KenKyu

Clinical Case Reports, Research & Trials 5: 01-09 (2020)

Review ISSN: 2581-6756

Three dimensional study of the mandibular occlusal plane in Angle class Ⅲ malocclusion with facial asymmetry.

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Received February 12, 2020; **Accepted** March 05, 2020; **Published** March 06, 2020

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Abstract

Objective: The inclination of the mandibular occlusal plane is multidimensional and is important for the diagnose, treatment and retention in Angle class Ⅲ malocclusion with facial asymmetry. The objective of this study was to analyze the space shape of the mandibular occlusal plane with three-dimensional reconstructed technology.

Methods: The experimental group (the facial asymmetric group) and the control group each with 20 cases were chosen according to some standards. The CBCT data were obtained and three-dimensional model were built with Mimics software. According to selected anatomical landmarks, the occlusal plane of the mandible and three reference planes were built, and the angles between the occlusal plane and the three reference planes were measured, that is the pitch angle ,the roll angle,the yaw angle.The difference between the 2 groups were analyzed, and the relationship between the chin deviation and the inclination of occlusal plane in the experimental group was analyzed by SPSS19.0 statistical software.

Results: Measurement results showed that there was a difference in the deflection characteristics of mandibular occlusal plane between two groups. The correlation analysis between the inclination of the occlusal plane and the degree of deviation chin showed that the pitch angle of the occlusal plane is negatively correlated with the degree of chin deflection, positively correlated with the roll angle and yaw angle, and the roll angle has the highest correlation($p<0.05$).

Conclusion: There was difference in the change of mandibular occlusal plane in the three dimensional between two groups,and in Angle class Ⅲ malocclusion with facial asymmetry , the changes of the mandibular occlusal plane in sagittal direction differ form horizontal direction and coronal direction ,and with the chin deflection increasing the occlusal plane deviate more in three dimension.

Introduction

Facial asymmetry is one of the most common facial deformities,it refers to complex malformation which is characterized by chin deflection more than 2mm[1]. Clinically,facial asymmetry in Angle class Ⅲ malocclusion is difficult to be treated because it is often accompanied by skeletal asymmetry, the overgrowth of mandible and the abnormal occlusion plane of the mandible. In the facial asymmetry patients, the body of the mandible and mandibular ramus are overgrown on the non-deviated side,and the mandibular ramus is inclined upward and inward on the deviated side, the mandibular occlusal plane often changes compensatively with the deviation of the mandibular,including the molar of the deviated side of the mandible occur to tongue inclination,and the molar of the non-deviated side of the mandible are more upright[2-5]. The change of compensation is reflected in coronal direction, horizontal direction and sagittal direction, namely, pitch angle (anteversion angle of the occlusal plane), roll angle（rotation angle of the occlusal plane) and yaw angle (swing angle of the occlusal

plane). With the development of orthognathic surgery, the combination of orthodontic-orthognathic treatment is used to improve the aesthetics and overcome the problem of functional reconstruction[6-7]. In orthognathic surgery, it is necessary not only to correct the left and right incongruity, but also to adjust the vertical and horizontal incongruity. The adjustment of any one dimension will affect the changes of other dimensions. Studies have shown the key to evaluate the success of orthognathic surgery lies in the stability of the postoperative occlusal plane [8-9]. Therefore, understanding the three-dimensional features of the occlusal plane of the mandibular is helpful to the orthognathic surgery and postoperative stability of the facial asymmetry. Previous literature on facial asymmetry mainly focused on the analysis of mandible asymmetry by two-dimensional [10], and correlation analysis of three-dimensional directions of mandible occlusal plane are rarely studied. With the development of three-dimensional technique, it overcomes the shortcomings of two-dimensional 's amplification,distortion and unclear overlap, and can more intuitively evaluate the spatial position change of mandible[6.11].This experiment measured and analyzed the degree of deviation of the occlusal plane in three dimensional, which could provide instruction for the clinical design of orthognathic surgery, optimize orthodontic-orthognathic treatment and establish stable postoperative result.

