Analysis of Facial Skeletal Characteristics in Patients With Chin Deviation

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Background: This study was undertaken to investigate the facial skeletal features associated with chin deviation.

Methods: Twenty-five patients (14 males and 11 females) diagnosed with chin deviations of more than 2 mm were recruited. Fifteen skeletal landmarks, including median and lateral points, were located on posteroanterior cephalograms. The CG–ANS (crista-galli of the ethmoid–anterior nasal spine) line and the perpendicular line through the CG were used as references. The differences between the distances from paired lateral points to reference lines were examined with intraclass correlation coefficients to analyze the symmetry of facial skeletal tissue. The factors associated with the amount or direction of chin deviation were analyzed by multiple regression analysis or by logistic regression analysis.

Results: Seventeen subjects (68%) showed chin deviation to the left side and 8 subjects (32%) to the right side. Sixty-eight percent of subjects presented with Angle Class III malocclusion. Horizontal distances of all paired lateral points to the y-axis, in mandibular body length and effective length, showed a low grade of symmetry. Only vertical distances of paired zygomaticofrontal sutures and zygonion points to the x-axis were asymmetric. However, there were no significant asymmetries of the gonial angle, ramus height, and vertical distances from other paired lateral points to the x-axis. The amount of chin deviation was associated with the absolute differences of the left and right antegonion to the y-axis and zygomaticofrontal suture to the x-axis. The direction of chin deviation was significantly associated with the difference in the effective length of bilateral mandibular halves.

Conclusion: Facial skeletal asymmetry exists in patients with chin deviation. This should be considered when planning treatment for both the nonsurgical and surgico-orthodontic cases with chin deviation. [*J Chin Med Assoc* 2010;73(1):29–34]

Key Words: asymmetry, chin deviation, facial skeleton, posteroanterior cephalogram

Introduction

A slight skeletal and soft tissue facial asymmetry can be found in normal subjects and even in those with esthetically pleasing faces.[1–6] In general, very few healthy young subjects show statistically significant mandibular asymmetry of any clinical importance.[7] However, patients with evident facial asymmetry can have reduced satisfaction with their facial appearance and thus a higher motivation to undergo orthodontic treatment to improve esthetics and occlusion.[8,9] Among orthodontic patients with facial asymmetry (34%), the prevalence of chin deviation was as high as 74% .[9] However, little research has been carried out on the mechanisms of chin deviation and the association between chin deviation and asymmetry in other parts of the facial skeleton during skeletal development.

Asymmetry in the area of the craniofacial skeleton can be found in 3 dimensions: sagittal, vertical, and transverse.[10–12] Growth of the cranium, maxilla, and mandible are closely related.[13] If not compensated by other areas, the asymmetric growth and development in any craniofacial skeleton may result in the deviation of the chin from the middle of the mandible. Therefore, patients with apparent chin deviation may also have marked asymmetry in other parts of the facial

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skeleton.[14,15] In addition, differences in the size of human mandibular halves are also well documented,[16,17] showing that it is strongly dependent on the muscular balance[18–20] and unilateral overgrowth[21–23] or undergrowth of the mandible,[24–26] both of which might also be related to previous infections or injury to the condylar region and lateral occlusion.[27–29] Asymmetry in mandibular halves usually results in a shift of the chin, and chin deviation can result from occlusal interferences and subsequent mandibular functional displacement. According to Schmid et al,[28] 70% of patients with facial asymmetry and chin deviation presented structural and displacement asymmetry, while only 10% showed pure displacement asymmetry.

The purpose of this study was to investigate the facial skeletal characteristics of patients with a deviated chin position. Clarifying the association between the severity of facial skeletal asymmetry and chin deviation can allow the mechanism of chin deviation to be determined and to develop more thorough clinical approaches to diagnosing facial asymmetry and planning treatment.

