Three-dimensional analysis of mandibular characteristics in patients with skeletal Class II malocclusion and chin deviation

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Introduction: This study aimed to analyze adults with mandibular characteristics of skeletal Class II malocclusion with chin deviation. **Methods:** Seventy-five adult patients aged from 18 to 35 years were included and divided into 3 groups on the basis of sagittal skeletal pattern and chin deviation: skeletal Class I symmetry group, skeletal Class II symmetry group, and skeletal Class II asymmetry group (25 patients per group). Mandibular measurements on cone-beam computed tomography images were performed, and the differences between 2 sides in each group and the differences among the 3 groups were investigated. **Results:** Compared with the contralateral side, the deviated side of patients in the Class II asymmetry group showed significantly smaller condyle angle to midsagittal plane, condylar height, ramal length, and length of the mandibular body, whereas it showed a significantly larger distance from condylion to the midsagittal plane, ramus angle to the horizontal plane, and distance from gonion to the midsagittal plane. Most linear measurements in the Class II symmetry group were significantly smaller than those in the Class I symmetry group. These linear measurements on the contralateral side of the Class II asymmetry group showed no significant difference with the Class I symmetry group, and these measurements on the deviated side of the Class II asymmetry group showed no significant difference with the Class II symmetry group. **Conclusions:** Length of the mandible, rotation of condyle, the inclination of the ramus, and position of gonion should be considered in subjects with skeletal Class II asymmetry when making diagnosis and treatment planning. (Am J Orthod Dentofacial Orthop 2021;160:392-400)

Facial symmetry is very important in esthetic evaluation. Mild facial asymmetry is usually difficult to detect, but when asymmetry increases, clinically observable facial deviation occurs.[1] According to the literature, the incidence of facial asymmetry ranges from 11% to 37%, and even up to 40%-50% if strictly defined.[2,3]

The mandible grows and develops for a long time and is not directly connected with the skull; thus, the most important manifestation of facial asymmetry is the asymmetry of the mandible, particularly chin deviation.[4]

Two-dimensional radiographic images were used to study the characteristics of the mandible in patients with chin deviation. However, 2-dimensional radiographic images have limitations such as distortion, elongation, and superimposition of the anatomic structures.[5,6] In recent years, cone-beam computed tomography (CBCT) with the advantages of high resolution and no magnification[7] have overcome the limitations of traditional images and widely used for analyzing chin deviation.[3,8]

Previous studies on chin deviation focused on patients with skeletal Class III malocclusion and skeletal Class I malocclusion.[3,9-11] Few studies on skeletal Class II asymmetry were available. Kim et al[12] compared chin-deviated patients with skeletal Class II and Class III malocclusion. They focused on the measurements of the ramus and mandibular body but not included condyle in their study. Thiesen et al[13] found that bilateral differences in gonion position and ramal height

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were significantly correlated with chin deviation in patients with Class II malocclusion. However, no comparison with patients with Class I malocclusion was performed in their study. In addition, the majority of mandibular measurements in their study were linear measurements. For a more meaningful clinical interpretation, we believe that analyzing with angular and linear measurements and comparing them with subjects with Class I malocclusion are helpful to figure out mandibular morphologic characteristics of patients with Class II malocclusion with chin deviation.

This study aimed to analyze mandibular characteristics of adults with skeletal Class II malocclusion with chin deviation. In this study, mandibular measurements on CBCT images were performed in patients with skeletal Class II asymmetry and patients with skeletal Class I and Class II symmetry. Then the differences between 2 sides in each group and the differences among the 3 groups were evaluated to analyze mandibular characteristics of patients with skeletal Class II malocclusion with chin deviation.

MATERIAL AND METHODS

Seventy-five adult patients seeking treatment at the Department of Orthodontics and Orthognathic Surgery in Peking University School and Hospital of Stomatology from 2015 to 2018 were enrolled in the study. CBCT images were taken for routine record of diagnosis and treatment planning. The study was approved by the Biomedical Ethics Committee of Peking University School and Hospital of Stomatology (PKUSSIRB-201946087).

