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Correlation between Cephalometric Reference Planes for Clinical Application to Articulators

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Purpose: This study aimed to find a correlation between the occlusal plane and two reference planes that are frequently used in semi-adjustable articulators.

Materials and Methods: Sixty-two males and fifty females with normal articulation were recruited and the lateral cephalograms of these patients were taken. The angles between the Frankfort horizontal (FH) and the occlusal planes, the angles between the gnathologic and the occlusal planes, and the angles between the FH and gnathologic planes were measured on the lateral cephalograms.

Result: The mean angles between the FH and the occlusal planes was 8.29°±3.62°, with 8.88°±3.09° and 7.63°±4.10° for male and female patients, respectively. The mean angles between the gnathologic and the occlusal planes was 2.77°±3.62°, and the angle between the FH and the gnathologic planes was 5.52°±3.62°. No significant differences were found in the measured angles between the male and female patients (P>0.05).

Conclusion: Different guidance angles may be applied to articulators for prosthodontic restoration, depending on the reference planes that the articulators use.

Key Words: Cephalometry; Dental occlusion; Frankfort horizontal plane; Gnathologic plane

Introduction

Several reference lines and planes for facial analysis have been widely used in dentistry, mainly in orthodontics and prosthodontics[1]. Especially in prosthodontics, diagnosis, and analysis of relationship among orofacial landmarks are necessary to determine references for positioning the cast occlusal

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plane and for recording functional jaw movement, that are essential for the fabrication of harmonious prosthesis[2].

Clinically, articulators represent patient's occlusion for prosthodontic restoration and for this purpose, records of reference planes are used to transfer information of static and functional jaw relationships to the articulator. Frankfort horizontal (FH) plane and gnathologic plane are mainly used to determine the occlusal plane, which is constructed by the heights of incisors and molars from these reference planes. Since the occlusal plane in the articulator is the determinant of the position of maxillary and mandibular casts, two casts mounted on articulators could represent the position of two jaws in a patient's skull and reproduce the actual jaw movement[3].

FH plane (used same as Frankfort plane) is a virtual horizontal plane in the skull, connecting the most inferior point of the bony orbit and superior border of both ear pillars. It is known that the FH plane is almost parallel to the horizontal plane when a person is in a natural upright posture. The FH plane is known to be stable so that it exhibits minimal change according to age increase and is recognized as a highly reproducible reference plane for prosthodontic usage. The FH plane is used for mounting a maxillary cast in an articulator using a facebow transfer to reproduce the relationship among two condyles and maxillary dentition of the patient[4].

The gnathologic plane requires the third reference point that is 43 mm above the maxillary right central incisal edge. This virtual point and both orifices of the external acoustic meatus form a gnathologic plane, which is the reference plane for mounting a cast in an articulator representing the FH plane[5].

The occlusal plane has two concepts-the prosthodontic occlusal plane for dentition in denture fabrication and the anatomic occlusal plane, which is a plane that connects mandibular incisors and the distobuccal cusps of both second molars. Camper's plane, one of the prosthodontic occlusal planes, is a plane that connects the nasal ala and the superior border of the external acoustic meatus. It is called the prosthodontic occlusal plane because it is almost parallel to the occlusal plane and is used to determine the occlusal plane of the wax rim in full denture fabrication. Gysi suggested the ala-tragus line, which connects the inferior border of the nasal ala and the inferior border of the external acoustic meatus, being more parallel to the anatomic occlusal plane[6,7].

Although studies on several reference lines and planes are in progress with the advancement of devices and radiographic analysis, clinicians rarely use radiographic diagnosis for prosthodontic restoration. Radiologic analysis can be used for prosthesis fabrication to improve the facial profile and determine the vertical dimension of occlusion and even the occlusal angle[8].

In this study, the relationship between these three reference planes (FH, gnathologic, occlusal planes) was measured using the lateral cephalogram of subjects with normal occlusions. We also discussed the method used for the application of the same occlusal plane in two articulators, using the FH or gnathologic plane for reference planes, which can lead to the fabrication of similar prostheses.

Materials and Methods

1. Patients

Sixty-two males and 50 females were studied, and their lateral cephalograms were used for our study. Subjects were dental students of the Seoul National University from 2003 to 2007, and among them, only those with normal occlusion were included after oral examination by residents in orthodontics. Three males who had been examined twice within this period were excluded. This study was approved by the Institutional Review Board of Seoul National University Dental Hospital (IRB No. CRI12030).