Methods

Twenty-five subjects over the age of 15 years diagnosed with chin deviation of more than 2 mm were selected from patients who started orthodontic treatment at Taipei Veterans General Hospital between 2000 and 2001. Data were collected on 14 males aged 19–33 years (mean age, 24.1 years), and 11 females aged 15–33 years (mean age, 22 years). None of the subjects had congenital craniofacial anomalies, previous orthodontic treatment, facial trauma, or any temporomandibular dysfunction history.

Patients were examined by an experienced orthodontist in the upright sitting posture with teeth in centric relation and lips in repose. The facial midline (the line connecting the soft tissue glabella and subnasale) was identified, then the direction and severity of chin deviation and Angle's classification of malocclusion of each patient were recorded. Following this, a 2-cm long iron wire was fixed with tape to the soft tissue of the menton (ME) to calculate the radiograph magnification and to identify the ME on radiogram.

Posteroanterior (PA) cephalograms of patients were taken in natural head position with teeth in centric relation and lips in repose. The criteria of qualified PA cephalograms included the following: (1) frontal sinuses and frontal bone are well demonstrated; (2) petrous bone fills the lower third of the orbits; (3) the distance from the lateral orbit margin to the cranial vault is equal bilaterally; (4) the anterior ethmoidal air cells and superior orbital fissure are visible.[30]

PA cephalograms were then traced on acetate paper, and 15 landmarks located. All the tracings and landmarks were scanned and digitized (Figure 1). The line passing through the crista-galli of the ethmoid (CG) and anterior nasal spine (ANS) was used as the vertical reference plane (y-axis), and a line perpendicular to this plane through CG represented the horizontal plane (x-axis). Using these landmarks in an x–y coordinate system, the skeletal facial asymmetry was quantified using the software Viewbox Version 2.6 (dHAL Software, Kifissia, Greece). The direction of ME deviation was assigned 0 when it was located left or 1 when it was located right of the y-axis. The distance of ME from the y-axis was the amount of chin deviation (MEDEV) and measured as an absolute value. Gonial angle, mandibular body length, ramus height, mandibular effective length, and perpendicular distance of lateral points from the x-axis and the y-axis

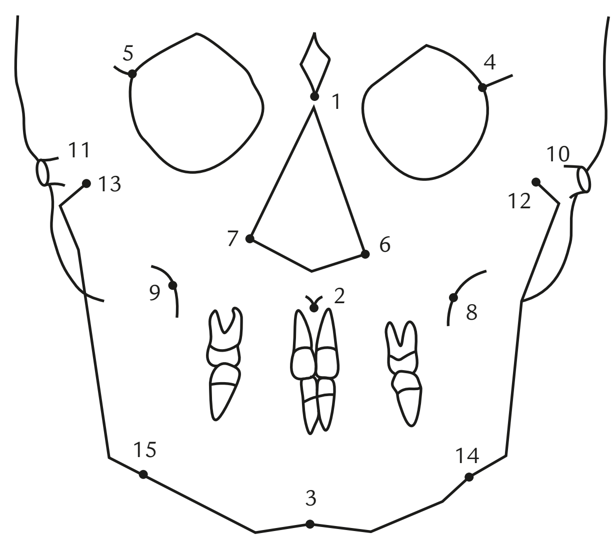

Figure 1. Landmarks. *Median points (on the midsagittal plane):* 1 = CG (crista-galli of the ethmoid); 2 = ANS (anterior nasal spine); 3 = ME (menton, located by projecting the mental protuberance on the lower mandibular border). *Lateral points:* 4 and 5 = ZFL and ZFR (zygomaticofrontal suture left and right, points at the medial margin of the zygomaticofrontal suture); 6 and 7 = NCL and NCR (nasal cavity at the widest point left and right); 8 and 9 = JL and JR (jugale left and right, the intersection of the lateral contour of the maxillary alveolar process and the lower contour of the maxillozygomatic process of the maxilla); 10 and 11 = ZL and ZR (zygonion left and right, points at the most lateral border of the center of the zygomatic arch); 12 and 13 = COL and COR (condylion left and right, most superior points of the condylar head); 14 and 15 = AGNL and AGNR (antegonion left and right, highest points in the antegonial notch).

were measured. The differences and absolute differences between paired left and right measurements were calculated.

