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Original article

Considerations for placement of mandibular buccal shelf orthodontic anchoring screw in Class III hyperdivergent and normodivergent subjects– A cone beam computed tomography study

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Purpose: The study simulated a mandibular buccal shelf (MBS) orthodontic anchoring screw insertion path and determine the effect of vertical skeletal pattern, insertion site, vertical level and insertion angle on the slope, cortical bone thickness and distance from molar root to the insertion path.

Materials and methods: Forty CBCT images of Class III subjects were divided equally into hyperdivergent and normodivergent groups. The slope of the MBS was measured at four different sites of insertion. Cortical bone thickness along the orthodontic anchoring screw insertion path and distance from molar root to the path were measured at different combinations of sites of insertion, vertical levels and insertion angles. Measured outcomes were compared between hypodivergent and normodivergent groups at different combinations of variables using factorial repeated ANOVA.

Results: The cortical bone thickness and the slope of the MBS were not different between hyperdivergent and normodivergent groups. However, posterior sites had a flatter slope than that of the anterior. Higher vertical level and insertion angle resulted in thicker cortical bone and higher distance from molar root. The mesial aspect of second molar site gave a higher distance from molar root than first/second molar contact point site.

Conclusion: The mesial aspect of the second molar appears to be a safe site for placement of MBS orthodontic anchoring screw as its slope was flatter and gave greater distance from molar root. Increasing vertical level or insertion angle resulted in a higher cortical bone thickness and distance from the molar root.

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1. Introduction

A type of Class III malocclusion with mild to moderate skeletal discrepancy can be corrected by orthodontic treatment alone to obtain a good and stable result [1]. Extraction of lower premolars can be done in order to retract lower anterior teeth and achieve a Class I canine relationship. However, there are circumstances where extraction cannot be done, such as already missing premolars and too little Class III discrepancy. The whole mandibular arch distalization is another option to correct a Class III relationship. However, it is considered one of the most difficult tooth movements in orthodontics [2].

The development of temporary anchorage devices (TADs), so-called orthodontic anchoring screws (OASs), has increased the effectiveness of lower arch distalization as demonstrated by a number of case reports [3–5]. These screws can be placed at different sites, such as the retromolar area and ramus of the mandible [3,5]. The mandibular buccal shelf (MBS) is another proposed area for OASs placement [6–9]. It is the buccal alveolar bone of the mandible from the first molar region to the external oblique ridge and is covered with the thickest cortical bone in the mandible [10–14]. OASs can be placed extraradicularly in this area and does not interfere with distalization [9]. Chang et al. [7] found that the slope of the MBS became flatter from anterior to posterior. As it became flatter, insertion of OASs is easier. However, the degree of this slope varies among different individuals [9]. Class III patients with a hyperdivergent vertical skeletal pattern often have a dental open bite tendency [6]. Biomechanical force from distalization may be beneficial to these patients as the distalizing force from the MBS orthodontic anchoring screws passes above the center of resistance of the mandibular dentition. This tends to rotate mandibular occlusal plane counterclockwisely and thus closes the bites [9].

Further study on the consideration of the MBS orthodontic anchoring screws placement in Class III hyperdivergent patients is needed since previous studies were not exclusively conducted in Class III hyperdivergent subjects [7,15]. Moreover, a number of studies [12,14] mentioned a difference in thickness of cortical bone in hyperdivergent patients. Horner et al. [12] reported a thinner cortical bone in second mandibular molars to first mandibular premolars regions of hyperdivergent patients compared to those of hypodivergent patients. Similar results were presented by Ozdemir et al. [14] in which mandibular buccal cortical bone at all interradicular sites from canine to second molar was thinner in hyperdivergent than in normo- and hypodivergent patients. Moreover, contact of OASs with root is considered one of the most frequent causes of failure [16]. Thus, finding a method for inserting OASs without contacting the root is also crucial for longevity of the OASs.

The purposes of this study were, firstly, to compare the slope of MBS between Class III hyperdivergent and Class III normodivergent patients at different sites. Secondly, to compare the cortical bone thickness of MBS between and within these two groups at different sites, different vertical levels and different insertion angles. Finally, to find the most appropriate site, vertical level, and insertion angle for placement of a MBS orthodontic anchoring screw without contacting the roots.

2. Materials and methods

Cone beam computed tomography (CBCT) images were obtained from the Department of Radiology, Faculty of Dentistry, Chulalongkorn University, Bangkok, Thailand. In order to minimize radiation exposure to subjects, a protocol of ALARA (As Low As Reasonably Achievable) was used in the Department of Radiology; the CBCT images did not cover the Nasion and Sella point. Thus, Wits appraisal and palatal plane to mandibular plane angle (PP-MP) were used to identify sagittal and vertical skeletal relationships. The inclusion criteria of the patients were: (i) age higher than 16 years, (ii) Wits appraisal showing Class III malocclusion (value less than −4.1 mm) [17], (iii) presence of lower first and second molars, (iv) no alveolar bone loss, and (v) no posterior crossbite or scissor bite. There were two "groups" of patients categorized by their vertical skeletal relationship. Subjects with PP-MP of 17.2–25.4° and 18.4–27.4° for male and female, respectively, were classified into the normodivergent group. While subjects with higher PP-MP than this were categorized as hyperdivergent [17]. There were 20 subjects in each group.

Each CBCT image was reconstructed and oriented with Infinitt® PACs software (Infinitt Healthcare Co., Ltd., Seoul, Korea). In the coronal view, the image was adjusted to make the axial plane parallel to the coronal occlusal plane which passed through mesiobuccal cusps of two contralateral mandibular first molars (Fig. 1). In the axial view, the image was rotated until the sagittal plane passed through the central groove of the mandibular first and second molars (Fig. 2). Finally, in the sagittal view, the image was adjusted until the axial plane parallel to the sagittal occlusal plane that passed through the occlusal contact point of the first premolar and first molar (Fig. 3). Because the same cortical bone thickness between left and right side of an individual was reported [13,18], all of the measurements were made on the side which had the best alignment of first and second mandibular molars. After selecting the side with the best alignment, the measurement were done on the right side in 25 patients and on the left side in 15 patients. Both of the Class III hyperdivergent and normodivergent groups underwent three measurements as follows:

1. The slope of the mandibular buccal shelf (Fig. 4).

   This slope was the angle formed by a line tangent to the MBS and the axial plane, and was measured at four different "sites of insertion". These were (i) the distal aspect of the mandibular first molar (the coronal plane in the sagittal view was placed at the distal cusp of the mandibular first molar, Fig. 4a), (ii) the mandibular first/second molars contact point (the coronal plane in the sagittal view was placed at the contact point of the mandibular first and second molars, Fig. 4b), (iii) the mesial aspect of the mandibular second molar (the coronal plane in the sagittal view was placed at the mesial cusp of the mandibular second molar, Fig. 4c) and (iv) the middle aspect of the mandibular second molar (the coronal plane in the sagittal view was placed at the buccal groove of the mandibular second molar, Fig. 4d).

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