns
U1	63.4 (26/41)	71.4 (35/49)	ns
L1	68.3 (41/60)	72.4 (55/76)	ns
Me	68.1 (48/72)	80.6 (80/98)	.0254

[a] Numbers in the parentheses denote number of subjects with left-sided deviation and those with deviation toward either side. N indicates number of subjects; ANS, anterior nasal spine; U1, incisal edge maxillary incisor; L1, incisal edge mandibular incisor; Me, Menton, and ns, not significant.

TABLE 3. Comparison of Subjects With a Deviation of Anatomic Landmarks from the Facial Midline Relative to All Subjects With Asymmetry Between the Landmarks[a]

	P-Value	
	Postnatal Group	Nonpostnatal Group
ANS vs U1	<.0001	.0114
ANS vs L1	<.0001	<.0001
ANS vs Me	<.0001	<.0001
U1 vs L1	.0023	.0011
U1 vs Me	<.0001	<.0001
L1 vs Me	.0181	.0130

[a] ANS indicates anterior nasal spine; U1, incisal edge maxillary incisor; L1, incisal edge mandibular incisor; and Me, Menton.

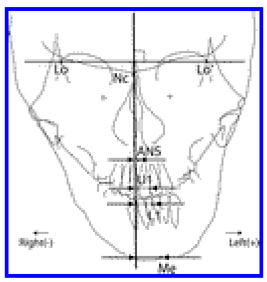
[a]Clinician, Department of Orthodontics, Osaka University Dental Hospital, Osaka, Japan.

[b]Professor and Chair, Department of Orthodontics and Dentofacial Orthopedics, Graduate School of Dentistry, Osaka University, Osaka, Japan.

[c]Associate Professor, Department of Orthodontics and Dentofacial Orthopedics, Graduate School of Dentistry, Osaka University, Osaka, Japan.

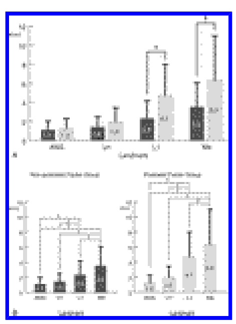
Corresponding author: Kenji Takada, DDS, PhD, Department of Orthodontics and Dentofacial Orthopedics, Graduate School of Dentistry, Osaka University, 1–8 Yamadaoka, Suita, Osaka, Japan 565–0871 (E-mail: ktakada@dent.osaka-u.ac.jp).

FIGURES Return to TOC



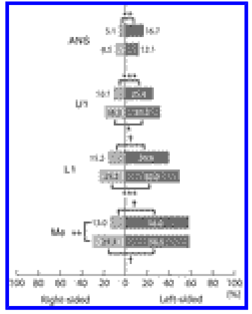
Click on thumbnail for full-sized image.

FIGURE 1. Reference points, planes, and linear measurements used on P-A cephalograms



Click on thumbnail for full-sized image.

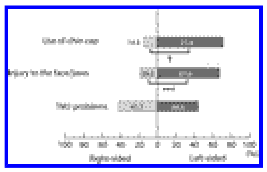
FIGURE 2A. Comparisons of mean absolute distances from each landmark to the facial midline between the Nonpostnatal Factor Group (n = 138) and Postnatal Factor Group (n = 82). Numbers in bars represent mean absolute distances (mm). Black indicates Nonpostnatal Factor Group; Gray, Postnatal Factor Group. ‡*P* < .0001**FIGURE 2B.** Comparisons of mean absolute distances from each landmark to the facial midline between the landmarks for the Nonpostnatal Factor Group (n = 138) and the Postnatal Factor Group (n = 82). Numbers in bars represent mean absolute distances (mm). ‡*P* < .0001



Click on thumbnail for full-sized image.

FIGURE 3. Proportions of subjects with deviation of landmarks are shown relative to all subjects in the Postnatal Factor Group (n = 82) and the Nonpostnatal Factor Group (n = 138). The figure shows proportional comparisons between the 2 groups for each of the left and right-sided deviations, and those between the left- and right-sided deviations for each group. Numbers in or beside bars represent percentages (%). Gray Stripes indicate Nonpostnatal Factor Group (n = 138); Gray nonstripped, Postnatal Factor Group (n = 82).

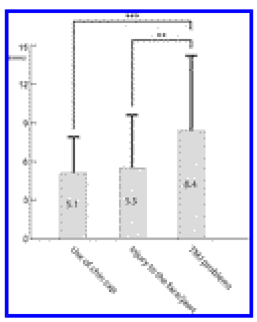
*, $P < .05$; **, $P < .01$; ***, $P < .001$; †$P < .0001$.



Click on thumbnail for full-sized image.

FIGURE 4. Proportions of subjects in the Postnatal Factor Group that showed deviation of the chin with respect to all subjects according to each factor calculated (ie, TMJ problems; n = 36), use of chin cap (n = 34), and injury to the face or jaws (n = 28). The proportional comparisons between the left- and right-sided deviations for each factor are also shown. Each subject was allowed more than 2 factors. The n indicates the total sample size.

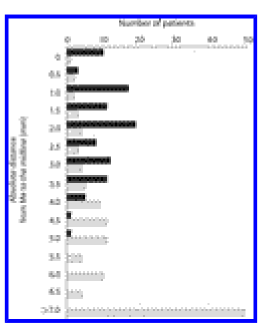
*, $P < .05$; **, $P < .01$; ***, $P < .001$; †$P < .0001$.



Click on thumbnail for full-sized image.

FIGURE 5. Comparisons of mean absolute distances from Me to the facial midline between the 3 factors (ie, TMJ problems; n = 36), use of chin cap (n = 34), and injury to the face or jaws (n = 28). Numbers in bars represent mean absolute distances (mm).

**, $P < .01$; ***, $P < .001$.



Click on thumbnail for full-sized image.

FIGURE 6. Distribution of patients that were judged by the panel of 10 orthodontists as showing jaw asymmetry and symmetry on the facial photographs according to the distance of jaw deviation at Menton shown on the P-A cephalograms.

Black indicates patients that were judged as showing jaw symmetry in the photographs; Gray, patients that were judged as showing jaw asymmetry in the photographs.
