Influence of Contracted Endodontic Access on Root Canal Geometry: An *In Vitro* Study

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Abstract

Introduction: Contracted endodontic cavities (CECs) have developed from the concept of minimally invasive dentistry and provide an alternative to traditional endodontic cavities (TECs). They have been designed in an effort to preserve the mechanical stability of teeth. The contracted cavity design preserves more of the dentin but may influence the geometric shaping parameters. The aim of this micro–computed tomographic study was to evaluate the influence of contracted endodontic cavities on the preservation of the original root canal anatomy after shaping with nickel-titanium rotary instruments. **Methods:** Thirty extracted human mandibular molars with fully formed apices and independent mesial canals were randomly assigned to group 1 (TEC) and group 2 (CEC). Each group was shaped using ProGlider (Dentsply Maillefer, Ballaigues, Switzerland) and WaveOne Gold (Dentsply Maillefer). Irrigation was performed with 10% EDTA and 5% sodium hypochlorite. Samples were scanned before and after canal shaping to match canal volumes (SkyScan; Bruker microCT, Kontich, Belgium [100 kV, 100 μA, and 15-μm resolution]), and images were analyzed to evaluate canal volumes, surface areas, and centroid shift on cross sections at −1 mm and −3 mm from the apex. **Results:** TECs showed a greater preservation of the original root canal anatomy with less apical transportation than CECs, possibly because of the absence of coronal interferences and, therefore, fewer pecking motions required to complete instrumentation. **Conclusions:** Within the limitations of this study, TECs may lead to a better preservation of the original canal anatomy during shaping compared with CECs, particularly at the apical level. *(J Endod 2017;■:1–7)*

Key Words

Centering ability, contracted endodontic access, micro–computed tomography, minimally invasive, nickel-titanium instruments, shaping outcomes

Significance

The influence of contracted endodontic access on root canal anatomy preservation after shaping with NiTi instruments was evaluated. The use of the traditional endodontic access during clinical practice may lead to less canal transportation at the apical level.

Access cavity preparation is considered a fundamental step in orthograde endodontic treatment (1). Complete removal of the pulp chamber roof is crucial to avoid bacterial contamination from pulp residues (2, 3). Moreover, an appropriate access may promote canal detection and enhance instrumentation efficacy by avoiding coronal interferences (4). Contracted endodontic cavities (CECs) have stemmed from the concept of minimally invasive dentistry (5, 6). They have been presented as an alternative to traditional endodontic access cavities (TECs) designed to preserve the mechanical stability of the tooth (7, 8). However, although the contracted cavity design retains more dentin, it may influence the geometric shaping parameters. In contracted access cavities, coronal interference may cause endodontic instruments to work primarily on the internal surface of the root canal, resulting in root canal transportation. Recent studies have shown that root canal transportation negatively affects long-term prognosis after endodontic procedures because of excessive removal of dentin and straightening of the original root canal curvature (9–13). However, no data are available regarding the influence of contracted cavities on geometric shaping outcomes.

Micro–computed tomographic (micro-CT) imaging is considered a reliable method to assess the quality of root canal shaping through the analysis of 2-dimensional (2D) and 3-dimensional (3D) geometric shaping parameters (14–16). The aim of this micro-CT study was to evaluate the influence of CECs on the preservation of the original root canal anatomy after shaping with nickel-titanium reciprocating instruments.

Materials and Methods

Freshly extracted mandibular first permanent molars with fully formed apices were used in accordance with the local ethics committee. A sample size of 15 per group was calculated with G*Power 3.1.4 (Kiel University, Kiel, Germany) to set the study power at 80% (a large effect size equal to 1 was considered for the sample size calculated). After debridement of the root surface, specimens were immersed in a 0.01% sodium hypochlorite (NaOCl) solution at 4°C for 24 hours and then stored in saline solution. A total of 40 teeth were selected. Specimens were mounted on a custom-made support in order to perform preliminary low-resolution micro-CT scans (SkyScan 1172; Bruker microCT, Kontich, Belgium) to attain an overall outline of the root canal anatomy and to ensure inclusion criteria were met (17). A total of 450

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0099-2399/$ - see front matter

https://doi.org/10.1016/j.joen.2017.11.010

low-resolution preliminary scans were acquired through a 225° rotation (180° plus cone angle of the X-ray source) using a 1.0-mm-thick aluminum filter under the following parameters: voltage = 100 kV, current = 80 μA, source-to-object distance = 80 mm, source-to-detector distance = 220 mm, pixel binning = 8 × 8, and exposure time/projection = 0.2 seconds. NRecon (Bruker microCT) software was used to reconstruct the axial slices with an isotropic voxel size of 36 μm. Reconstructed axial and volume parameters were visualized using DataViewer software (Bruker microCT), and morphologic parameters of the mesiobuccal (MB) canals were calculated.

MB canals that met the following criteria were included in the analysis: canals measuring 12 ± 2 mm from the canal orifice to the apical foramen, 10°–30° primary root curvature in the clinical buccolingual view according to the Schneider method (18) and in the proximal view after a 90° rotation along the axis, $2 < r \leq 6$ mm main curvature radius (19), and a point of maximum curvature located within the middle third of the root canal. Teeth with confluent canals or accentuated isthmuses were excluded. Teeth with significant calcifications and those not concurring with the aforementioned inclusion criteria regarding canal curvature and patency were excluded.

