A digital approach to evaluating tooth root position following tooth movement without repeated CBCT scans

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INTRODUCTION

Cone-beam computed tomography (CBCT) scans are essential tools for diagnosis, and repeated assessments are typically required for treatment evaluation and monitoring. Nevertheless, patients and the parents of pediatric or adolescent patients are often concerned about repeated radiation exposure. This report describes the concept of a three-dimensional (3D) virtual tooth model composed of intraoral-scanned crowns and CBCT-scanned roots. A 3D virtual tooth model was initially generated by integrating an intraoral scan and CBCT scan before treatment, and root positions during treatment were subsequently monitored by obtaining an additional intraoral scan and registering it into the pretreatment virtual tooth model. Thus, root positions at any stage of treatment could be estimated without the need for an additional CBCT scan.

METHODS & MATERIAL

A 19-year-old girl visited the Department of Orthodontics with a chief complaint of upper anterior protrusion. The treatment objectives were: (1) establish functional occlusion with normal overjet and overbite and (2) improve facial appearance by resolving anterior protrusion. Orthodontic treatment with premolar extraction, right maxillary second premolar, left maxillary first premolar, and bilateral mandibular first premolars were planned. After 2 years and 4 months, treatment, including anterior retraction, was completed. No significant root resorption was observed on the post-treatment panoramic radiograph; however, the roots of the left maxillary canine and second premolar appeared to be in contact. The 3D virtual tooth model generated from CBCT and intraoral scans obtained before treatment were used to confirm root contact.

METHODS & MATERIALS

1. Intraoral scans of the maxillary and mandibular arches were obtained after pretreatment using a TRIOS scanner.
2. The scan data were reprocessed as standard tessellation language (STL) files using Ortho Analyzer software.
3. The CBCT scan was imported into InVivo5 software for tooth segmentation.
4. The tooth was isolated from the alveolar bone, segmented individually, and saved as an STL file.
5. The segmented teeth and intraoral scan were imported into Rapidform 2006.
6. The segmented teeth and intraoral scan were registered using the registration function of the software to fabricate the 3D virtual tooth model.
7. The patient's maxillary arch was scanned post-treatment using an intraoral scanner.
8. The post-treatment intraoral scan was registered to the 3D virtual tooth models.

METHODS & MATERIALS

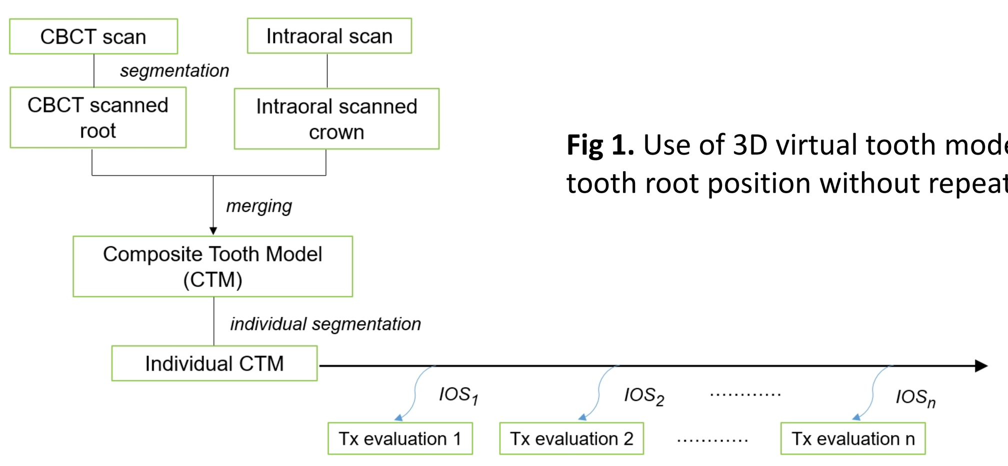

Fig 1. Use of 3D virtual tooth model for evaluating tooth root position without repeated CBCT scans