To test for repeatability, 10 patients and their cephalograms were randomly selected. Clinical examinations, tracings, and measurements of each cephalogram were repeated by the same orthodontist 1 week later. Measurement errors were determined by intraclass correlation coefficient, r_i. There was no statistical difference between measurements.

To analyze the symmetry of the facial skeleton in patients with chin deviation, the differences between vertical or horizontal distance of each paired lateral point to the x- or y-axis were examined with r_i. If the differences were not statistically significant and the lower limit of the 95% confidence interval of r was >0.75, then the left and right distances were considered to be equal and the paired points symmetric, otherwise the paired points were considered asymmetric.

The following was done to investigate which skeletal landmarks were associated with the amount of chin deviation: MEDEV was assigned as dependent variable Y and the absolute differences of left and right measurements as independent variable X. The correlation coefficient between independent and dependent factors was tested by bivariate correlation and significance ($p<0.05$) and further analyzed by multiple regression.

The following was done to analyze which facial skeletal landmarks were associated with the direction of chin deviation: direction of chin deviation was used as dependent variable Y and the difference between left and right measurements as independent variable X. An independent sample *t* test was used to examine the association between direction of chin deviation and each of the variables. Significances ($p<0.05$) were further analyzed by logistic regression. The statistical analyses were performed using SPSS version 10.0 (SPSS Inc., Chicago, IL, USA).

Results

This study included 25 patients with chin deviation of more than 2 mm. Ten (40%) subjects had a chin deviation of between 2 and 4 mm; 7 (28%) between 4 and 6 mm; 2 (8%) between 6 and 8 mm; and 6 (24%) between 8 and 10 mm. Seventeen subjects (68%) showed chin deviation to the left side and 8 subjects (32%) to the right side. The numbers of subjects presenting Angle Class I, II, and III malocclusion were 5 (20%), 3 (12%), and 17 (68%), respectively.

The distances between left and right lateral points to the x- or y-axis were compared for the analysis of symmetry of facial skeleton in patients with chin deviation. Gonial angle, ramus height, and vertical distances from all lateral points to the x-axis were symmetric except for the zygomaticofrontal suture (ZF) and zygonion. However, mandibular body length and effective length, horizontal distances from all lateral points to the y-axis, and vertical distance from ZF and zygonion to the x-axis, showed a low grade of symmetry (Table 1).

Using bivariate correlation, it was found that the absolute left and right difference of antegonion (AGN) to the y-axis (AHAGN), ZF to the x-axis (AVZF), ramus height, and mandibular effective length showed significant correlations with the amount of chin deviation. After further analysis by multiple regression analysis, it was found that the amount of chin deviation was significantly associated with the absolute horizontal difference between left and right AGN to the y-axis and the absolute vertical difference between left and right ZF to the x-axis (Table 2).

$$y = 2.693 + 0.575 \times 1 - 0.427 \times 2 \; (R^2 = 0.747)$$

where y = MEDEV (mm); 1 = AHAGN (mm); 2 = AVZF (mm).

The difference between left and right gonial angle, mandibular body length and effective length, ramus height, AGN to the y-axis, and zygonion to the x-axis were significantly associated with the direction of chin deviation. Since mandibular body length and effective length were highly associated in terms of Pearson's correlation ($r=0.894$), only mandibular effective length was included in logistic regression analysis with the above factors. The results showed that for every 1-mm distance of left mandibular effective length longer than that of the right side, the possibility of chin deviation to the right side was 2.2 fold of that to the left side (Table 3).