Asymmetry was defined by the deviation of gnathion from the midsagittal plane.[3] Patients with a gnathion deviation <2 mm were categorized as relative symmetry. In contrast, those with a deviation >4 mm were categorized as asymmetry.

Patients with skeletal Class II malocclusion were included with the following inclusion criteria: (1) aged from 18 to 35 years; (2) Mongolian; (3) permanent dentition, no missing teeth except the third molar; (4) ANB angle, $>4.7°$, Wits appraisal, >2.8; and (5) no prior orthodontic or orthognathic treatment. Exclusion criteria included: (1) retained deciduous teeth and ectopic teeth; (2) crowns or significant restorations in posterior teeth; (3) severe periodontitis; (4) systemic diseases; (5) cleft lip or palate, osteoarthritis of temporomandibular; and (6) trauma or tumor.

Patients with skeletal Class I malocclusion were included with the following inclusion criteria: (1) $0° < \text{ANB angle} < 4°$ and $-2 < \text{Wits appraisal} < 0$, (2) relatively symmetrical mandible, (3) crowding less than 2 mm and no obvious gaps, and (4) other inclusion criteria the same as that for subjects with skeletal Class II malocclusion. Exclusion criteria included: (1) crossbite or scissors-bite in posterior teeth, (2) crossbite or edge-to-edge position in anterior teeth, and (3) other exclusion criteria the same as that for patients with skeletal Class II malocclusion.

The condylar height was considered to be one of the core indexes. In the preliminary experiment, the condylar height was reported as 20.67 ± 3.41 mm on the nondeviated side of patients with skeletal Class II malocclusion with chin deviation and was 18.14 ± 2.10 mm on patients with skeletal Class II malocclusion without chin deviation. On the basis of these results, according to the formula proposed by Chow et al,[14] at least 22 subjects are needed per group to reject the null hypothesis that patients with chin deviation were the same as patients without chin deviation, with a power of 0.8. The probability of type I error associated with this hypothesis test was 0.05 http://powerandsamplesize.com/Calculators/.

Patients information in each group was summarized as follows: (1) Class I symmetry group included 25 patients with skeletal Class I malocclusion (6 males, 19 females; average age, 23.46 ± 3.99 years) with gnathion deviation <2 mm; (2) patients with skeletal Class II malocclusion were further divided into 2 subgroups according to the degree of gnathion deviation from midsagittal plane measured on 3-dimensional (3D) CBCT images; (3) Class II symmetry group included 25 patients with skeletal Class II malocclusion (3 males, 22 females; average age, 25.57 ± 4.55 years) with gnathion deviation <2 mm, crowding <4 mm, and no obvious gaps. Patients with crossbite or scissors-bite in posterior teeth or crossbite or edge-to-edge position in anterior teeth were excluded; and (4) Class II asymmetry group included 25 patients with skeletal Class II malocclusion (5 males, 20 females; average age, 25.08 ± 3.59 years) with gnathion deviation >4 mm.

No significant difference was noted among the 3 groups regarding gender and age (Table I).

All images were taken with a NewTom Scanner (NewTom G, Marburg, Germany) at these settings: 2.81 mA, 110 kV, exposure time of 3.6 seconds, isotropic voxels, axial slice thickness of 0.3 mm, and scanning area of 15×15 cm. Patients underwent CBCT in natural head posture and maximum dental intercuspation.

Digital imaging and communications in medicine data of obtained images were imported into the Dolphin 3D Imaging software (version 11.8; Dolphin Imaging and Management Solutions, Chatsworth, Calif) to reconstruct 3D images. The plane passing through 2 orbitals, and the right porion was the Frankfort horizontal (FH) plane, and the plane perpendicular to the horizontal plane and passing through nasion and basion was the midsagittal plane (MSP).[11]

Table I. Characteristics of the sample

Group	*Class I symmetry group*	*Class II symmetry group*	*Class II asymmetry group*	P *value*
Sex (n)				0.541*
Female	19	22	20	
Male	6	3	5	
Age, y (mean ± SD)	23.46 ± 3.99	25.57 ± 4.55	25.08 ± 3.59	0.120†

SD, Standard deviation.
*Pearson chi-square test; †Kruskal-Wallis 1-way analysis of variance test.

