Influence of Access Cavity Design on Root Canal Detection, Instrumentation Efficacy, and Fracture Resistance Assessed in Maxillary Molars

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Abstract

Introduction: The aim of this study was to assess the influence of contracted endodontic cavities (CECs) on root canal detection, instrumentation efficacy, and fracture resistance assessed in maxillary molars. Traditional endodontic cavities (TECs) were used as a reference for comparison. **Methods:** Thirty extracted intact maxillary first molars were scanned with micro–computed tomographic imaging at a resolution of 21 μm, assigned to the CEC or TEC group (n = 15/group), and accessed accordingly. Root canal detection was performed in 3 stages: (1) no magnification, (2) under an operating microscope (OM), and (3) under an OM and ultrasonic troughing. After root canal preparation with Reciproc instruments (VDW GmbH, Munich, Germany), the specimens were scanned again. The noninstrumented canal area, hard tissue debris accumulation, canal transportation, and centering ratio were analyzed. After root canal filling and cavity restoration, the sample was submitted to the fracture resistance test. Data were analyzed using the Fisher exact, Shapiro-Wilk, and t tests (α = 0.05). **Results:** It was possible to locate more root canals in the TEC group in stages 1 and 2 (P < .05), whereas no differences were observed after stage 3 (P > .05). The percentage of noninstrumented canal areas did not differ significantly between the CEC (25.8% ± 9.7%) and TEC (27.4% ± 8.5%) groups. No significant differences were observed in the percentage of accumulated hard tissue debris after preparation (CEC: 0.9% ± 0.6% and TEC: 1.3% ± 1.4%). Canal transportation was significantly higher for the CEC group in the palatal canal at 7 mm from the apical end (P < .05). Canal preparation was more centralized in the palatal canal of the TEC group at 5 and 7 mm from the apical end (P < .05) and in the distobuccal canal of the CEC group at 5 mm from the apical end (P < .05). There was no difference regarding fracture resistance among the CEC (996.30 ± 490.78 N) and TEC (937.55 ± 347.25 N) groups (P > .05). **Conclusions:** The current results did not show benefits associated with CECs. This access modality in maxillary molars resulted in less root canal detection when no ultrasonic troughing associated to an OM was used and did not increase fracture resistance. *(J Endod 2017;43:1657–1662)*

Key Words

Endodontic cavity, fracture resistance, instrumentation efficacy, micro–computed tomography, minimally invasive intervention

Significance

The influence of CECs on root canal preparation outcomes and fracture resistance remains limited and controversial. We provide new insights regarding root canal detection, instrumentation efficacy (noninstrumented canal area, hard tissue debris accumulation, canal transportation, and centering ratio), and fracture resistance of maxillary molars. The current results did not show benefits associated with CECs compared with TECs.

Traditional endodontic cavities (TECs) emphasize straight-line pathways into root canals to increase preparation efficacy and prevent procedural errors (1, 2). However, a concern related to TECs is the amount of tooth structure removed, which may reduce its resistance to fracture under functional loads (3, 4). As an alternative to this traditional approach, minimally invasive endodontic cavities or contracted endodontic cavities (CECs) have been described (3,5–11), emphasizing the importance of preserving the tooth structure, including pericervical dentin. It was already shown that CECs improved the fracture resistance of premolars and mandibular molars; however, this kind of access compromised the efficacy of root canal instrumentation in lower molars (8). Yuan et al (9) showed, through finite element analysis, that CECs reduced stress in the occlusal and cervical regions when performed in mandibular molars. On the other hand, another study showed that CECs were not able to improve the fracture resistance of maxillary molars when compared with TECs (10). Thus, the influence of CECs on the root canal preparation outcomes and fracture resistance remains limited and controversial. Moreover,

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no data regarding the location of root canals and debris accumulation when performing CECs have been provided.

Therefore, the present study aimed to assess the influence of CECs on root canal detection, instrumentation efficacy (noninstrumented canal area, hard tissue debris accumulation, canal transportation, and centering ratio), and fracture resistance assessed in maxillary molars. TECs were used as a reference for comparison. The null hypothesis tested was that there would be no influence of the type of endodontic cavity on any of the investigated outcomes.

Materials and Methods

Sample Size Estimation

The sample size was estimated based on studies comparing TECs and CECs (8, 11), both with 10 teeth per group. Accordingly, for analysis with α = 0.05 and 80% power, at least 10 teeth were allocated for each of the following groups: CEC (experimental) and TEC (control).

Sample Selection

After ethics approval (reference #1.559.163), 49 human first maxillary molars extracted for reasons not related to this study with fully formed apices and intact crowns were preselected using periapical radiographs. Teeth were selected based on the following inclusion criteria for chamber and root canal anatomy: similar general dimensions, length and degree of canal curvature, and pulp chamber height <2 mm. The sample was stored in a 0.9% saline solution at 4°C and used within 6 months after extraction.

