Influence of Intracanal Materials in Vertical Root Fracture Pathway Detection with Cone-beam Computed Tomography

Kamile Leonardi Dutra, DDS, MSc, PhD, * *Camila Pachêco-Pereira, DDS, MBA, MSc,* † *Eduardo Antunes Bortoluzzi, DDS, MSc, PhD,* ‡ *Carlos Flores-Mir, DDS, MSc, PhD,* § *Manuel O. Lagravère, DDS, MSc, PhD,* § *and Márcio Corrêa, DDS, MSc, PhD* ¶

Abstract

Introduction: Investigating the vertical root fracture (VRF) pathway under different clinical scenarios may help to diagnose this condition properly. We aimed to determine the capability and intrareliability of VRF pathway detection through cone-beam computed tomographic (CBCT) imaging as well as analyze the influence of different intracanal and crown materials. **Methods:** VRFs were mechanically induced in 30 teeth, and 4 clinical situations were reproduced *in vitro*: no filling, gutta-percha, post, and metal crown. A Prexion (San Mateo, CA) 3-dimensional tomographic device was used to generate 104 CBCT scans. The VRF pathway was determined by using landmarks in the Avizo software (Version 8.1; FEI Visualization Sciences Group, Burlington, MA) by 1 observer repeated 3 times. Analysis of variance and post hoc tests were applied to compare groups. **Results:** Intrareliability demonstrated an excellent agreement (intraclass correlation coefficient mean = 0.93). Descriptive analysis showed that the fracture line measurement was smaller in the post and metal crown groups than in the no-filling and gutta-percha groups. The 1-way analysis of variance test found statistically significant differences among the groups measurements. The Bonferroni correction showed statistically significant differences related to the no-filling and gutta-percha groups versus the post and metal crown groups. **Conclusions:** The VRF pathway can be accurately detected in a nonfilled tooth using limited field of view CBCT imaging. The presence of gutta-percha generated a low beam hardening artifact that did not hinder the VRF extent. The presence of an intracanal gold post made the fracture line appear smaller than it really was in the sagittal images; in the axial images, a VRF was only detected when the apical third was involved. The presence of a metal crown did not generate additional artifacts on the root surface compared to the intracanal gold post by itself. *(J Endod 2017;■:1–6)*

Key Words

Cone-beam computed tomography, diagnostic accuracy, endodontic treatment, vertical root fracture

Significance

Map reading the fracture line pathway may help to avoid misdiagnosing this condition in the presence of intracanal radiopaque materials and may increase the performance of treatment options extracting more information from CBCT imaging.

Vertical root fractures (VRFs) involve either a partial or complete rupture of the tooth root structure that extends along the vertical axis (1). They can have an internal origin and extend through the periodontal space either to the apical or coronal portions. VRFs can involve the whole length of the root or only a section of it, involving only 1 or both sides of the root (2). The reported prevalence of VRFs varies from 11%–20% (3), and their etiology is frequently linked to either previous endodontic treatment or teeth restored using overextended (more than half of the root length) intracanal posts; however, their occurrence in nonrestored teeth has been also described (4–7).

VRFs may provide a feasible path for bacterial penetration with a consequent inflammatory process followed by resorption of the alveolar bone mimicking other conditions such as periodontal disease or failed endodontic treatment (8, 9). For this reason, the early detection of VRFs is important to prevent extensive and additional damages to the periodontal tissues and also unnecessary treatment and costs (1). Unfortunately, clinical examination provides limited information for VRF detection and is based on unspecific signs and symptoms (8). Moreover, radiographic examination usually conducted with traditional periapical radiography (PR) is limited by its 2-dimensional nature, leading to an overlap of adjacent structures that commonly masks fractures and false-negative diagnoses (10). The radiologic evaluation of VRFs may be improved by the use of tridimensional imaging such as cone-beam computed tomographic (CBCT) imaging (11, 12). Limited field of view (FOV) CBCT imaging has already been established as the imaging modality of choice for the diagnosis and

From the *CAPES Foundation, Ministry of Education of Brazil, Brasília, DF, Brazil; †Department of Radiology, Faculty of Medicine and Dentistry, University of Alberta, Edmonton, Alberta, Canada; ‡Department of Endodontics, Federal University of Santa Catarina, Florianópolis, Brazil; §Department of Dentistry, Orthodontic Graduate Program, Faculty of Medicine and Dentistry, University of Alberta, Edmonton, Alberta, Canada; and ¶Department of Radiology, Federal University of Santa Catarina, Florianópolis, Brazil.

Address requests for reprints to Dr Kamile Leonardi Dutra, Federal University of Santa Catarina, Department of Dentistry, Campus Reitor João David Ferreira Lima, s/n, Trindade, Florianópolis, SC, Brazil, 88040-900. E-mail address: kamileldutra@gmail.com
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management of root fractures by the American Association of Endodontics joint position statement and the SEDENTEXCT guidelines (10, 13). The accuracy values of CBCT imaging for the detection of VRFs vary largely, ranging from 68%–99% (11).

Although previous studies have been performed to identify the capability of a CBCT scan in the detection of VRFs, they solely focused on the presence or absence of the fracture, which usually leads to the decision of either extracting the teeth or not (11). To increase the performance of treatment options, more information needs to be extracted from imaging examinations such as the complete extent of the fracture. However, there is a lack of research focused on identifying the complete fracture pathway using CBCT imaging.