Table II. Landmarks used in the study

Landmark	*Abbreviation*	*Definition*
Condylion superius	Co	Most superior point of the condyle
Condylion lateralis	C-lat	Most lateral point of the condyle head
Condylion medialis	C-med	Most medial point of the condyle head
Gonion	Go	Most inferior and posterior point on the contour of the gonial angle
Condylion anterius	C-ant	Most anterior point of the condyle head
Condylion posterius	C-pos	Most posterior point of the condyle head
Sigmoid notch	Sn	Most inferior point of the sigmoid notch
Gnathion	Gn	Most anterior inferior point of the contour of the bony menton

Landmarks were located in 3D reconstructions and multiplanar reconstruction view, with measurement scales of 0.01 mm and 0.01°.

Landmarks used in the study are defined in Table II and illustrated in Figure 1. Measurements used to evaluate the morphology of the mandible[3,15,16] are defined in Table III and illustrated in Figure 2. The side that the gnathion deviate toward was defined as a deviated side, and the opposite side was defined as the contralateral side.

Statistical analysis

SPSS software (version 20.0; IBM, Armonk, NY) was used for statistical analysis. Two weeks after completion of all data measurements, 5 patients were randomly selected from each group for repeated measurements. The intraclass correlation coefficient was used to evaluate the observer's reliability. All intraclass correlation coefficient values were >0.95, indicating good reliability in the group.

The Wilcoxon signed rank test was used for intragroup comparison between the deviated and the contralateral side. Mann-Whitney U test and Kruskal-Wallis 1-way analysis of variance was used for intergroup comparisons.

RESULTS

Measurements on skeletal Class I and Class II symmetry groups showed no significant difference between 2 sides in each group except for ramal length (Co-Go) and gonial position (Go-MSP) in the Class II symmetry group ($P > 0.05$; Table IV). So, the means of 2 sides in each group were used for the following analysis and comparison.

In the skeletal Class II asymmetry group, condyle height (⊥Co-Sn), Co-Go, and mandibular body length (Go-Gn) on the deviated side were smaller than that on the contralateral side ($P < 0.05$; Table V). Condyle angle to the midsagittal plane on the deviated side, with the average value of 64.82°, was significantly smaller than that on the contralateral side, with the average value of 68.14° ($P < 0.05$; Table V). Ramus angle to the horizontal plane (∠C-lat-Go-FH) on the deviated side was larger than that on the contralateral side ($P < 0.01$; Table V). Distance from condylion to the midsagittal plane was larger on the deviated side than that on the contralateral side ($P < 0.05$; Table V). Distance from gonion to the Go-MSP was significantly larger on the deviated side than that on the contralateral side ($P < 0.01$; Table V). No significant difference was found between bilateral joint space (anterior, superior, and posterior).

Multiple comparisons among 3 groups showed significant differences in the condyle, ramus, and mandibular body ($P < 0.05$; Table V).

The anteroposterior dimension of the condyle (C-ant-C-pos), ⊥Co-Sn, Co-Go, and Go-Gn in the Class I symmetry group were significantly larger than those in the Class II symmetry group.

The C-ant-C-pos, ⊥Co-Sn, Co-Go, and Go-Gn on the contralateral side of the Class II asymmetry group showed no significant difference with the Class I symmetry group, and these measurements on the deviated side of the Class II asymmetry group showed no significant difference with the Class II symmetry group ($P > 0.05$; Table V). Deviated side of the Class II asymmetry group showed the largest ∠C-lat-Go-FH and the largest distance from gonion to the Go-MSP among all groups.