To obtain an outline of the root canals, the specimens were scanned in a micro–computed tomographic (micro-CT) device (SkyScan 1173; Bruker microCT, Kontich, Belgium) using the following parameters: 70 kV and 114 mA, isotropic resolution of 21 μm, 360° rotation around the vertical axis, rotation step of 0.5°, camera exposure time of 7000 milliseconds, and frame averaging of 5. X-rays were filtered with a 1-mm-thick aluminum filter to reduce beam hardening artifacts. Images were reconstructed with NRecon v.1.6.9 software (Bruker microCT) using 30% beam hardening correction and ring artifact correction of 5, resulting in the acquisition of 900 to 1000 transverse cross sections per tooth. After reconstruction of the images, the root canals were then matched to create 15 pairs based on similar morphologic elements of the canal (number, volume, surface area, and configuration). One tooth from each pair was randomly assigned to the CEC or TEC group and accessed accordingly. Each group consisted of 12 teeth that presented the second mesiobuccal (MB2) root canal and 3 teeth that did not present the MB2 root canal.

TEC

Endodontic cavities were drilled with high-speed diamond burs (1014; KG Sorensen, São Paulo, Brazil) and an Endo Z drill (Dentsply Maillefer, Ballaigues, Switzerland) following conventional guidelines already described in the literature (1, 12). The roof of the chamber was removed, and an unimpeded (straight-line) access into the coronal third of the root canal was established (Fig. 1*A*).

CEC

Endodontic cavities were drilled with high-speed diamond burs (1014-3080, KG Sorensen). The teeth were accessed at the central fossa and extended only as necessary to detect canal orifices, preserving pericervical dentin and part of the chamber roof (3, 10) (Fig. 1*B*).

Root Canal Detection

In both groups, canal orifices were detected with an endodontic explorer #6 (Golgran, São Caetano do Sul, Brazil) and size 6, 8, 10, or 15 K-files (Dentsply Maillefer) in 3 stages:

1. Stage 1: The detection was performed without the use of magnification.
2. Stage 2: The detection was performed under magnification (16×) using an operating microscope (OM) (DF Vasconcellos; Valença, Rio de Janeiro, Brazil).
3. Stage 3: The detection of teeth, in which not all canals (including the MB2 canal) were located with an OM, was performed under magnification as described in the previous stage and with the aid of ultrasonic tips (E3D e E7D; Helse Dental Technology, Santa Rosa de Viterbo, São Paulo, Brazil). Small wear (maximum of 2 mm) was performed on the mesial wall of the pulp chamber following the buccal-palatine direction.

The root canal that was not found after stage 3 was considered "not detected." A single experienced operator, who did not know the distribution of the specimens between the groups and did not have prior access to the micro-CT data, performed the endodontic cavities, root canal detection, preparation, and filling procedures.

Root Canal Preparation and Filling Procedures

Root canals were negotiated with a size 10 K-file until its tip was visualized on the apical foramen, and the working length was established 1.0 mm shorter. The root canals were prepared with Reciproc R25 (25/0.08) and R40 (40/0.06) instruments (VDW GmbH, Munich, Germany) in buccal and palatal roots, respectively. Instruments were driven with the VDW Silver motor (VDW GmbH) according to the manufacturer's instructions. Each instrument was used in 1 tooth and then discarded. Between successive steps, the canals were irrigated with 2 mL 2.5% sodium hypochlorite (NaOCl) with 30-G Endo-Eze needles (Ultradent Products Inc, South Jordan, UT) inserted up to 2 mm from the apical foramen. Final irrigation was performed with 5 mL 2.5% NaOCl followed by 5 mL 17% EDTA (pH = 7.7) for 1 minute followed by 5 mL 2.5% NaOCl. Then, the canals were dried with R25 or R40 absorbent paper points (VDW GmbH), and the specimens were submitted to a postoperative scan and reconstruction applying the aforementioned parameters.

After that, the sample was filled using a single-cone technique associated with vertical condensation using AH Plus sealer (Dentsply De Trey, Konstanz, Germany) and Reciproc R25 and R40 gutta-percha cones in buccal and palatal roots, respectively. Endodontic cavities were filled with 37% phosphoric acid gel (Condac 37; FGM, Joinville, Brazil), rinsed with water, and air dried, and 2 layers of bonding agent (Adper Single Bond 2; 3M ESPE, St Paul, MN) were applied interspersed by a light jet of air and followed by each cured for 20 seconds (Radii-cal; SDI, Bayswater, Australia). The composite restoration (Filtek Z350 XT; 3M ESPE, Sumaré, Brazil) was applied in increments of at most 2-mm thick and each cured for 20 seconds. Then, the teeth were stored in a 0.9% saline solution at 4°C for all stages of this study.

Micro-CT Evaluation

The image stacks of the specimens after root canal instrumentation were rendered and coregistered with their respective preoperative data sets using an affine algorithm of the 3D Slicer 4.6.2 software (13). The noninstrumented canal area was determined by calculating the number of static voxels (voxels present in the same position on the canal surface before and after instrumentation) and expressed as a percentage of the