Impacts of Contracted Endodontic Cavities on Primary Root Canal Curvature Parameters in Mandibular Molars

Melissa A. Marchesan, DDS, MS, PhD,[*] Adam Lloyd, BDS, MS,[*] David J. Clement, DDS,[†] Joseph D. McFarland, DDS, MDS,[*] and Shimon Friedman, DMD, MSc[‡]

Abstract

Introduction: The purpose of this study was to provide information regarding the debate on contracted endodontic cavities (CECs); their impacts on angle, location, and radius of the primary canal curvature (PCC) were assessed in type IV mesial root canals of mandibular molars at different stages of instrumentation. Impacts on treatment time were also assessed. **Methods:** Twenty-four teeth were matched by radiographic and micro–computed tomographic criteria and accessed via CECs (CEC, n = 12) or nonextended traditional endodontic cavities (TECs, n = 12). PCC parameters were radiographically determined using a repositioning apparatus before glide path preparation (PI), after glide path preparation, and after final instrumentation (FI). Instrumentation was performed with PathFiles (13/.02, 16/.02; Dentsply Maillefer, Ballaigues, Switzerland) and ProFile Vortex files (Dentsply Tulsa Dental Specialties, Tulsa, OK) to size 30/.04 at the working length under copious irrigation. Changes in PCC were measured with ImageJ (National Institutes of Health, Bethesda, MD). The instrumentation time was recorded. Data were analyzed with 2-way repeated measures analysis of variance ($\alpha < .05$) and Tukey honest significant difference tests. **Results:** A significant ($P < .001$) decrease in the mean angle and increase in the mean radius were detected at each instrumentation stage for both CECs (angle: PI = 42.57° ± 8.00°, FI = 32.61° ± 5.17°; radius: PI = 6.48 ± 1.81 mm, FI = 10.55 ± 1.48 mm) and TECs (angle: PI = 38.80° ± 7.15°, FI = 30.08° ± 6.99°; radius: PI = 6.97 ± 2.31 mm, FI = 11.01 ± 2.20 mm). PCC location shifted apically ($P < .001$). Changes in PCC parameters did not differ significantly between CECs and TECs ($P > .05$). The treatment time was significantly ($P < .0001$) longer for CECs (83.17 ± 6.71 minutes) than for TECs (33.18 ± 9.20 minutes). **Conclusions:** Instrumentation of curved mesial canals reduced the severity and abruptness of PCC and shifted the PCC location apically similarly in mandibular molars with CECs and those with nonextended TECs. The extended treatment time with CEC merits consideration when debating CECs versus TECs. *(J Endod 2018;■:1–5)*

Key Words:

Dental pulp cavity, endodontic cavity, instrumentation efficiency, nickel-titanium instrument

Significance

No significant differences were found in PCC angle, radius, and location between the CEC and the TEC groups. The canal preparation time was significantly increased when working through a CEC access design.

Endodontic treatment of mandibular molars may challenge even experienced clinicians because of the curved canals in the mesial root. Root canal curvature and instruments' design (1), alloy, and mode of use (2) are the main factors governing instrumentation. Canal curvature has been characterized in regard to its angle and radius (3); a greater angle makes the curve more severe, and a smaller radius makes the curve more abrupt. As both curvature severity and abruptness increase, the strain on instruments and their pressure on the dentin walls also increase (1), potentially leading to transportation of canal pathways (4, 5). The location of the primary canal curvature (PCC) (ie, the distance of its center from the root apex) may also impact the cyclic fatigue and the point of maximal flexure of instruments as they engage the canal walls (3).

To facilitate treatment of the curved mesial root canals in mandibular molars and to prevent procedural errors, the traditional endodontic cavity (TEC) guidelines highlight an adequate "outline form" but also "convenience form" and "extension for prevention" (6, 7), specifically intended to reduce the severity of canal curvature. Accordingly, the cavity is extended beyond just a direct instrument pathway into canal orifices (6); however, the associated loss of tooth structure undermines the tooth's biomechanical responses to functional loads (8–10) and is a recognized risk factor for fracture in root-filled teeth (11, 12).