METHODS & MATERIALS

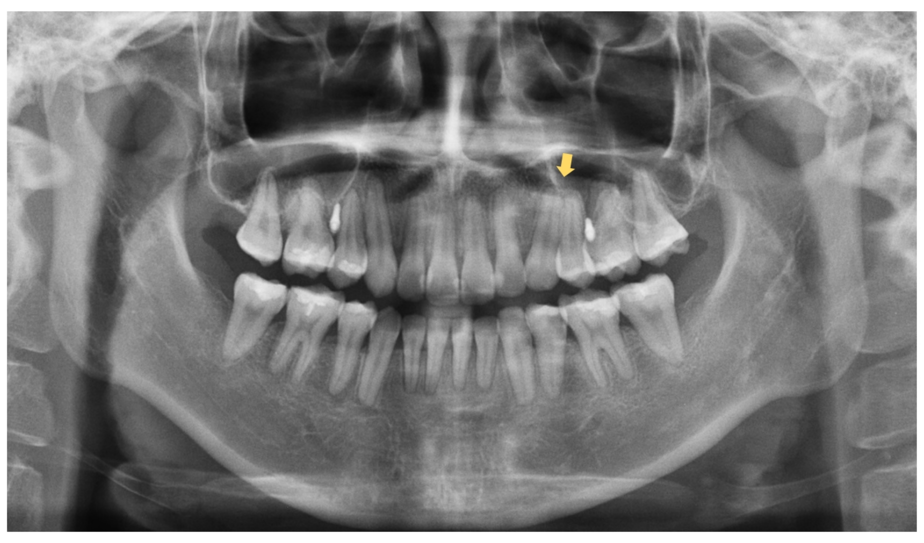

Fig 2. Panoramic radiographs after treatment.