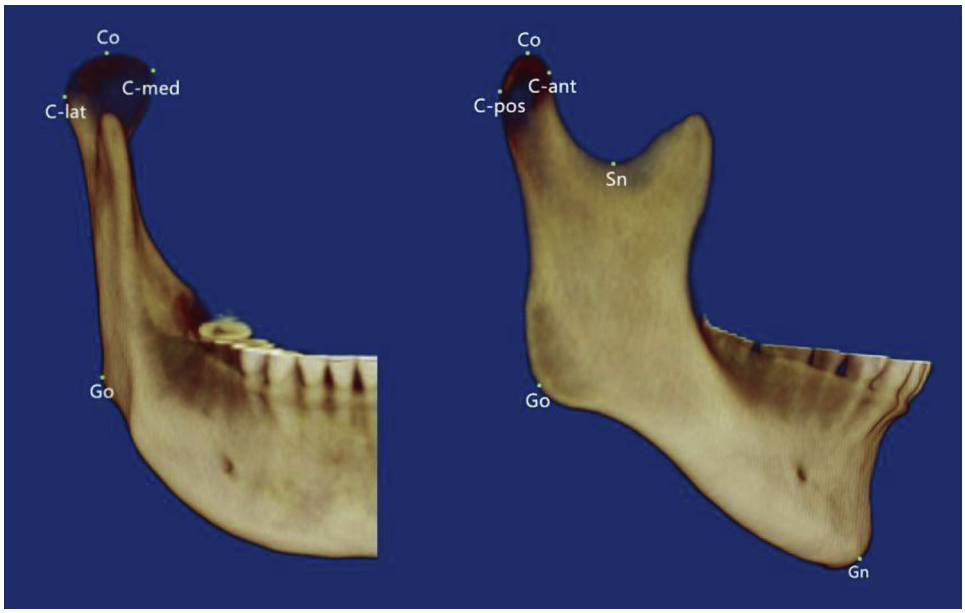

Fig 1. Landmarks used in the study. *Co,* Condylion superius; *C-lat,* Condylion lateralis; *C-med,* Condylion medialis; *Go,* Gonion; *C-ant,* Condylion anterius; *C-pos,* Condylion posterius; *Sn,* sigmoid notch; *Gn,* Gnathion.

DISCUSSION

Orthognathic surgery is usually needed for patients with chin deviation. Previous studies have found that chin deviation is associated with asymmetry of the bilateral condyle, ramus, and mandibular body.[3,9-13,16-18] Many studies have focused on patients with skeletal Class III or Class I malocclusion with chin deviation.[3,9-12,16,17] Available literature on patients with Class II asymmetry is insufficient. In this study, mandibular characteristic of patients with skeletal Class II malocclusion with chin deviation was analyzed on the basis of CBCT images.

In this study, patients aged >18 years were collected to minimize the growth effect. There were no significant differences among the 3 groups regarding gender and age of subjects.

Bilateral comparison of the mandibular morphology in both symmetry groups showed no significant difference for most of the measurements (Table IV), indicating that nondeviated gnathion was correlated with good symmetry of mandible. So, the means of 2 sides in each group were used for the following analysis and comparison.

When comparing Class I and Class II symmetry groups, the C-ant-C-pos, ⊥Co-Sn, Co-Go, and Go-Gn in the Class I group were larger than those measured in the Class II group (Table V), which agreed with previous studies that condyle,[19] ramus,[20] and mandibular body[21] were smaller in subjects with Class II malocclusion than subjects with Class I malocclusion. Jacob et al[22] made a longitudinal study on adolescents and found that compared with patients with Class I malocclusion, patients aged from 10 to 15 years with Class II malocclusion exhibit less vertical condylar growth and less gonial modeling. It can be concluded that the mandible of patients with Class II malocclusion was less developed than that of patients with Class I malocclusion.

For the Class II asymmetry group, statistically significant differences were found between 2 sides for most of the measurements, indicating obvious mandibular asymmetry (Table V). But superior, anterior, and posterior joint space showed no significant difference between 2 sides, which agreed with Kim et al[10] for patients with Class III malocclusion with chin deviation.

The ⊥Co-Sn, Co-Go, and Go-Gn on the contralateral side of the Class II asymmetry group were larger than those measured on the deviated side (Table V), which means the chin deviates to the side with a shorter condyle, ramus, and mandibular body. This result was similar to lots of the previous studies[3,12,23,24] for chin deviation.