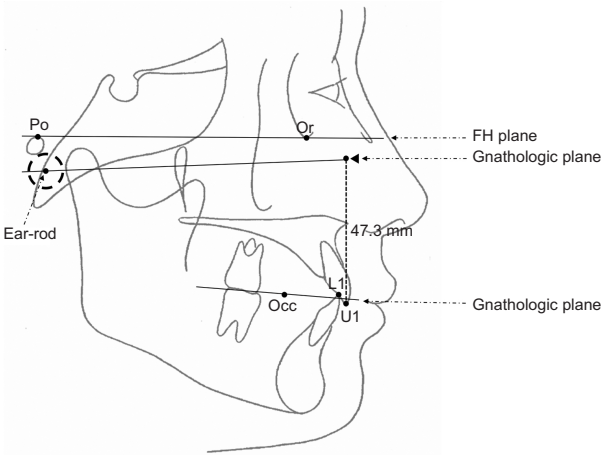

Fig. 1. Scheme of reference points for radiographic analysis. Lateral cephalograms were traced and reference points for this study were marked on cephalograms. The anterior reference point for the gnathologic plane was marked vertically, at more than 47.3 mm (black arrowhead) from maxillary central incisor (U1), and the posterior reference point, a center of ear-rod was used to form the gnathologic plane. Po: porion, Or: orbitale, U1: upper incisor, L1: lower incisor, Occ: occlusal point, FH: Frankfort horizontal.

2. Methods for Analysis

For radiographic analysis, the lateral cephalograms of a total of 109 subjects were traced (Fig. 1). The third point of the gnathologic plane (43 mm above the maxillary right central incisor) was presented at more than 47.3 mm from the maxillary central incisor on the lateral cephalogram from the vertically relocated cephalogram, considering the magnification ratio (110%). Moreover, the orifice of the external acoustic meatus and the ear-rod from the lateral cephalogram were marked at the mid-point of the two centers of ear-rods. These two points were connected to create a gnathologic plane. The occlusal plane was drawn by connecting the mid-point between the maxillary central incisor edge, the mandibular central incisor edge, and the occlusal point. After drawing the three reference planes (FH, gnathologic, and occlusal planes), the angles between these planes were measured. The analysis of the angle between these reference planes was per-

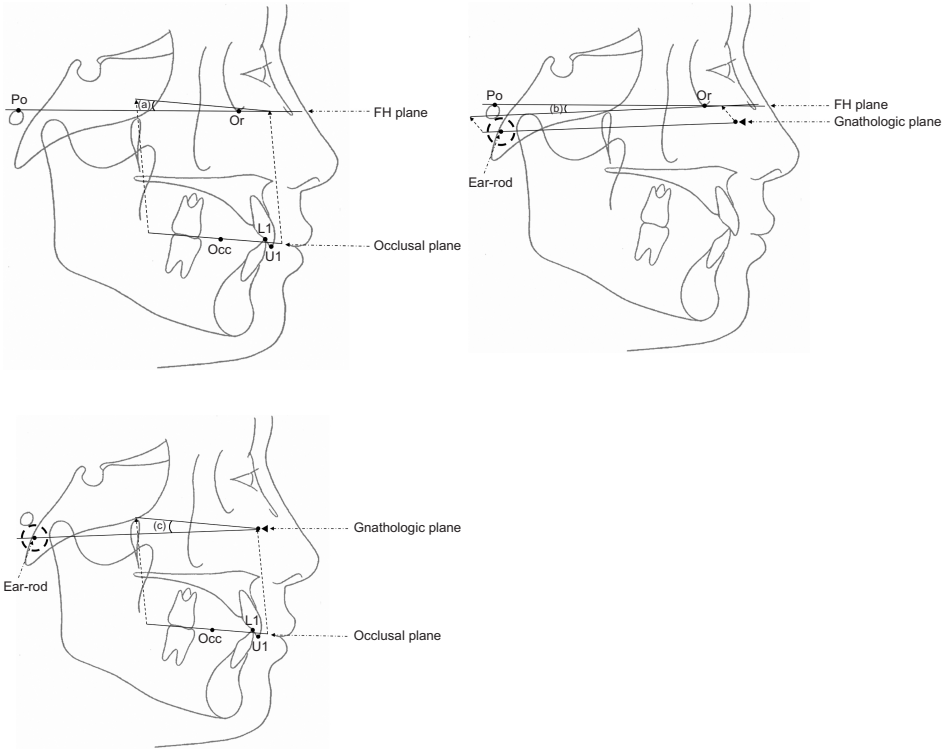

Fig. 2. V-ceph (CyberMed, Inc., Seoul, Korea) setting for analysis. This figure shows an example of the measurement of an angle between the FH and occlusal planes (a), between the FH and gnathologic planes (b), and between the gnathologic and occlusal planes (c). Po: porion, Or: orbitale, U1: upper incisor, L1: lower incisor, Occ: occlusal point, FH: Frankfort horizontal.