Materials and Methods:

Research object

This study was approved by the Committee of Ethics in Qingdao municipal hospital. Informed consent was obtained from the 40 patients before the study.All procedures performed in this study complied with the ethical standards of the 1964 Helsinki declaration and its later amendments or comparable ethics standards.The sample was selected from patients who came to the Department of Oral Orthodontics in Qingdao municipal hospital. Mean age: 24.51±5.50years; 20 males, 20 females. The study inclusion criteria were as follows:

The experiment group (20 cases)

1. Deviation of submental point from median sagittal plane was greater than 2mm in ICP and MPP[1] ;
2. There is no severe abrasion、missing teeth and periodontal disease, and the crowdedness of the upper and lower dentition is not more than I degrees and the two sides are evenly distributed;
3. No facial trauma history, no orthodontic history, no unilateral condylar hypertrophy, tumor and genetic diseases that can cause asymmetric facial development;
4. No deformed teeth, missing teeth, no restoration;.
5. The occlusal relationships was Angle class Ⅲ malocclusion, and ANB<0°.

The control group (20 cases)

1. Deviation of submental point from median sagittal plane was less than 2mm in ICP and MPP;
2. There is no severe abrasion、missing teeth and periodontal disease, and the crowdedness of the upper and lower dentition is not more than I degrees and the two sides are evenly distributed;
3. No facial trauma history, no orthodontic history, no unilateral condylar hypertrophy, tumor and genetic diseases that can cause asymmetric facial development;
4. No deformed teeth, missing teeth, no restoration;

Research Methods

Imaging Examination

The data were collected by CBCT (KaVo The USA). All CT images collected were taken by the same equipment and person in this experiment. During the scan, the patients keep body naturally relaxed and remained standing, no movement, no swallowing, no deep breathing. A continuous scan performed from the top of the skull to the lower margin of mandible with the voltage of 120 KV, the current of 100 mA. The scan layer thickness and the reconstruction interval were defined as 0.35 mm and 0.33 mm, getting images of 466 37 after the scan. The data were saved and output in Dicom format.

Construct Three-Dimensional Models

All CBCT scan data were imported into Mimics 17 software(Materialise software company, Belgium) on Dicom format. The craniofacial bone and mandible were reconstructed.

Measurement Items

Correcting the head positions of the three-dimensional models before measurement from the coronal, sagittal, and horizontal direction.

1. The reference points with a total of 11 markers were selected (see Table 1,Figure.1)

2. The reference planes : 1).The Median Sagittal plane(MSP): this plane is perpendicular to the line of the two frontal zygomatic points through the nasion point[1](Figure.2.A); 2).The Horizontal plane(FH):the plane formed by the middle point of PO, right orbitale point (OrR) and left orbitale point (OrL)(Figure.2.C); 3). The Coronal plane(COR): the plane passes through the skull base point (Ba) and is perpendicular to the plane of the FH and MSP(Figure.2.B).

3. The measuring planes: 1).The mandibular occlusal plane (Figure.2.D):It is an plane formed by connecting the middle adjacent point of the mandibular central incisor to the mesial buccal apex of the first molar on both sides; 2).The median sagittal plane of the mandibular occlusal plane(Figure.2E):the plane passes through the middle adjacent point of mandibular incisors and is perpendicular to the line connecting the mesial buccal tip of the first molar on both sides(Table 2).

4. The measurement items were measured by Mimics 17 software.

Statistical analysis

All the data were measured by the same person and the average value was taken three times each time. The SPSS 19.0 statistical software (IBM Corporation, NY) was used to perform Independent-Sample T Test and the Pearson correlation analysis. Independent-Sample T tests was used to analyze the data between the two groups ; Pearson correlation analysis was used to analyze the data of chin deviation and the occlusal plane of the facial asymmetry.The test level was a= 0.05,P<0.05 indicates that the difference was statistically significant.