In addition, when 3 groups were compared, the C-ant-C-pos, ⊥Co-Sn, Co-Go, and Go-Gn on the contralateral side of the Class II asymmetry group were similar to those in Class I symmetry group. In addition,

Table III. Measurements to evaluate the morphology of the mandible

Variable	*Measurement*	*Definition*
Joint space		
Superior (mm)	Superior joint space (mm)	Distance perpendicular to the FH plane between Co and the articular fossa outline
Anterior (mm)	Anterior joint space (mm)	Distance parallel to the FH plane between C-ant and the articular eminence outline
Posterior (mm)	Posterior joint space	Distance parallel to the FH plane between C-pos and the articular fossa outline
Condyle		
∠C-MSP (°)	Condyle angle to midsagittal plane	Angle between the midsagittal plane and the line connected C-lat and C-med
∠C-FH (°)	Condyle angle to horizontal plane	Angle between the horizontal plane and the line connected C-lat and C-med
⊥Co-Sn (mm)	Condylar height	Vertical distance from Co to Sn (horizontal plane passing through Sn)
C-lat-C-med (mm)	Mediolateral dimension of the condyle	Distance between C-lat and C-med
C-ant-C-pos (mm)	Anteroposterior dimension of the condyle	Distance between C-ant and C-pos
Co-MSP	Condylar position	Distance from Co to the midsagittal plane
∠Co-Sn-FH (°)	Condylar neck angle to FH plane	Angle between the horizontal plane and the line connected Co and Sn
∠C-lat-Go-FH (°)	Ramus angle to horizontal plane	Angle between the horizontal plane and the line connected C-lat and Go
Co-Go (mm)	Ramal length	Distance between Co and Go
Go-Gn (mm)	Length of mandibular body	Distance between Go and Gn
Go-MSP (mm)	Gonial position	Distance from Go to the midsagittal plane

these measurements on the deviated side of the Class II asymmetry group were similar to those in the Class II symmetry group (Table V). As this study and previous studies proved,[21,22] the mandible of patients with Class II malocclusion was less developed than that of patients with Class I malocclusion. It can be concluded that the deviation observed in Class II patients might be more related to underdevelopment of the deviated side than overdevelopment of the contralateral side.

Condylar rotation of 2 sides in the Class II asymmetry group was more asymmetrical than in symmetry groups. The mean condyle angle to the midsagittal plane on deviated side of the Class II asymmetry group was 64.82°, significantly smaller than on the contralateral side, with an average value of 68.14°. In addition, in symmetry groups, this average value was 67.66° in the Class I group and 67.92° in the Class II group, with no bilateral difference (Table V). Kim et al[10] reported that the mean condyle angle to the horizontal plane in patients with Class III malocclusion without chin deviation and contralateral side of patients with Class III malocclusion with chin deviation was 12°-15°, which converted to the condyle angle to midsagittal plane used in this study was 75°-78°, 4°-6° smaller than that on deviated side of patients with Class III malocclusion with chin deviation. These results indicated that similar to patients with Class III malocclusion, compared with the contralateral side, condyle rotated more inwardly on the deviated side. Oh et al[16] also found that condyle rotated more asymmetrically in patients with Class I and Class III malocclusion with chin deviation than those without deviation.

With an extensive literature review, we found that condyle angle to midsagittal plane in patients with Class III malocclusion was obviously larger than in patients with Class II malocclusion.[10,15,18,25] Condyle height in patients with Class II malocclusion was smaller compared with Class III patients,[19] and as demonstrated by this study, condyle height was smaller on the deviated side than that on the contralateral side. The rotation of condyle causing smaller condyle angle to midsagittal plane might be to compensate for the lack of condyle height to make the occlusion as stable as possible.