Discussion

According to a criterion used previously, chin deviation of more than 2 mm was considered asymmetric.[9,31,32] In this study, the amount of chin deviation was determined clinically and in the range of 2 to 10 mm. The ratio of chin deviation to the left side and to the right side was about 2 to 1 in this study. The prevalence of chin deviation to the left side over the right side has been reported previously.[9,32,33] In our study sample, the horizontal or vertical distances from right landmarks to the y- or x-axis were larger

Table 1. Symmetry of facial skeleton landmarks in patients with chin deviation

Variable	r_i between left and right measurements	Lower confidence limit of r_i
Gonial angle	0.9583	0.7568
Mandibular body length	0.3599	–0.3735*
Ramus height	0.9562	0.9040
Mandibular effective length	0.9109	0.7107*
HZF	0.7844	0.5208*
HZ	0.9277	0.2785*
HNC	0.6080	–0.1490*
HJ	0.8709	0.2963*
HCO	0.8342	0.0153*
HAGN	–0.4459	–2.5547*
VZF	0.8700	0.6969*
VZ	0.7301	0.3964*
VNC	0.9186	0.8618
VJ	0.9449	0.8599
VCO	0.9325	0.8520
VAGN	0.9265	0.8376

**p* < 0.05 *for asymmetry between left and right variables.* r_i *= intraclass correlation coefficient; HZF = difference between horizontal distances of paired zygomaticofrontal suture points to the y-axis; HZ = difference between horizontal distances of paired zygonion points to the y-axis; HNC = difference between horizontal distances of paired nasal cavity points to the y-axis; HJ = difference between horizontal distances of paired jugale points to the y-axis; HCO = difference between horizontal distances of paired condylion points to the y-axis; HAGN = difference between horizontal distances of paired antegonion points to the y-axis; VZF = difference between vertical distances of paired zygomaticofrontal suture points to the x-axis; VZ = difference between vertical distances of paired zygonion points to the x-axis; VNC = difference between vertical distances of paired nasal cavity points to the x-axis; VJ = difference between vertical distances of paired jugale points to the x-axis; VCO = difference between vertical distances of paired condylion points to the x-axis; VAGN = difference between vertical distances of paired antegonion points to the x-axis.*

Table 2. Factors associated with the amount of chin deviation analyzed by multiple regression

Dependent variable	Step	Independent variable	R	R^2	R^2 increase	F	*p*	Odds value	Beta value
MEDEV	1	AHAGN	0.812	0.659	0.659	44.433	0.000	0.610	0.812
	2	AHAGN	0.864	0.747	0.088	32.532	0.000	0.575	0.766
		AVZF					0.011	–0.427	–0.301
		Constant						2.693	

MEDEV = 2.693 + 0.575 × AHAGN – 0.427 × AVZF. Dependent variable: *MEDEV (mm) = amount of chin deviation.* Independent variables included in analysis: *AHAGN (mm) = absolute horizontal difference between left and right antegonions to y-axis; AVZF (mm) = absolute vertical difference between left and right zygomaticofrontal sutures to x-axis; ARH (mm) = absolute difference between left and right ramus heights; AEF (mm) = absolute difference between left and right effective lengths.*

Table 3. Factors associated with the direction of chin deviation analyzed by logistic regression

Independent factor	B value	Wald	*p*	Exp(B)	R^2	95% CI for Exp(B)	
						Lower	Upper
DEF	0.754	4.883	0.027	2.215	0.806	1.089	4.149
Constant	0.238	0.082	0.774	1.269			

Dependent variable: *direction of chin deviation, where "0" = to left and "1" = to right.* Independent variables included in analysis: *DGO = difference between left and right gonial angles; DHAGN = difference between left and right antegonions to y-axis; DVZ = difference between left and right zygonions to x-axis; DRH = difference between left and right ramus heights; DEF = difference between left and right effective lengths. All the differences were calculated as left side value minus right side value.*

than those from the left landmarks, which indicated that the horizontal and vertical dimensions of the right side of the face were longer than those of the left side of the face and might contribute to the more frequent deviation of the chin to the left side.