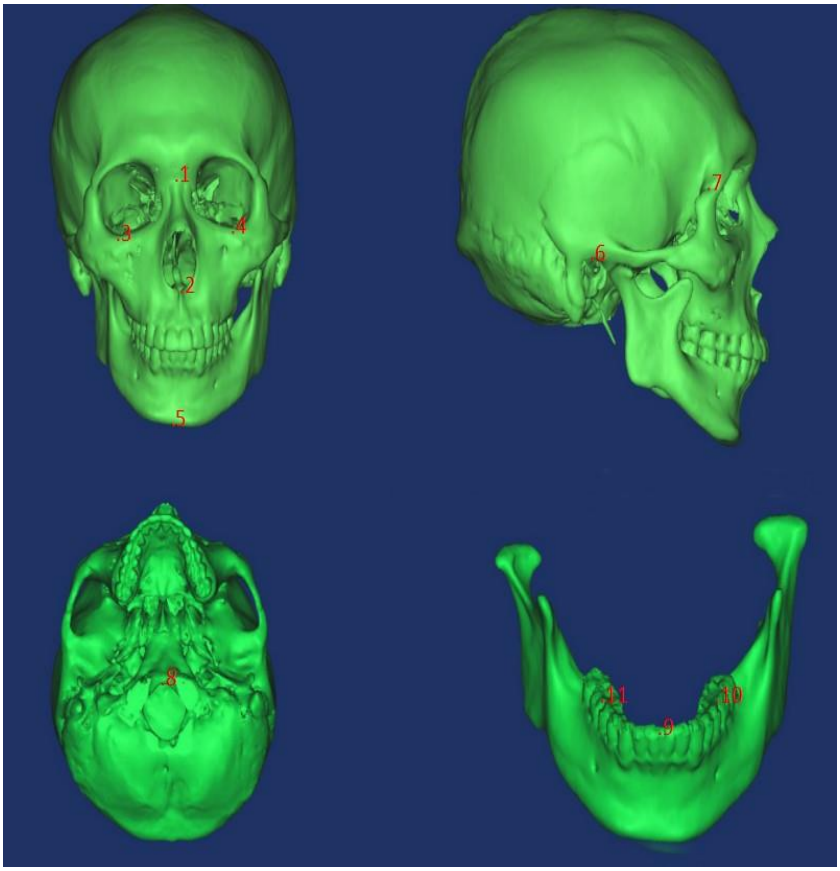

Figure 1: Craniofacial anatomical landmarks

1. Nasion 2. Anterior nasal spine 3. Orbitale(R) 4.Orbitale(L) 5.Menton 6.Ear point 7. Frontalzygomatic point 8.Basion 9.Lower incisor 10.First molar point (L) 11.First molar point (R)

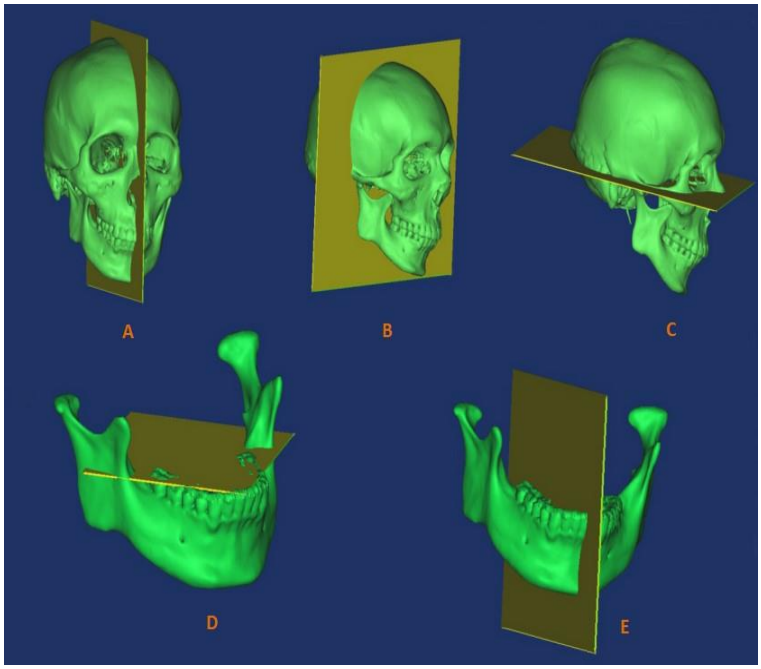

Figure 2: Reference planes and Mandibular plane

A.The median sagittal plane B..The coronal plane C.The horizontal plane

D.The mandibular occlusal plane E. The median sagittal plane of the mandibular occlusal plane