In addition to the condylar rotation, patients with Class II malocclusion with chin deviation also have a displacement of condyle and gonion (Table V). Distance from condylion to the midsagittal plane was statistically different between the contralateral and deviated sides. Roque-Torres et al[18] also reported that anteroposterior condyle position showed significant correlations with lateral displacement of skeletal and dental midlines in patients with Class II malocclusion. It seemed that patients with Class II malocclusion with chin deviation showed unbalanced condyle position. However, this was different from some other studies,[3,13,16,26] that claim that condylar position, which is described as the center of condyle or the most medial point of the condyle, showed no bilateral difference in patients with chin deviation. The difference might be related to reference points used in different studies. For example, Lee et al[11] found that for patients with skeletal Class III malocclusion with chin deviation, the most lateral point of the condyle was positioned more laterally on the contralateral side than that on the deviated side,

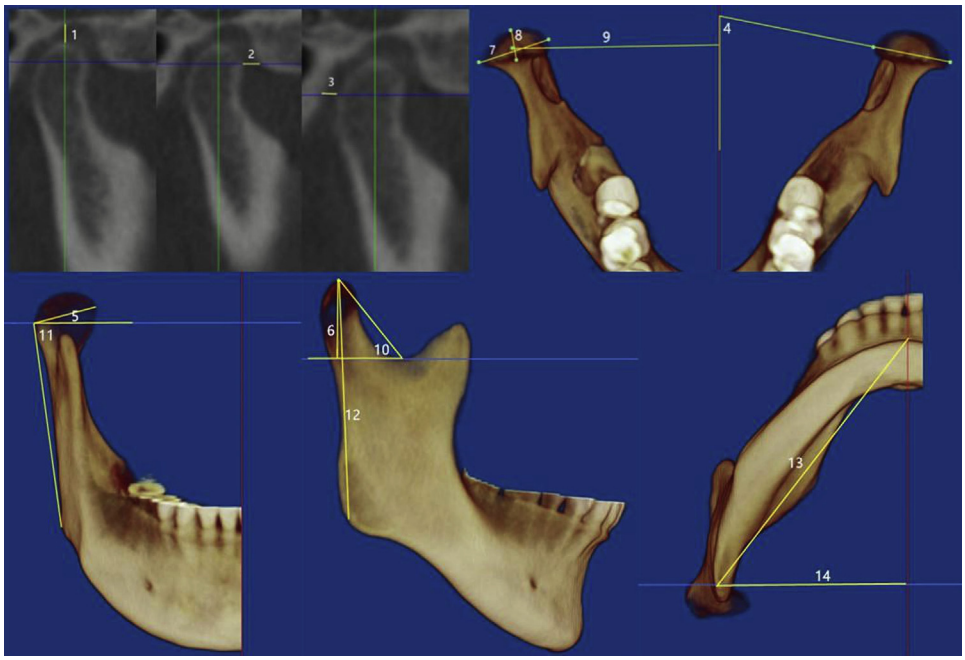

Fig 2. Measurements to evaluate the morphology of the mandible: **1,** superior joint space; **2,** anterior joint space; **3,** posterior joint space; **4,** midsagittal plane (∠C-MSP); **5,** ∠C-FH; **6,** ⊥Co-Sn; **7,** C-lat-C-med; **8,** C-ant-C-pos; **9,** condylion to the midsagittal plane (Co-MSP); **10,** ∠Co-Sn-FH; **11,** ∠C-lat-Go–FH; **12,** Co-Go; **13,** Go-Gn; **14,** Go-MSP.

Table IV. Comparison of mandibular morphology between the deviated and contralateral side in Class I and Class II symmetry groups