Table 1. Means and standard deviation of the measured angles between the planes

Patients	FH–occlusal planes (°)	Gnathologic–occlusal planes (°)	FH–gnathologic planes (°)
Male (n=59)	8.88±3.09	2.67±3.44	6.21±2.53
Female (n=50)	7.63±4.10	2.78±3.98	4.84±3.09
Total (n=109)	8.29±3.62	2.77±3.62	5.52±3.62

FH: Frankfort horizontal.

formed using the V-ceph 5.5 software (CyberMed, Inc., Seoul, Korea) (Fig. 2), and the statistical analysis between the results of males and females was conducted using the R software (R 3.6.1; R Foundation for Statistical Computing, Vienna, Austria). The independent-sample t-test was used with the threshold for statistical significance set at 0.05. The measured angles were as follows: 1) angles between the FH and occlusal planes; 2) angles between the gnathologic and occlusal planes; and 3) angles between the FH and gnathologic planes.

Result

Table 1 shows the measured angles between the planes. The mean and standard deviation of the angles measured between the FH and occlusal planes were 8.88°±3.09° for the male patients and 7.63°±4.10° for the female patients. The mean value for the total (n=109) was 8.29°±3.62°. For the angles measured between the gnathologic and occlusal planes, the mean values were 2.67°±3.44° for the male patients, 2.78°±3.98° for the female patients, and 2.77°±3.62° for all included patients. The angles between the FH and gnathologic planes were measured, and the calculated mean values were as follows: 6.21°±2.53° for the male patients; 4.84°±3.09° for the female patients; and 5.52°±3.62° for all patients. A significant difference was found between the FH–occlusal plane and the gnathologic–occlusal plane angles ($P<0.05$). There were no significant differences in the measured angles between sex ($P>0.05$).

Discussion

In this study, a total of 109 lateral cephalograms were used to analyze the angles between the FH, gnathologic, and occlusal planes. According to Downs[9], the angle between the FH and occlusal planes has an average value of 9.3°, whereas Goldsman[10] suggested 8.6° as the average, with the proposed probability index as an average range of 8° to 12°[11]. In this study, the mean angle was 8.29°, which was similar to previous studies. The mean value was 8.29° in male and 7.63° in female. Since they had no significant difference according to the independent-sample t-test with 95% reliability, both were assumed to be in a normal range.

Camper's line (plane) is another widely used reference line for denture occlusion, alternatively called as the prosthetic occlusal plane. It is known to have a difference of 2.1° to 6.1° with natural dentition and its occlusal plane[12], although this value is regarded as insignificant. It is also known that Camper's line is inclined at 12° to the FH plane[2]. Collectively, the angle between the FH and prosthetic occlusal planes should be approximately 6° to 10°. Hence, the average angle between these two planes in our study (8.29°) seems to be in the applicable range for prosthesis fabrication.

The gnathologic plane, proposed by Guichet, had an inclination of average 5.52° to the FH plane. The posterior reference point of the gnathologic plane can vary among the porion, the hinge axis[13], or the ear-rod which was used in the present study. This uncertainty could affect the measurement. The reference points in the gnathologic plane are clinically described on the soft tissue, not on the bone. Thus,

the bony reference posterior points corresponding to the clinical points are necessary to define in the gnathologic plane for the cephalometric analysis.

Monteith proposed that the occlusal plane angle (the angle between the FH plane and the occlusal plane) can be calculated using the Porion-Nasion-Anterior Nasal Spine angle, which was used to fabricate complete esthetic dentures for patients[14,15]. However, using the FH plane as a reference plane for maxillary cast mounting, the occlusal inclination may become too steep for the manipulation in the articulator[16,17]. In contrast, the results of this study showed that the gnathologic plane was almost parallel to the occlusal plane, which can be clinically advantageous for prosthodontic restoration.

Based on the results of this study and simple calculation, subtractions of the FH–gnathologic plane angles from the FH–occlusal plane angles produce the gnathologic–occlusal plane angles which can be applied to the conversion of the settings between different articulator systems using different reference planes. This implies that prosthodontic restorations can have similar morphologies harmonious with the chewing patterns of patients, using different articulators. Further studies are required to make conversion tables between the settings of different articulators using the equations of mandibular movement and their clinical validation. Further investigations are also needed for the patients with different Angle's malocclusions.

Conclusion

Since there was a significant difference between the FH–occlusal plane and the gnathologic–occlusal plane angles, the settings of both the condylar and incisal guidance angles may be changed for prosthodontic restoration depending on the reference planes of articulators. Within the limitations of this study, we conclude that it might be unnecessary to use different articulator settings according to the patient's sex.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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