Abbreviations	Definition
N	The intersection of the nasal forehead and the nasal suture
FMO	The fossa malar os-frontale
O	The lowest point of the lower edge
P	The top point of the external auditory canal
ANS	Tip of the nose
Me	The lowest point of the crotch
L6	The first molar near the middle cheek apex
L1	Lower middle incisor
Ba	Midpoint of the occipital foramen

Table 1: Measurement Points Measurement Items

Angle	Definition
The pitch angle	Projection of the occlusal plane and the coronal plane on the sagittal plane
The roll angle	Projection of the occlusal plane and the horizontal plane on the coronal plane
The yaw angle	Projection of the median sagittal plane of the occlusal plane and the median plane of the craniofacial plane in the horizontal plane

Table 2: The occlusal Plane Angle measurement items

Results

There was a statistical difference between the normal group and the experimental group ($p<0.01$).

1. The change in the horizontal direction of mandibular occlusal plane in the experimental group

In the horizontal direction, the anatomical occlusal plane is mainly represented by the counterclockwise rotation,and the angle with the horizontal plane is the roll angle.Pearson correlation analysis between the degree of chin deflection and the roll Angle of occlusal plane showed that the degree of chin deflection was positively correlated with roll Angle, and the correlation coefficient was 0.702.The significant difference test showed high potential relativity, $p<0.05$.(Table 4,Figure 3)

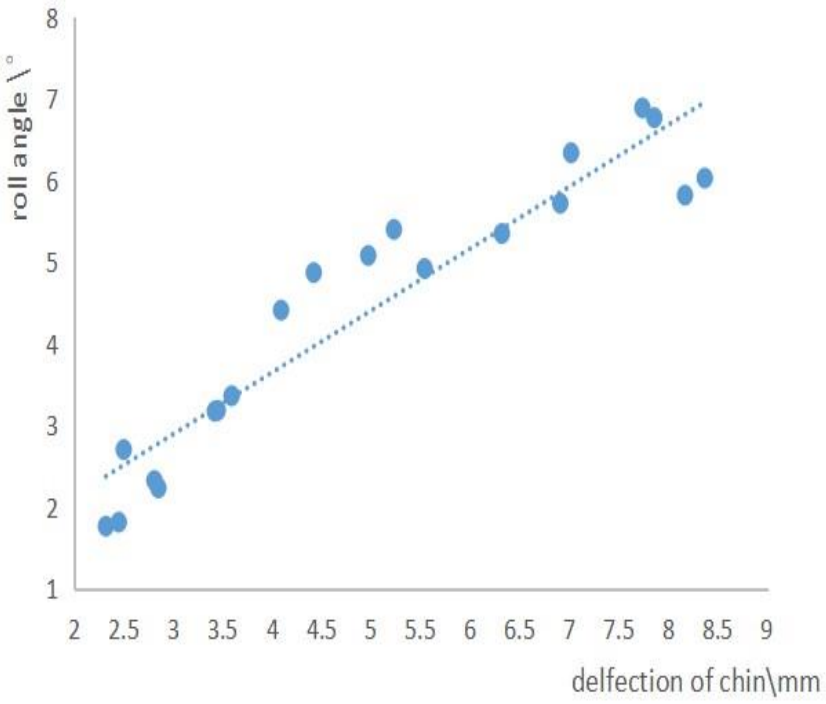

Figure 3: The changes of roll Angle of occlusal plane in the experimental group

Group/(N=20)	Chin deviation(mm)	Pitch angle(°)	Yaw angle（°）	Roll angle（°）
The control group	0.771±0.424	13.575±8.129	2.421±1.525	1.026±0.634
The experiment group	5.228±2.086	24.037±9.322	9.425±4.986	4.485±2.186
P	<0.001*	<0.017*	<0.001*	<0.001*

Table 3: Analysis results of data related to the control group and the experiment group

*Statistically significant at P <0.05.