	Class I symmetry group			*Class II symmetry group*		
Variable	*Deviated side*	*Contralateral side*	P *value*	*Deviated side*	*Contralateral side*	P *value*
Joint space						
Superior (mm)	3.08 ± 0.88	2.94 ± 0.70	0.209	2.68 ± 0.86	2.71 ± 0.67	0.920
Anterior (mm)	3.28 ± 1.10	2.82 ± 0.87	0.067	2.74 ± 0.88	2.83 ± 0.85	0.932
Posterior (mm)	2.77 ± 0.72	2.70 ± 0.76	0.731	2.74 ± 0.67	2.74 ± 0.58	0.945
Condyle						
∠C-MSP (°)	67.34 ± 9.15	67.98 ± 8.26	0.527	68.08 ± 10.41	67.78 ± 10.66	0.440
∠C-FH (°)	9.32 ± 11.56	6.97 ± 10.78	0.067	11.43 ± 9.81	10.70 ± 9.10	0.609
⊥Co-Sn (mm)	21.02 ± 5.22	21.18 ± 5.12	0.253	18.06 ± 2.10	18.01 ± 1.51	0.948
C-lat-C-med (mm)	17.61 ± 1.86	17.76 ± 1.97	0.493	17.94 ± 2.28	17.70 ± 2.07	0.120
C-ant-C-pos (mm)	8.14 ± 0.98	8.16 ± 0.92	0.930	7.55 ± 0.91	7.40 ± 0.76	0.503
Co-MSP	51.90 ± 3.00	51.27 ± 2.52	0.092	51.72 ± 2.61	52.55 ± 2.28	0.097
Ramus						
∠Co-Sn-FH (°)	50.32 ± 6.36	49.90 ± 6.61	0.089	48.88 ± 4.30	48.27 ± 3.31	0.667
∠C-lat-Go-FH (°)	77.22 ± 3.03	77.74 ± 2.51	0.374	76.36 ± 3.14	75.89 ± 2.78	0.171
Co-Go (mm)	57.48 ± 4.16	56.81 ± 4.18	0.072	55.28 ± 4.85	53.98 ± 4.84	0.007*
Mandibular body						
Go-Gn (mm)	84.32 ± 3.08	84.54 ± 3.29	0.423	80.19 ± 5.38	80.59 ± 6.23	0.451
Go-MSP (mm)	46.99 ± 4.11	46.44 ± 3.49	0.330	48.02 ± 3.65	46.53 ± 3.19	0.005*

Note. Values are mean ± standard deviation.
*Statistically significant difference evaluated by Wilcoxon signed rank test, with a significance level of 5%.

Table V. Comparison of mandibular morphology between deviated and contralateral side in asymmetry group, and among either side in asymmetry group and the other 2 symmetry groups

	Class II asymmetry group						
Variable	*Deviated side*	*Contralateral side*	P *value*[†]	*Class I symmetry group*	*Class II symmetry group*	P *value*[‡]	*Multiple comparison*[§]
Joint space							
Superior (mm)	2.85 ± 1.06	2.85 ± 0.66	0.858	3.01 ± 0.74	2.69 ± 0.73	0.383	S1 = S2 = C S1 = S2 = D
Anterior (mm)	3.42 ± 1.16	3.17 ± 1.12	0.247	3.05 ± 0.82	2.78 ± 0.78	0.285	S1 = S2 = C S1 = S2 = D
Posterior (mm)	3.54 ± 1.26	3.61 ± 1.44	0.795	2.73 ± 0.63	2.74 ± 0.54	0.031*	S1 = S2 = C D > S1* D > S2*
Condyle							
∠C-MSP (°)	64.82 ± 10.68	68.14 ± 11.46	0.022*	67.66 ± 8.29	67.92 ± 9.70	0.973	S1 = S2 = C S1 = S2 = D
∠C-FH (°)	14.00 ± 9.39	11.75 ± 10.2	0.207	8.14 ± 10.36	11.07 ± 8.74	0.333	S1 = S2 = C; S1 = S2 = D
⊥Co-Sn (mm)	18.86 ± 2.86	20.65 ± 3.71	0.016*	21.10 ± 5.15	18.04 ± 1.73	0.001*	S1 > S2* S1 > D* D = S2 C = S1 C > S2*
C-lat-C-med (mm)	17.67 ± 3.04	18.17 ± 3.34	0.180	17.69 ± 1.81	17.82 ± 2.11	0.811	S1 = S2 = C S1 = S2 = D
C-ant-C-pos (mm)	8.03 ± 1.33	8.13 ± 1.29	0.510	8.15 ± 0.93	7.47 ± 0.76	0.042*	S1 > S2* D = S1 D = S2 C = S1 C > S2*
Co-MSP	53.03 ± 3.1	52.29 ± 2.99	0.030*	51.59 ± 2.63	52.13 ± 2.13	0.328	S1 = S2 = C S1 = S2 = D
Ramus							
∠Co-Sn-FH (°)	48.6 ± 4.23	48.58 ± 4.52	0.700	50.11 ± 6.38	48.57 ± 3.42	0.931	S1 = S2 = C S1 = S2 = D
∠C-lat-Go-FH (°)	79.28 ± 5.05	75.43 ± 5.08	0.002*	77.48 ± 2.50	76.12 ± 2.83	0.010*	S1 = S2 = C D = S1 D > S2*
Co-Go (mm)	54.67 ± 6.00	57.34 ± 7.19	0.041*	57.14 ± 4.03	54.63 ± 4.66	0.118	S1 > S2* D = S1 D = S2 C = S1 C = S2
Mandibular body							
Go-Gn (mm)	78.92 ± 10.63	83.28 ± 8.68	<0.001*	84.43 ± 3.12	80.39 ± 5.70	0.035*	S1 > S2* D < S1* D = S2 C = S1 C = S2
Go-MSP (mm)	49.70 ± 5.17	46.15 ± 4.80	0.003*	46.71 ± 3.67	47.27 ± 3.21	0.027*	S1 = S2 = C D > S1* D = S2