The emerging concept of contracted endodontic cavity (CEC) designs focuses on strategic dentin preservation (13–15), which is in-line with the concepts of minimally invasive dentistry (16). The main features of CECs in mandibular molars are partial preservation of the pulp chamber soffit and pericervical dentin extending 4 mm coronal and 4–6 mm apical to the crestal bone (13, 14). CEC designs not only feature

From the *Department of Endodontics, University of Tennessee Health Science Center, College of Dentistry, Memphis, Tennessee; †The University of Oklahoma College of Dentistry, Oklahoma City, Oklahoma; and ‡Faculty of Dentistry, University of Toronto, Toronto, Ontario, Canada.

Address requests for reprints to Dr Adam Lloyd, Department of Endodontics, University of Tennessee Health Science Center College of Dentistry, 875 Union Avenue, Memphis TN 38163. E-mail address: alloyd@uthsc.edu
0099-2399/$ - see front matter

https://doi.org/10.1016/j.joen.2018.07.008

contracted outline forms but, notably, they also forego convenience form and extension for prevention. Recent studies assessed the biomechanical (17–20) and canal instrumentation efficacy (17, 18) impacts of CECs to explore the potential benefits and risks. Fracture strength in mandibular premolars and molars with unrestored CECs was improved compared with teeth with TECs (17). When CECs were restored with bonded composite resin, the fracture strength of maxillary molars was comparable with that of similar teeth with TECs in 2 studies (18, 20), and improved for maxillary and mandibular premolars and molars in another study (19). Instrumentation efficacy appeared to be compromised only in distal canals of mandibular molars (17, 18). All studies reported no instrument fracture during instrumentation of canals in teeth with CECs (17, 18, 20, 21).

Because the mesial canals' curvature is not intentionally reduced in mandibular molars with CECs, the angle of file access in the mesial canals is greater than in molars with TECs (21), which may lead to accentuated transportation of canal pathways during instrumentation compared with molars with TECs (21). Furthermore, the contracted cavity is likely to increase instrumentation difficulty and time (15, 20, 21). To investigate the specific impacts of CECs on instrumented curved canal pathways, the aim of this study was to assess the changes in angle, radius, and location of PCC in type IV (22) mesial root canals of mandibular molars with CECs that occur at different phases of instrumentation. The time required for complete instrumentation also was recorded. Both the changes in curved canal pathways and the instrumentation time are potential concerns to clinicians. It was hypothesized that no significant difference would be detected in both outcome measures between molars with CECs and TECs.

Material and Methods

Tooth Specimens

Extracted human mandibular molars obtained from a bank of teeth were evaluated in 2 perpendicularly oriented radiographic views subsequent to institutional review board approval (#14-03591-XM). Twenty-four teeth were selected according to the following inclusion criteria: intact or minimally restored crowns, radiographic pulp chamber height <2 mm, mesial canal PCC angle > 30° according to Pruett et al (3), average length of 21 mm, and 2 distinct pathways and foramina as verified by micro–computed tomographic (μ-CT) imaging (ACTIS BIR 150/130; Varian Medical Systems, Palo Alto, CA). Images were acquired at 75 kV and 100 μA through 360° of rotation around the vertical axis, resulting in an approximate cross-sectional pixel size of 30 μm.

Selected teeth were embedded in epoxy resin (Stycast 1266; Henkel Electronic Materials, LLC Salisbury, NC) to allow precise positioning on the radiographic and μ-CT stages. PCC parameters were only determined for the mesial-buccal (MB) and mesial-lingual (ML) canals.