2. The change in the coronal direction of mandibular occlusal plane in the experimental group

In the coronal direction, the anatomical occlusal plane is mainly represented by the change of pitch state,and the angle with the coronal plane is the pitch angle.Pearson correlation analysis between the degree of chin deflection and the pitch Angle of the occlusal plane showed that the degree of chin deflection was negatively correlated with pitch Angle, and the correlation coefficient was -0.115. The significant difference test showed high potential relativity($p<0.05$), and showing a counterclockwise change.(Table 4,Figure 4)

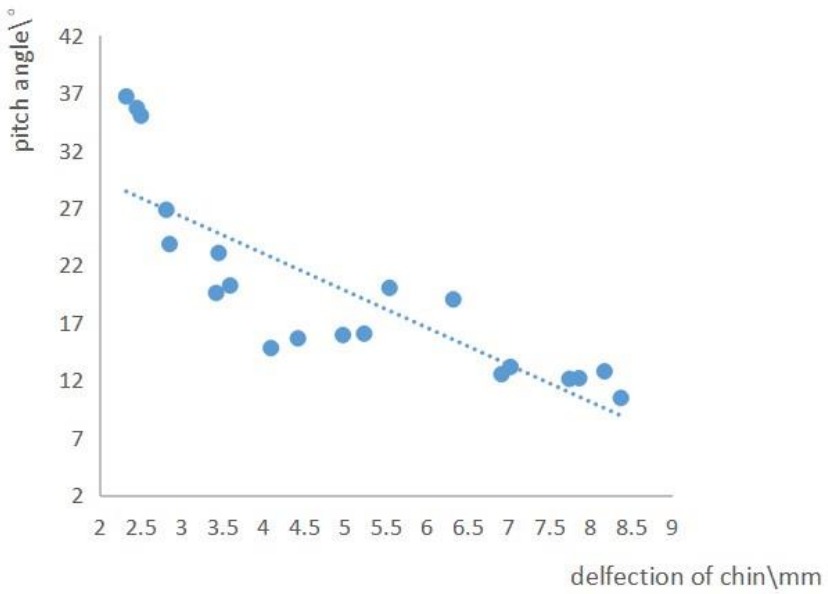

Figure 4: The changes of pitch Angle of occlusal plane in the experimental group

3. The change in the sagittal direction of mandibular occlusal plane in the experimental group

In the sagittal direction, the anatomical occlusal plane is mainly represented by left, right swing,and the angle with the sagittal plane is the yaw angle.Pearson correlation analysis between the degree of chin deflection and the yaw Angle of the occlusal plane showed that the degree of chin deflection was positively correlated with the yaw Angle, the correlation coefficient was 0.393, and The significant difference test showed high potential relativity($p<0.05$).that is, the greater the degree of chin deflection, the more inclined the occlusal plane was to the deflection side.(Table 4,Figure 5)

Degree of deviation in the chin	Pitch angle	Yaw angle	Roll angle
r	-0.115	0.702	0.393
P	0.683	0.004*	0.042*

Table 4: Correlation analysis between the degree of deviation of the chin and the change of the occlusal plane in the experiment group

*:Statistically significant at P <0.05.

