Three-dimensional evaluation of upper anterior alveolar bone dehiscence after incisor retraction and intrusion in adult patients with bimaxillary protrusion malocclusion*

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Abstract: Objective: The purpose of this study was to evaluate three-dimensional (3D) dehiscence of upper anterior alveolar bone during incisor retraction and intrusion in adult patients with maximum anchorage. Methods: Twenty adult patients with bimaxillary dentoalveolar protrusion had the four first premolars extracted. Miniscrews were placed to provide maximum anchorage for upper incisor retraction and intrusion. A computed tomography (CT) scan was performed after placement of the miniscrews and treatment. The 3D reconstructions of pre- and post-CT data were used to assess the dehiscence of upper anterior alveolar bone. Results: The amounts of upper incisor retraction at the edge and apex were (7.64±1.68) and (3.91±2.10) mm, respectively, and (1.34±0.74) mm of upper central incisor intrusion. Upper alveolar bone height losses at labial alveolar ridge crest (LAC) and palatal alveolar ridge crest (PAC) were 0.543 and 2.612 mm, respectively, and the percentages were (6.49±3.54)% and (27.42±9.77)%, respectively. The shape deformations of LAC-labial cortex bending point (LBP) and PAC-palatal cortex bending point (PBP) were (15.37±5.20)° and (6.43±3.27)°, respectively. Conclusions: Thus, for adult patients with bimaxillary protrusion, mechanobiological response of anterior alveolus should be taken into account during incisor retraction and intrusion. Pursuit of maximum anchorage might lead to upper anterior alveolar bone loss.

Key words: Alveolar bone loss, Adult patients, Computed tomography, Three-dimensional registration

1 Introduction

The tooth-alveolar bone complex is a complicated mechanical unit combining both mineralized and periodontal soft tissues in orthodontic tooth movement, of which the main function is to transfer the occlusal force from the tooth to the surrounding bone. However, little is known about alveolar bone adaptation during incisor retraction and intrusion, especially in adult patients with maximum anchorage. Despite the fact that the relationship between maximum anchorage and tooth displacement has been well-recognized (Lai et al., 2008; Yao et al., 2008; Liu et al., 2011), retrospective alveolar bone loss assessment remains to be established. Meikle (1980) and Fuhrmann (1996; 2002) discovered that retraction of the upper anterior tooth might induce dehiscence, even fenestration in the cortical plate. Edwards (1976) and Hwang and Moon (2001) reported the limitation...
of alveolar bone modeling and remodeling during retraction and intrusion of maxillary incisors. Kim Y. et al. (2009) evaluated alveolar bone loss around incisors in surgical skeletal Class III patients, and Nelson and Artun (1997) showed the relationship between age and alveolar bone loss. Wehrbein et al. (1995) and Evangelista et al. (2010) appraised the prevalence of alveolar bone dehiscence in untreated patients and subjects who have undergone tooth retraction. However, Decker and Chen (2009) demonstrated good upper alveolar bone adaptation after 32 years of follow-up by case report. Shimpo et al. (2003) thought that lingual alveolar bone height was maintained due to bone formation during moving first molar lingually in rats. Further research is necessary for alveolar bone dehiscence involving large incisor retraction and intrusion in adult patients with maximum anchorage.

In order to assess dentoalveolar morphology in both sagittal and vertical dimensions, orthodontists often use cephalometric tracings. However, this fails to reveal dehiscence in palatal cortical bone attributed to surrounding bone superimposition (Mah et al., 2010). For this reason, three-dimensional (3D) evaluation is necessary, which could provide 3D displacements for dentoalveolar changes (Vannier, 2003; Nakasima et al., 2005; Garib et al., 2010). Cone beam computed tomography (CBCT) cannot quantify the dentoalveolar changes by pre- and post-treatment 3D registration, due to lack of stable references with 3D craniofacial model (Cevidan et al., 2010). CT scanning might be an acceptable imaging technique supplying a quantitative assessment of upper alveolar bone by CT registration in clinics (Nelson and Michael, 1998), and might permit an accurate topographical calculation of alveolar bone displacements (Liu et al., 2010). Therefore, this study was designed to evaluate maxillary alveolar bone morphology after incisor retraction and intrusion in adult bimaxillary malocclusion by retrospective 3D registration.

2 Materials and methods

2.1 Subjects and treatment procedures

This research was accepted by the Research Ethic Committee of Shandong University Dental School. Twenty bimaxillary dentoalveolar protrusion patients (mean age (22.28±3.16) years) were randomly selected. All patients received information about the procedure including the damage of CT radiation lesion and miniscrew methodologies and gave consent. Then the four first premolars were extracted and the patients were treated by using oriental preadjusted appliance KOSAKA slot brackets (OPA-K, Tomy, Fukushimaken, Japan), and miniscrews were placed as anchorage for the integral retraction and intrusion of the maxillary tooth. Force of 150 g per side of elastic chains was applied from the miniscrew to the upper crimpable hook to retract and intrude the upper anterior tooth (Fig. 1). The patients were visited at one month intervals.

2.2 CT data acquirement

The whole skull CT scan was performed at one week after implanting the miniscrews (T1), and post-treatment (T2), respectively, which was undertaken in the same way by 16-row helical CT. The CT scan was performed perpendicular to the apical-coronal direction on each slice, using the lateral scanogram of the head position to set the gantry angle. The CT data were saved as digital imaging and communications in medicine (DICOM) format.

2.3 3D virtual model reconstruction

All 3D models were constructed from CT images with a voxel dimension of 0.350 mm×0.625 mm×0.625 mm. The bone and tooth structures were separated by the threshold based on Hounsfield unit (HU) in Materialism’s interactive medical image control system (MIMICS). In order to include the alveolar regions and exclude tooth structure, a lower limit of 392 HU and a higher limit of 1900 HU were defined. The tooth excluding bone structure was separated with a lower limit of 1500 HU and a higher limit of