Sixty-eight percent of our asymmetric subjects had Class III malocclusion. Many investigators have also reported facial asymmetry in subjects with skeletal Class III deformity.[2,21,23,32] Given the fact that mandibular prognathism was predominant in patients with Class III malocclusion in Taiwan,[34–36] we suspected that mandibular hyperplasia or condylar overgrowth may increase the risk of asymmetric growth of the mandible and result in chin deviation.

In this study, patients with obvious chin deviation also had significant horizontal asymmetry in paired skeletal landmarks in the upper, middle, and lower face. Bilateral mandibular body length and effective length were also asymmetric. However, except at the ZF and zygonion, there was no significant vertical asymmetry between paired landmarks. These data suggested that chin deviation might be associated with asymmetric horizontal dimensions of the right and left face. Our analyses also showed that the amount of chin deviation was mostly associated with the absolute horizontal difference of the right and left AGN, which accounted for 65.9% of chin deviation. This might be because the AGN is closest to the chin, and therefore the horizontal difference of right and left AGN had the most significant effect on the amount of chin deviation.

However, combining the absolute horizontal difference of AGN and the vertical difference of ZF explained 74.7% of chin deviation. This suggested that vertical asymmetry between the right and left halves of the upper face might also have an influence on chin deviation. There were a few patients with obvious chin deviation in our study who also presented with a significant vertical asymmetry between the right and left sides of the face. Occlusal cant in the frontal plane has also been suggested to be a reflection of facial asymmetry.[37] Dentoalveolar asymmetry in children might lead to a further progressive change that influences the condyle-fossa relationship, leading to a deviation of the mandible.[38] Therefore, imbalance in the vertical growth between the right face and left face might still be associated with chin deviation in some cases.

Because of the limitations of PA cephalograms, asymmetry in facial depth could not be measured in this study. Theoretically, asymmetry in facial depth might also contribute to chin deviation. The importance of this factor will be investigated in the future. In our study, the direction of chin deviation was associated with the difference between left and right mandibular effective length. Therefore, asymmetry in the lower face was most closely associated with the amount and direction of chin deviation.

Our study showed that asymmetry in other facial areas existed in patients with chin deviation. Correction of chin deviation by mandibular jaw surgery or genioplasty alone could not remove the asymmetry in other areas that might be significant and of concern to patients. Our experience also revealed that pure mandibular setback surgery to correct the anteroposterior jaw relation and malocclusion on skeletal Class III patients associated with severe chin deviation might not achieve a complete correction of the deviated chin. The need for genioplasty to assist the transverse correction of the midline of the chin should be carefully evaluated before surgery. Therefore, thorough facial examination and explanation of the procedure to the patient are imperative during treatment planning to ensure patient satisfaction.

In conclusion, this study analyzed the facial skeletal characteristics of 25 patients with chins that deviated more than 2 mm using PA cephalograms. The following were found:

1. Seventeen subjects (68%) showed chin deviation to the left side and 8 subjects (32%) to the right. Sixty-eight percent of subjects presented with Angle Class III malocclusion.
2. Horizontal distance of all paired lateral points to the y-axis, mandibular body length and effective length showed a low grade of symmetry. Only vertical distances of paired ZF and zygonion points to the x-axis were asymmetric. However, there were no significant asymmetries of gonial angle, ramus height or vertical distances from other paired lateral points to the x-axis.
3. The amount of chin deviation was associated with the absolute differences of the left and right AGN to the y-axis and the ZF to the x-axis in multiple regression analysis.
4. The direction of chin deviation was significantly associated with the difference in bilateral mandibular effective length. For every 1 mm the left mandibular effective length was longer than that of the right side, the possibility of chin deviation to the right side was 2.2 fold that of the left.

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