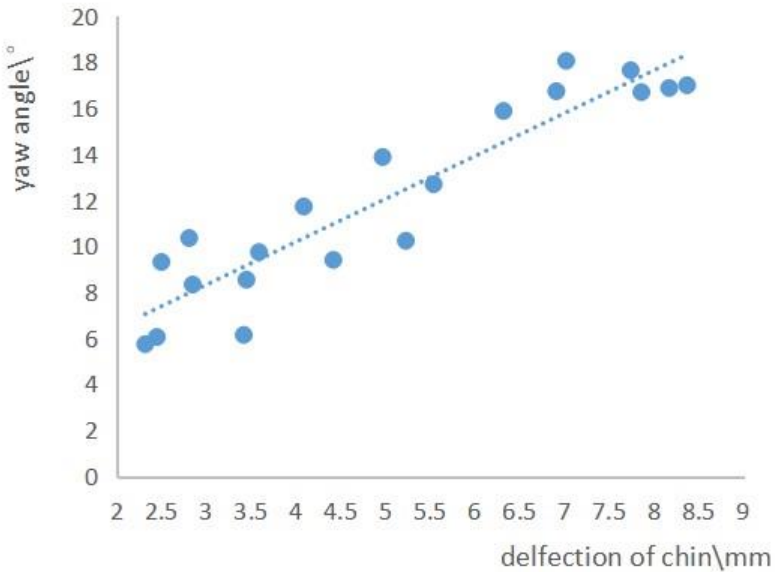

Figure 5: The changes of yaw Angle of occlusal plane in the experimental group

Discussion

The facial asymmetry has higher incidence especially in the Angle class III malocclusion and affect facial aesthetics in the lower 1/3 of the face [12].There are many influencing factors for facial asymmetry, such as trauma, tumor, temporomandibular joint disease, unilateral chewing, malocclusion, etc[13]. Patients with facial asymmetry always have incongruous mandible and the occlusal plane. Previous studies on the occlusal plane of facial asymmetry mainly focus on the maxilla,some scholars have analyzed the features of the occlusal plane of the patients with facial asymmetry and found that there was no significant difference in the angle of the occlusal plane[6.14].Compared with the maxilla, the mandible is the only movable bone in the cranial face, and plays an important role in facial symmetry. Therefore, symmetry analysis of the mandible is indispensable and difficult in the design of orthognathic surgery[15].In the process of mandible change, the teeth are accompanied by different degrees of compensation,the occlusal plane will establish an occlusal fulcrum on the side of molar elongation, and the molar of the oblique side of the mandible will occur to the tongue tilt, its obliquity increases gradually with mandible obliquity [2-4]. The characteristic of the occlusal plane in three dimensional space, namely, pitch angle, roll angle and yaw angle, were significantly different between the two groups. The results of this study confirm that the swinging tendency of the occlusal plane is consistent with the inclination trend and

direction of the chin,that is,the occlusal plane swings towards the deviation side, and the swing amplitude increases gradually with the extent of chin deflection.The rotation angle of the plane in the horizontal direction, except for some patients with the plane inclined to the deviation side, the majority of patients with the plane inclined to the non-deviation side.In the previous measurement and analysis of facial asymmetry, the chin was used as an effective parameter in the measurement [16-17].The degree of deflection of the chin will affect the three dimensional morphology of mandible and the characteristics of mandibular occlusal plane. In this study, the degree of deflection of the chin is negatively correlated with the the pitch angle,this may be one of the reasons for aggravating class Ⅲ malocclusion,and roll angle and yaw angle are positively correlated.Therefore, it is speculated that due to the asymmetry of the mandibular ramus,s height on both sides, the anatomical plane of the mandible has obvious rotational in the vertical and sagittal directions, and the horizontal swing mainly comes from the transverse displacement of the mandible.This suggests that the chin is a sensitive indicator for both the maxillofacial bone morphology and the characteristics of the occlusal system. For patients with facial asymmetry, if the change of the occlusal plane is small, clinical orthodontic treatment can achieve general results,the problem of the sagittal swing of the occlusal plane needs to be solved first, namely, straighten occlusal plane, can then use a nail resistance and other auxiliary methods to solve the relationship of upper and lower dentition in sagittal direction , namely Ⅲ occlusal class problem,finally, the vertical direction of the upper and lower dentition was fine adjusted. It is easy to simplify the treatment of facialasymmetry.But if the change of the occlusal plane is too large, the deformity can only be solved by orthognathic surgery [18]. In this experiment, the the pitch angle is negatively correlated with the deflection of the chin, the occlusal plane changes counterclockwise when the extent of chin deviation increases, while the mandible moves clockwise and the mandible rotates downward during the operation,and it can improve the Angle class Ⅲ malocclusion. The rotation angle and the yaw angle are positively correlated with deflection of the chin, and the correlation was statistically significant ($p<0.05$). The inclination changes of the occlusal plane are mainly reflected in the sagittal direction and the horizontal direction, that is, the greater the degree of deviation of the chin, the more obvious the change of the horizontal direction and the sagittal direction. It suggests that in orthognathic surgery, in the process of correcting chin deviation, the change of the occlusal plane is more obvious in the horizontal direction. After the bilateral sagittal mandibulotomy, the anterior mandible swung to the non-deviated side and tilted to the deviated side to establish a stable occlusal relationship.

Conclusion

During the growth of patients with facial asymmetry, not only the bone development is affected, but also the occlusal relationship is disordered, resulting in the change of occlusal plane in different directions, and different degrees of tilt change, which further aggravates the difficulty of treatment for patients with facial asymmetry.

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