Note. Values are mean ± standard deviation.
S1, means of the 2 sides of Class I symmetry group; *S2*, means of the 2 sides of Class II symmetry group; *C*, contralateral side; *D*, deviated side.
*Statistically significant difference, with a significance level of 5%; [†]Wilcoxon signed rank test; [‡]Kruskal-Wallis 1-way analysis of variance test; [§]Mann-Whitney U test.

but the center of the condyle and most medial point of the condyle showed no bilateral difference. Therefore, more researches were needed to verify the characteristics of condyle position in patients with chin deviation.

This study also showed that for patients in the Class II asymmetry group, the average distance from gonion to the Go-MSP was 3.55 mm larger on the deviated side than that on the contralateral side, which means gonion located more laterally on the deviated side than that on the contralateral side. This result agreed with the studies of Thiesen et al.[13,26] The difference of bilateral gonial position was more obvious than that of condylar position, which consists with the result that ∠C-lat-Go-FH on the deviated side was larger than that on the contralateral side (Table V). The mean ramus angle to horizontal plane was 79.28° on the deviated side, significantly larger than that on the contralateral side of the Class II asymmetry group, Class I symmetry group, and Class II symmetry group, with the average value of 75.43°, 77.48°, and 76.12° respectively (P <0.05; Table V). Kim et al[12] also reported that the average value of ramus angle to midsagittal plane in patients with Class II malocclusion with chin deviation was 11.9° on the deviated side and 16.3° on the contralateral side, which converted to the ramus angle to horizontal plane used in this study was 78.1° on the deviated side and 73.7° on the contralateral side. It is verified that ramus inclined more laterally on deviated side of patients with Class II malocclusion with chin deviation, which was also found in previous studies for patients with Class III malocclusion.[12,23,24]

Therefore, when making an orthognathic surgery plan for patients with Class II malocclusion with chin deviation, not only the length difference between 2 sides of the mandible but also the unbalanced rotation of condyle, inclination of the ramus, and position of gonion should be considered.

However, the sample size of this study is relatively small, and the vertical pattern was not taken into account. Further study with a larger sample size and classification of the vertical pattern will be helpful to confirm our findings.

CONCLUSIONS

1. Patients from the Class II asymmetry group showed significant differences between measurements on the contralateral and deviated sides, whereas patients from the Class I and Class II symmetry groups showed little bilateral difference.
2. For patients with Class II malocclusion with chin deviation, the chin deviated to the side with a shorter condyle, ramus, and mandibular body. The length difference might be more related to underdevelopment of the deviated side than overdevelopment of the contralateral side.
3. Compared with the contralateral side, condyle on deviated side of patients with Class II malocclusion with chin deviation rotated more inwardly.
4. Gonial position and ramal inclination were more laterally on deviated side of the Class II asymmetry group than those on the contralateral side of the Class II asymmetry group and both symmetry groups.

AUTHOR CREDIT STATEMENT

Wenxin Lv contributed to methodology, validation, formal analysis, investigation, data curation, and original draft preparation; Qiong Nie contributed to conceptualization, methodology, resources, manuscript review and editing, and supervision; and Yan Gu contributed to conceptualization, methodology, resources, manuscript review and editing, and supervision.

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