New clues for early management of maxillary impacted central incisors based on 3-dimensional reconstructed models

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Introduction: The objective of this study was to provide new clues for the prevention and early management of root dilacerations in impacted maxillary central incisors. **Methods:** Cone-beam computed tomography images of 108 patients with unilateral impacted maxillary central incisors were obtained and reconstructed into 3-dimensional models. Crown direction, crown height, root length, bone thickness, and position and angle of root dilaceration were measured in the sagittal-view sections. K-value, defined as the ratio between the available length of the direct root and the ideal length of the direct root, was proposed, and the relationships between K-values with root dilacerations were studied. Root development of the contralateral erupted maxillary incisor was also assessed. Independent *t* test, chi-square test, and 1-way analysis of variance were used for data analysis. **Results:** Root dilacerations occurred when the K-values were 0.16 to 0.19 (palatal impaction), 0.25 to 0.53 (labial impaction), and 0.69 to 0.75 (nasal impaction). The position and angle of root dilacerations were different among nasal, labial, and palatal impactions ($P < 0.01$). K-values and positions of root dilacerations among nasally, labially, and palatally impacted incisors were in descending order, respectively. Retarded root formation was noted in the impacted incisors compared with the contralateral incisors ($P < 0.001$). **Conclusions:** Nasal, labial, and palatal impacted incisors had different patterns of root dilacerations. Analyses of crown direction and K-value may aid in evaluating root dilacerations at early dental ages and facilitating early intervention of impacted incisors. (Am J Orthod Dentofacial Orthop 2018;154:390-6)

Impacted maxillary central incisors pose a challenge for dental treatment due to their influence on facial esthetics and phonetics.[1] Among the various treatment alternatives, which include incision sprouts, orthodontic extrusion, denture replacement, autologous transplantation, extraction, and biologic induction, appropriate orthodontic traction is the optimal choice for the maintenance of bone volume to achieve functional and esthetic outcomes.[2-7]

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Orthodontic treatment entails guiding the impacted tooth into proper alignment in addition to establishing the normal contour of the tooth. The key to a successful treatment outcome depends on the method and timing of traction.[2] Therefore, it is important to understand the eruption mechanisms and that root dilacerations of impacted maxillary incisors occur in different locations and at different development stages so that appropriate treatment regimens can be designed.

Conventional theories associate tooth eruption with root extension, periodontal ligament, and dental follicle, whereas recent studies have challenged these theories in several ways.[8] It has been advocated that the tooth is pushed upward toward the oral cavity because of growth of the lamina dura rather than growth of its own root, confirming the independence between tooth eruption and root elongation.[9] Artificial teeth with intact dental follicles and metal or silicone "tooth germs" were found to erupt on schedule.[10] Tooth eruption is also influenced by cortical plate, mucosa, retained deciduous incisors, odontomas, and supernumerary teeth.[11] The periodontal ligament was confirmed to provide an eruptive impetus by the shrinking and cross-linking of collagen

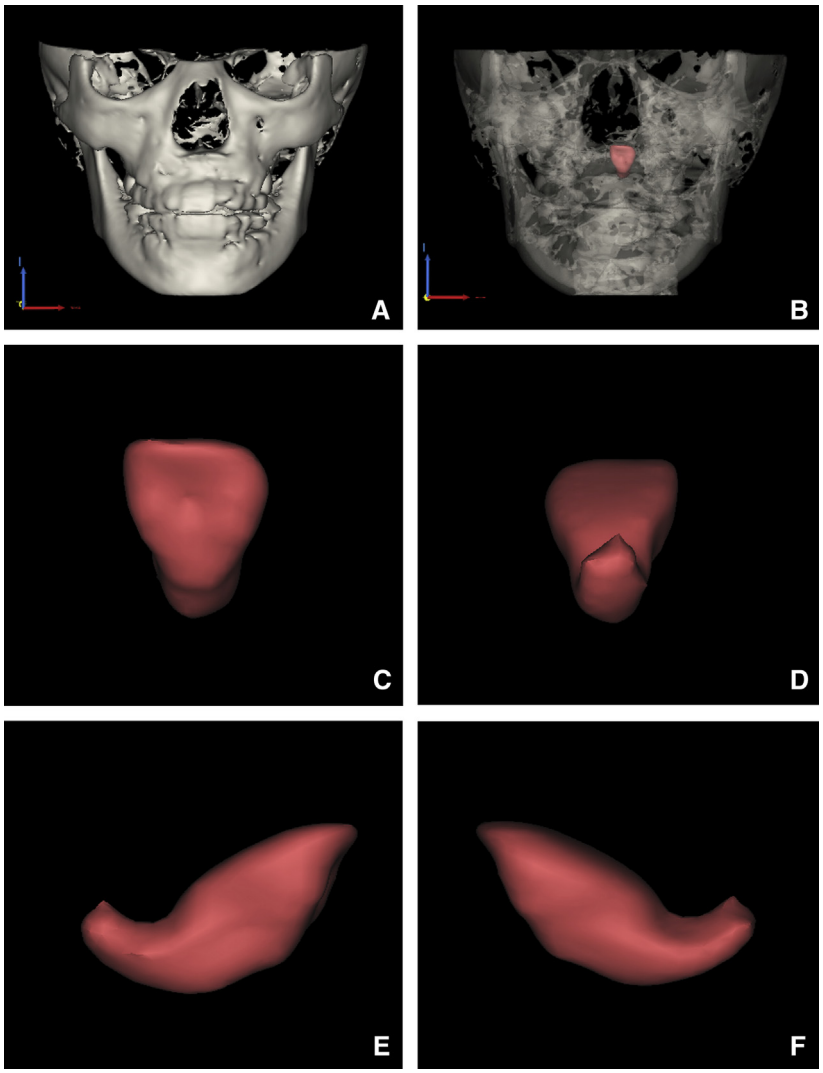

Fig 1. A and **B,** 3D models of the skull and the impacted incisor, color-coded to identify and inspect the relationship between the impacted incisor and the maxilla; **C-F,** anterior view, posterior view, and right and left lateral views of the 3D models of the impacted incisor, respectively.

fibers and the contraction of periodontal ligament fibroblasts.[12]

Previous studies related to root dilacerations of impacted teeth were based on either 2-dimensional images or certain views of cone-beam computed tomography (CBCT) images, which cannot accurately show the 3-dimensional (3D) root morphology due to labiolingual or mesiodistal inclination and rotation of impacted teeth. To evaluate tooth impactions and root dilacerations accurately, it is necessary to interpret CBCT images along the long axis of the impacted incisor on the sagittal plane in a 3D model.

Although there are many case reports of impacted dilacerated incisors, a quantitative study on impacted incisors and root dilacerations is lacking. We conducted a retrospective analysis of a large sample of CBCT images and proposed some parameters to evaluate root dilacerations of impacted central incisors in reconstructed 3D models, and also compared different groups based on the direction of the crown. We aimed to provide new clues for early management of impacted maxillary central incisors based on the direction of the crown and the extent of the dilacerations to prevent severe root dilacerations from affecting esthetics and oral