Groups and Endodontic Procedures

One operator (J.D.M.) performed all endodontic procedures under a clinical microscope (OPMI Pico; Carl Zeiss Meditec Inc, Jena, Germany) at ×10.9 magnification. Specimens were divided into CEC and TEC groups (n = 12). CEC was initially prepared in all teeth with new #392 mosquito burs (Spring Health Diamonds, St Louis Park, MN) in a high-speed handpiece under water spray (17). Vertical lines were drawn on the buccal and mesial surfaces of the mesiobuccal root bulges and extended to the occlusal surface, where their intersection corresponded to the approximate position of the MB pulp horn. Access was initiated immediately mesial to the central fossa and extended in the pulpal, distal, and lingual directions, maintaining portions of the pulp chamber soffit and pulp horns. Pulp tissue from undercut pulp horns and calcified tissue were removed with a modified DG-16 explorer. In the nonextended TEC group (n = 12), cavities were subsequently expanded with LA Axxess burs (SybronEndo, Glendora, CA) and refined with BUC-1 ultrasonic tips (SybronEndo). The outlines corresponded to the locations of canal orifices, resulting in centrally located cavities without radicular straight-line extension. Representative CEC and TEC outlines are shown in Figure 1*A–D*.

MB and ML canals were negotiated with ISO size 6, 8, and 10 K-type files (Roydent Dental Products, Johnson City, TN) to the minor apical foramen, and the working length (WL) was established 0.5 mm shorter. The specimen was inserted into a fixed mold mounted on a radiographic Plexiglas apparatus (23). A preinstrumentation (PI) radiographic image was captured with a size 10 file at the WL after rotating the stage to capture the maximum angle of curvature separately for the MB and ML canals (23). The stage positions for viewing the MB and ML were recorded as reference for subsequent radiographic capture.

A glide path (GP) was established with size 10 K-files followed by rotary PathFiles 13/.02 and 16/.02 (Dentsply Maillefer, Ballaigues, Switzerland). With size 10 K-files reinserted to the WL in the MB and ML canals, specimens were repositioned on the stage and rotated, and GP radiographic images were captured as described earlier. The mesial canals were instrumented with ProFile Vortex instruments (Dentsply Tulsa Dental Specialties, Tulsa, OK) in a crown-down sequence of 30/.04, 25/.04, and 20/.04 and a subsequently increasing instrument size at the WL to 30/.04. Distal canals were similarly instrumented to size 40/.04 at the WL to enable recording of the total time required for instrumentation of all canals. During instrumentation, canals were irrigated with 2 mL 8.25% sodium hypochlorite between successive instruments (total 10 mL per canal), and size 10 K-files were used to recapitulate canals to the WL. Final instrumentation (FI) radiographic images were captured as before with size 10 K-files in the MB and ML canals.

Outcome Measures

The PI, GP, and FI radiographic images were imported into PowerPoint (Microsoft Corp, Redmond, WA) as previously described (3), and lines were drawn to depict the long axes of canals coronal and apical to PCC (Fig. 2*A–C*). Images were imported into ImageJ 1.41 software (National Institutes of Health, Bethesda, MD), and the angle (degree), radius (mm), and location of PCC (mm) were measured for the MB and ML canals of each specimen. All measurements were performed by 1 examiner (D.J.C.) who coauthored the original canal curvature and radius classification study (3).

In addition, the total instrumentation time (minutes) encompassing active canal instrumentation, instrument changes, and irrigation was recorded for the MB, ML, and distal canals. Recording was suspended during radiographic exposures.

Analysis

Data for each curvature parameter were analyzed with 2-way repeated measures analysis of variance within and between each of the groups. Tukey pair-wise testing was used post hoc. The instrumentation time for both groups was compared using the unpaired t test. Significance was set at .05 (SigmaPlot 13; Systat Software Inc, Chicago, IL).

Results

None of the endodontic instruments used fractured during canal instrumentation. The PI measurements (Fig. 2*A*) revealed that specimens in groups CEC and nonextended TEC did not differ significantly (P > .1) in the angle, radius, and location of the primary canal