Selected samples were then scanned at a higher spatial resolution (SkyScan 1172). A total of 2400 projections were acquired through a 360° rotation step using a 1.0 mm-thick aluminum-copper filter. High-resolution scans were conducted under the following parameters: voltage = 100 kV, current = 100 μA, source-to-object distance = 80 mm, source-to-detector distance = 220 mm, pixel binning = 2 × 2, and total scan duration = 2 hours 32 minutes. NRecon software was used to reconstruct the axial slices with an isotropic voxel size of 16 μm, and standardized parameters were used for beam hardening (60%) and ring artifact correction (7%). Reconstructed axial slices and volumes were visualized using DataViewer software. Image stacks were processed for volume registration and matching and cutting plane selection by DataViewer software. The registration algorithm was based on the mean square difference between the gray values of the 2 image sets. The alignment steps were set to 0.9 μm with a 0.0001-unit tolerance on the voxel intensity. Root canal paths were analyzed with high-resolution 3D rendering and orthogonal cross sections to assess the baseline homogeneity of the groups (apical cross-sectional diameters 1 mm from the apical foramen and root canal surface area and volume). The Shapiro-Wilk test was used to determine normality, and the degree of homogeneity was evaluated using 1-way analysis of variance (ANOVA) (5% level of significance).

Of the 40 teeth assessed for inclusion, 10 were excluded because of anatomic features and severe calcification of the root canal. The remaining 30 teeth were randomly allocated to the following experimental groups (n = 15): TEC and CEC (Fig. 1*A–D*). According to previous guidelines for the minimally invasive access, contracted cavities in the CEC group were accessed at the central fossa and extended only as necessary to access canal orifices while preserving pericervical dentin and part of the chamber roof (3, 20–23). Mesiodistal, buccolingual, and circumferential precervical dentin removal was minimized (23). TECs in the TEC group were drilled following conventional guidelines; outline and cervical dentin were modified as needed until all orifices could be visualized in the same field of view and straight access to canal orifices could be achieved without coronal interferences (20–24) (Fig. 1). The mean volume of removed dental tissue and the occlusal surface area of the endodontic cavities were measured. The mean angles of file access in the MB root canals were measured for both groups, and in the CEC group the actual file access was compared with the assumed straight access (Fig. 2*A* and *B*). The straight access design was determined in the maximum curvature view from the line between the center of the primary curvature and the corresponding pulp horn landmark (20). After access cavity preparation, all MB root canals were shaped. Canal scouting and the initial glide path were performed in all specimens with a size 10 K-file at the working length (WL) using Glyde (Dentsply Maillefer, Ballaigues, Switzerland) as the lubricating agent (0.80 mg) (25). The WL was established under high magnification (OPMI Pro Ergo; Carl Zeiss, Oberkochen, Germany) by subtracting 0.5 mm from the length at which the tip of the instrument was visible at the apical foramen. The pulp chamber was filled with 5% NaOCl (Niclor 5; OGNA, Muggiò, Italy) throughout instrumentation. Mechanical glide path preparation was performed using ProGlider (Dentsply Maillefer) (tip size = 0.16 mm, taper = 0.02 up to 0.85) and an endodontic engine (X-Smart, Dentsply Maillefer) with a 16:1 contra-angle at 300 rpm and 4 Ncm at the full WL. A clinical professor experienced in endodontics using WaveOne Gold Primary (WOG) (0.25, 0.07 taper) and an X-Smart motor (300 rpm, 4 Ncm) shaped all specimens at the WL. New instruments were used for each specimen, and instruments were removed from the canal and cleaned after every 3 pecking motions until the WL was reached. Mechanical instruments were used with an in-and-out motion with no intentional brushing effect. The number of pecking motions required for the glide path with PG and shaping with WOG were recorded. Irrigation was performed with disposable conventional handheld syringes and 30-G endodontic needles taken 2 mm short of the WL without engaging the root canal walls. Specimens were irrigated by alternating 5% NaOCl with 10% EDTA to a total of 10 mL of each solution per specimen. Recapitulation with a size 10 K-file was performed between each instrument.

Root canals were dried with absorbent sterile paper points and microscanned for posttreatment analyses. 3D models of the root canals before preparation and after shaping with WOG were matched, and micro-CT scans were managed to enable pre- and postoperative evaluation for each group.

Root canal sections and volumes were analyzed with CTAn software (Bruker microCT). The volume of interest was set from the furcation to the anatomic root apex, generating 700 to 900 cross sections for each specimen saved in the bitmap format. 3D (volume and surface area) and 2D (root canal centroid shift, maximum and minimum diameter, and cross-sectional area) parameters were assessed (26). Root canal volumes were calculated as the volume of binarized objects within the volume of interest. Surface areas were calculated from the exposed vertical surfaces by pixel differences between adjacent cross sections (27). Increases in volume and surface areas were analyzed for each group by subtracting the scores of the untreated canals from those of their treated counterparts. Root canal sections orthogonal to the canal axis were set at 2 levels: 1 mm and 3 mm from the apical foramen. These were selected as the areas most representative of the critical shaping points (13), and 2D parameters were analyzed at each level. The same cutting plane orientation was used for pre- and posttreatment samples. Axial slices were imported and analyzed with CTAn software using an automated minimum threshold algorithm (28); micro-CT analyses were performed preoperatively and after shaping by an experienced operator who was blind to specimen allocation. The major diameter was calculated as the distance between the 2 most distant pixels in the object. The minor diameter was defined as the longest chord orthogonal to the respective major diameter (26). Canal transportation was assessed from the centers of gravity that were calculated for each slice (17). The center of gravity for each scanning slice at the 2 levels of analysis was traced, and coordinates on both axes of planar images were recorded. Average canal transportation was subsequently calculated by the centroid shift, in millimeters, before and after instrumentation (17).

Data distribution was analyzed with the Shapiro-Wilk normality test. One-way ANOVAs ($P < .05$) were used to analyze any differences