METHODS & MATERIALS

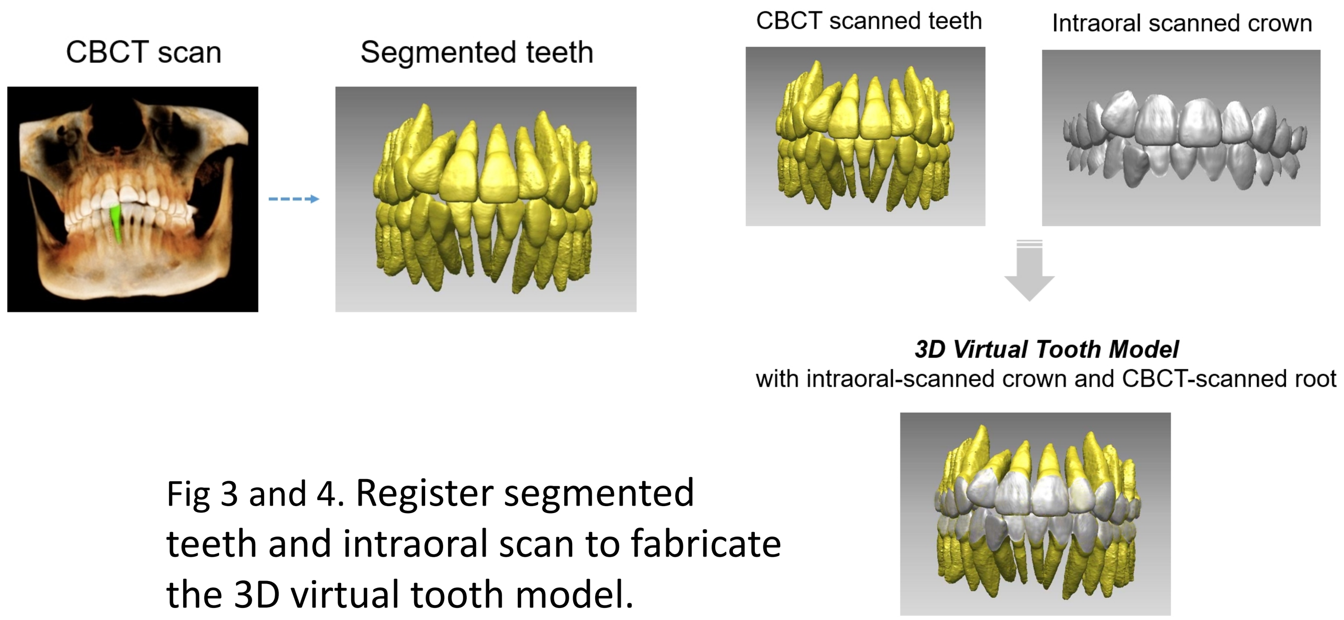

Fig 3 and 4. Register segmented teeth and intraoral scan to fabricate the 3D virtual tooth model.

METHODS & MATERIALS

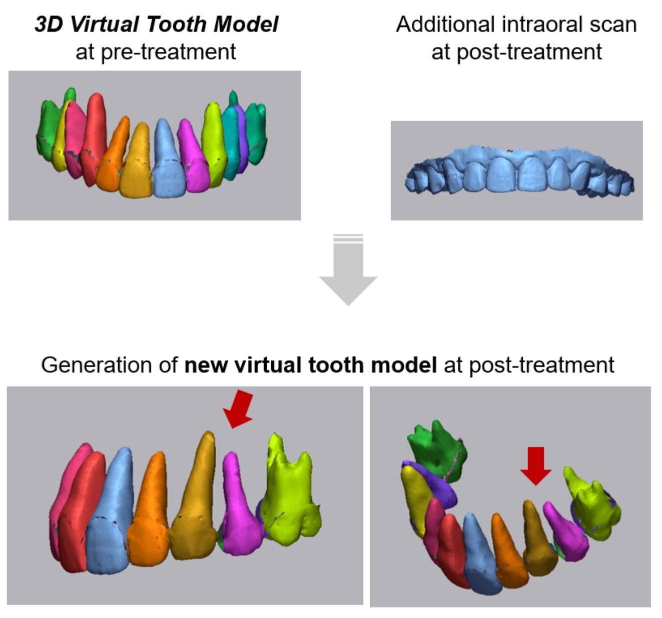

Fig 5. After registration of post-treatment intraoral scan onto 3D virtual tooth model, the resulting root positions were estimated.

RESULTS

Post-treatment intraoral scans were registered onto the pre-treatment 3D virtual tooth models, and the resulting root positions were estimated. While there appeared to be contact between the roots of the left maxillary canine and second premolar on the 2D panoramic radiograph, the use of the 3D virtual tooth models indicated that there was sufficient space. Adequate space was also observed between the right maxillary canine and second premolar roots. The resulting position of the root could be predicted without additional CBCT scans for the visualization and evaluation of the distance between roots after treatment. Previous studies have attempted to combine CBCT images and laser-scanned models to evaluate root positions. They reported that root positions could be predicted from a combination of pre-treatment CBCT images and post-treatment laser-scanned model images. Pre-treatment CBCT images do not provide detailed information on crown morphology and occlusion. When interdigitating between the maxillary and mandibular teeth is tight or crown restorations are present, artifacts may occur on CBCT images. Thus, it is difficult to integrate CBCT images and laser-scanned model images.

DISCUSSION

The limitations of this method are that the virtual tooth model must be generated with data obtained from CBCT and intraoral scans at the initial visit, and the process of fabricating the 3D virtual model requires additional time and effort. However, as a result of the development of various 3D reverse engineering programs in recent years, the working time required for 3D virtual model generation has been greatly reduced. This technique provides a way to look at the tooth position and may provide better predictability. The application of the virtual tooth model benefits the patient by reducing radiation exposure while providing the clinician with a precise treatment evaluation for monitoring root position.

CONCLUSION

A digital approach to the application of a 3D virtual tooth model using intraoral scans and CBCT scans is described. This technique benefits the patient by reducing radiation exposure while providing the clinician with a precise treatment evaluation for monitoring root position without the hazards of increased radiation exposure.

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