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AJO-DO

Relationship of maxillary 3-dimensional posterior occlusal plane to mandibular spatial position and morphology

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Introduction: The purpose of this study was to examine the relationship of the 3-dimensional (3D) posterior occlusal plane (POP) and the mandibular 3D spatial position. The relationship of the POP to mandibular morphology was also investigated. **Methods:** Retrospective data from a convenience sample of pretreatment diagnostic cone-beam computed tomography scans were rendered using InVivo software (Anatomage, San Jose, Calif). The sample consisted of 111 subjects (51 male, 60 female) and included growing and nongrowing subjects of different races and ethnicities. The 3D maxillary POP was defined by selecting the cusp tips of the second premolars and the second molars on the rendered images of the subjects. The angles made by this plane, in reference to the Frankfort horizontal plane, were measured against variables that described the mandibular position in the coronal, sagittal, and axial views. The POP was also compared with bilateral variables that described mandibular morphology. **Results:** There were significant differences of the POP among the different skeletal malocclusions ($P < 0.0001$). The POP showed significant correlations with mandibular position in the sagittal ($P < 0.0001$), coronal ($P < 0.05$), and axial ($P < 0.05$) planes. The POP also showed a significant correlation with mandibular morphology ($P < 0.0001$). **Conclusions:** These findings suggest that there is a distinct and significant relationship between the 3D POP and the mandibular spatial position and its morphology. (Am J Orthod Dentofacial Orthop 2016;150:140-52)

Early in the history of our specialty, both clinicians and researchers were aware of the relevance of the occlusal plane in the diagnosis and treatment of malocclusions. References to the occlusal plane can be found throughout the orthodontic literature. In 1947, Björk[1] mentioned in his textbook that the steepness of the occlusal plane diminishes with prognathism. Bushra[2] stated that the flatter the occlusal plane, "the more forward the face." Downs,[3] in 1948, noted that Class II malocclusions tend to have steeper occlusal planes, and Class III malocclusions have flatter occlusal planes. Riedel[4] observed an apparent perpendicular relationship between the occlusal plane and the A-B plane in normal occlusions. Schudy,[5] in 1963, mentioned the relationship of the occlusal plane to function and its significance in treatment. Several authors stated that Tweed obtained more favorable profiles because of his control of the occlusal plane by minimizing the untoward effects of Class II mechanics with his anchorage preparation.[6-8]

The relationship of the occlusal plane to mandibular position continued to be observed as numerous studies, starting in the 1970s, began to show that during normal dentofacial development, both the occlusal plane and the mandibular plane flattened as the mandible rotated forward with growth.[9-11] Sato et al[12] demonstrated that the occlusal plane flattened excessively in growing patients with skeletal Class III malocclusions.

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Traditionally, the occlusal plane was defined as a line from the incisors to the first molars. In a 1996 study, the authors proposed an alternative way to describe the curvature of the occlusal plane.[13] They divided it into anterior and posterior components, with the anterior occlusal plane defined as a line drawn from the incisal edge of the maxillary central incisor to the cusp tip of the mandibular second premolar, and the posterior occlusal plane (POP) as a line from the cusp tip of the mandibular second premolar to the midpoint of the mandibular second molar at the occlusal surface.

These investigations have shown that the 2-dimensional (2D) POP correlates with anteroposterior mandibular position and predicts both Class II and Class III malocclusions.[12,13] More recently, Tanaka and Sato[14] conducted a longitudinal study using data from the Burlington Growth Center on white subjects and concluded that during normal Class I growth, the 2D POP flattens with age along with a concomitant decrease in the mandibular plane angle, as well as an increase in forward mandibular position. These findings are similar to previous studies with Japanese and African American samples.[9-11] The occlusal plane has also been implicated in the different mandibular morphologies of high-angle Class II malocclusions compared with normal Class I and low-angle Class II malocclusions.[15] A recent study with 3-dimensional (3D) cone-beam computed tomography (CBCT) data also found significant differences in the POP between Class II and Class III subjects.[16]

From the coronal perspective, the cant of the POP has shown a distinct and significant relationship with a deviation of the chin from the midline and the mandibular lateral deviation.[17-19] Researchers have found that the most common trait in facial asymmetries is a mandibular midline deviation.[20,21] Most studies on mandibular lateral deviation have been conducted using posteroanterior cephalograms, which are reliable in evaluating asymmetries but have inherent inaccuracies because of difficulties in identifying anatomic structures, projection errors, and lack of reproducibility.[22] There are also limitations to conventional 2D lateral cephalograms such as superimposition of bilateral structures and the inherent distortion of the radiograph.[23] To improve on these limitations, CBCT can be used to more accurately analyze and study the 3D relationships of the various craniofacial structures.[24,25] CBCT scans are on a 1:1 scale; therefore, there are no distortions associated with the data, and anatomic landmarks can more accurately be identified 3 dimensionally; this then provides the ability to select and measure bilateral structures with greater precision.[26]

The purpose of this study was to examine the relationship of the 3D POP to mandibular spatial positioning as well as its morphology using CBCT data.

Table I. Criteria for each class type

Class type	*APDI*	*FMA (°)*
Class I	78-82	
Class II, high angle	<78	>25
Class II, low angle	<78	<25
Class III, high angle	>83	>25
Class III, low angle	>83	<25

APDI, Anteroposterior dysplasia indicator; *FMA*, Frankfort-mandibular plane angle.

MATERIAL AND METHODS

Three-dimensional data were obtained from CBCT scans taken of patients at the principal investigator's private orthodontic practice (J.C.C.) as part of their pretreatment diagnostic records. The retrospective convenience sample consisted of 111 subjects (51 male, 60 female) and included growing and nongrowing subjects of different ethnicities. The selection criteria for the sample were patients (1) who signed the consent to use records section in the Informed Consent Form provided by the American Association of Orthodontists, (2) with fully erupted permanent dentition including maxillary second molars, (3) without syndromes or craniofacial anomalies, and (4) with no previous orthodontic treatment.

The sample was divided into Class I, Class II, and Class III based on the anteroposterior dysplasia indicator developed by Kim.[27] The anteroposterior dysplasia indicator was selected over the more commonly used ANB angle because it considers both dentoalveolar and skeletal relationships that cannot be described by 1 measurement. The anteroposterior dysplasia indicator has been shown to have more diagnostic significance when comparing anteroposterior discrepancies.[28] To take the vertical dimension into consideration, the Class II and Class III samples were further divided into high-angle and low-angle classifications based on the Frankfort horizontal plane to mandibular plane angle (Table I). Age and sex characteristics of the 5 groups were as follows: Class I (13 female, 10 male; mean age, 16.6 years; range, 11-41 years), high-angle Class II (14 female, 0 male; mean age, 17.2 years; range, 11-45 years), low-angle Class II (12 female, 14 male; mean age, 14.8 years; range, 11-39 years), high-angle Class III (11 female, 13 male; mean age, 20.5 years; range, 9-39 years), and low-angle Class III (10 female, 14 male; mean age, 20.7 years; range, 11-53 years).

The DICOM data were obtained using a Kodak 9500 Cone Beam 3D System (90 kW, full field of view: 200 × 184 mm, 0.3-mm voxel resolution, and 2-15 mA; Kodak, Rochester, NY) and was imported

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