Therefore, the aim of this study was 2-fold:

1. To verify whether VRFs could be observed using CBCT imaging considering the extent of the fracture line pathway
2. To analyze the influence of an intracanal cast gold post, gutta-percha, and metallic crown on VRF characteristics observed through CBCT imaging.

To the best of our knowledge, this is the first study investigating a VRF pathway following a standardized method based on 3-dimensional (3D) landmarks using CBCT manual segmentation software.

Material and Methods

Institutional ethical committee approval was obtained under number 180/09FR271239. A prospective sample of 30 single-rooted human teeth was selected from an available pool of extracted teeth from a previous study (14). Exclusion criteria included root anomalies, an obliterated root canal, preexisting cracks, root fractures or endodontic treatment, and the presence of caries or noncarious lesions on root surfaces. Digital PR was performed to validate the sample selection.

All teeth had their root canal prepared with an R50 file (Reciproc, VDW, Germany), were decoronated at the cementoenamel junction, and were randomly coded via a computer (15, 16). VRFs were induced in all teeth by applying a mechanical force into the root as per Monaghan et al (17). After VRF induction, the 2 root fragments were placed by best fit together in their original position and glued with cyanoacrylate (Super-Bonder; Henkel Ltda, São Paulo, Brazil) to simulate the immediate post-trauma situation (16, 18). During the preparation, 4 roots broke in more than 2 fragments, thus, they were excluded. Afterward, each root was coated with a wax layer and placed, 1 at a time, into an empty maxillary anterior socket of a dentate dry human skull also coated with 5-mm-thick wax (14).

The following 4 clinical conditions were performed individually and followed a standardized order:

1. *No filling*: simulating untreated teeth.
2. *Gutta-percha*: a noncemented passively well-fitting R50 gutta-percha cone (Reciproc) was placed into the canals.
3. *Post*: a noncemented type III gold alloy post was casted into the root chamber.
4. *Metal crown*: a metal ceramic crown was adapted to the teeth. Digital PR validated all adaptations.

CBCT images were obtained with a Prexion (San Mateo, CA) 3D tomography device set at 90 kVp and 4 mA with an exposure time of 19 seconds. A limited FOV of 5.6 cm was applied, and a voxel size of 0.1 mm was generated (10). The images were converted into a Digital Imaging and Communications in Medicine format and rendered into a volumetric image using Avizo Software (Version 8.1; FEI Visualization Sciences Group, Burlington, MA).

A total of 104 CBCT images were analyzed 3 times with a 1-week interval by a blinded and previously calibrated dental radiologist with considerable experience in dentomaxillofacial tomographic imaging. The VRF pathway was determined by using landmarks in the software through the use of virtual spherical markers of a 0.5-mm diameter in the x-, y-, and z-axes (19). The landmarks were manually localized in the volume rendering. The entry, exit, and medium points were placed on the fracture line, and the gaps between them were filled with equidistant landmarks named α_n and β_n (Fig. 1*A–D*). An additional landmark was positioned at the anatomic apex. Each landmark automatically created a coordinate number, which was then manually

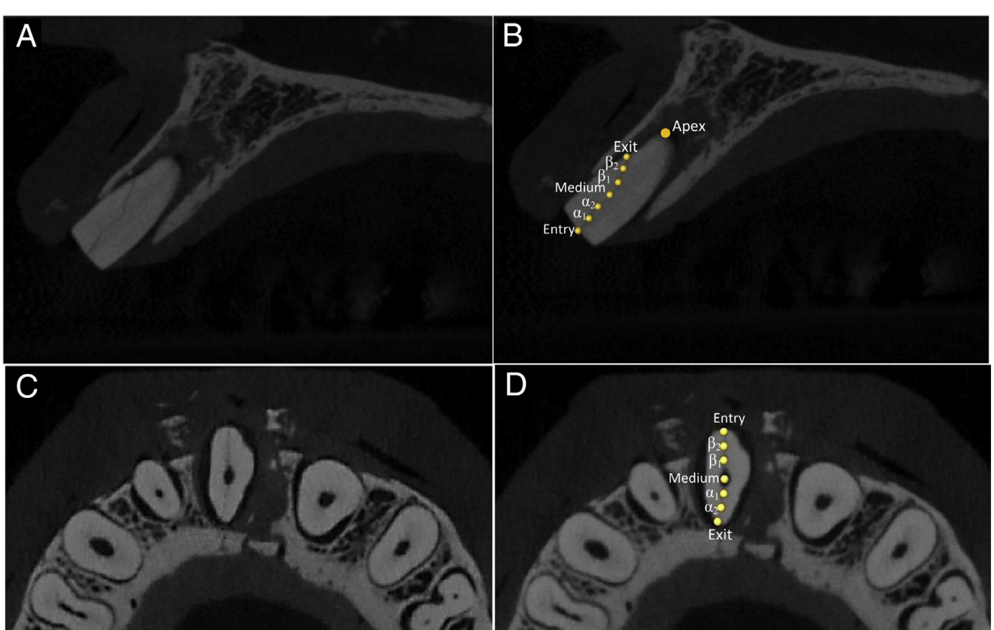

Figure 1. The entry, exit, and medium points placed on the fracture line and the gaps between them filled with equidistant landmarks named α_n and β_n. (*A* and *B*) The sagittal plane. (*C* and *D*) The axial plane.