Presence of Voids after Continuous Wave of Condensation and Single-Cone Obturation in Mandibular Molars: A Micro-Computed Tomography Analysis

Elaine Faga Iglecias, DDS, MSc, PhD, Laila Gonzales Freire, DDS, MSc, PhD, George Táccio de Miranda Candeiro, DDS, MSc, PhD, Marcelo dos Santos, DDS, MSc, PhD, João Humberto Antoniazzi, DDS, MSc, PhD, and Giulio Gavini, DDS, MSc, PhD

Abstract

Introduction: The objective of this study was to assess the presence of voids in mesial root canals of mandibular molar teeth obturated by using the single-cone (SC) and continuous wave of condensation (CWC) obturation techniques, and results were analyzed by using micro–computed tomography. **Methods:** Twenty-four mandibular molars with fully developed roots and mesial root curvature ranging from 25° to 35° were instrumented by using Reciproc R25 files, and then they were obturated by using the SC and CWC techniques. Specimens were scanned before and after obturation for micro–computed tomography analysis (voxel size, 17.42 μm). After volumetric analysis and tridimensional reconstruction of the root canals, data were analyzed by using analysis of variance and the Tukey test. **Results:** No significant differences were observed between the 2 techniques in terms of total percentage volume of voids: CWC = 3.91% $\pm$ 0.72%; SC = 6.52% $\pm$ 1.16% ($P > .05$). Only in the cervical third, CWC showed a significantly lower percentage of voids when compared with SC, namely 2.86% $\pm$ 0.94% vs 8.00% $\pm$ 1.86%, respectively ($P < .05$). **Conclusions:** The percentage volume of voids was similar in the 2 groups and was influenced by the obturation technique only in the cervical third. *(J Endod 2016;■:1–5)*

Key Words

Micro-computed tomography, obturation techniques, root canal filling, voids

From the Department of Restorative Dentistry, Faculty of Dentistry, University of São Paulo, São Paulo, Brazil.

Address requests for reprints to Prof Dr Giulio Gavini, Av. Prof. Lineu Prestes, 2227, CEP 05508-000 São Paulo, SP, Brazil. E-mail address: ggavini@usp.br

0099-2399/$ - see front matter

http://dx.doi.org/10.1016/j.joen.2016.11.027

Significance

This study evaluates the quality of obturation of mesial canals of mandibular molars obturated by means of single-cone technique and continuous wave of condensation. We show that both obturation techniques are similarly efficient to fill the root canal space.

The objective of obturation is to fill and seal the root canal system as effectively as possible after cleaning and shaping. Studies have demonstrated the close relationship between quality of root canal obturation and treatment success (1). Adequate obturation of the root canal system, especially of its ramifications, involves several challenges primarily because of difficulties involved in the adherence of material to root canal walls, making the filling material adhere to root canal walls. Poor adhesion may create voids in the interface between filling material and dentin, which facilitates bacterial movement toward the apical third of the root, potentially leading to apical periodontitis (2).

To achieve high-quality obturation, material characteristics have to be taken into consideration and also the specific obturation technique that is used. Studies have shown the advantages of using thermoplastic obturation techniques, especially in oval or irregular root canals (3). In gutta-percha cones tapered according to the final shape of canals prepared by using different mechanized instrumentation systems, the single-cone (SC) technique has been increasingly popular. The advantages of this technique include easy handling, low cost, and short procedure time (4, 5). Among the disadvantages of this approach, the presence of porosities when dealing with large volumes of filling material, setting contraction, and material dissolution are worth noting (6).

Micro–computed tomography (micro-CT) applied to endodontics allows three-dimensional assessment of the quality of obturation, and this makes it possible to identify areas of failure and voids. In addition, micro-CT allows quantification of the volume of filling material present in the canal, with the important advantage of preserving the specimen (7–11). Despite the advantages of micro-CT in assessing obturation quality, few studies have used this imaging method to compare the SC technique with the continuous wave of condensation (CWC) technique (12, 13). Specifically, it would be useful to know whether the use of tapered gutta-percha cones in the SC technique is as effective as when the SC technique is combined with the thermoplastic CWC technique in terms of the quality of root canal filling. The aim of the present study was to assess the presence of voids along the entire root canal and to assess each of the root's lengths, specifically by using medial canals of mandibular molars obturated by using the CWC and SC techniques, which were analyzed by using micro-CT.

Materials and Methods

Sample Selection and Specimen Preparation

A total of 24 extracted human mandibular molar teeth were used from the Tooth Bank at University of Sao Paulo, Brazil. The present study was approved by the Research

Ethics Committee of the same university (protocol no. 15598). All teeth were intact and had fully developed roots and mesial root curvature ranging from 25° to 35° according to the method of Schneider (14), which was confirmed on baseline buccolingual and mesiodistal radiographic views. Previously, the teeth were scanned by micro-CT (SkyScan 1176; Bruker-microCT, Kontich, Belgium) to investigate the internal anatomy of root canals. The selected teeth presented type II configuration according to the classification of Vertucci (15).

The teeth were transversely sectioned by using a precision sectioning cutter (Isomet 1000; Buehler, Lake Bluff, IL) to obtain a specimen with size of 17 mm. Coronal access was performed by using spherical diamond burs #1014 (KG Sorensen, São Paulo, Brazil) and Endo Z burs (KG Sorensen) at high-speed rotation under refrigeration. Mesial canals were explored by using #10 K-files (Dentsply Maillefer, Ballaigues, Switzerland), and working length was established 1 mm short of the point where the tip of the instrument became visible at the apical foramen. Verification of the file's apical position was made with the aid of an operating microscope at a magnification setting of 8.

All procedures were conducted by a single endodontist (E.F.I.). A glide path was established by using #15 K-file. Then, both mesial canals were instrumented by using Reciproc R25 files (VDW GmbH, Munich, Germany) coupled to VDW Silver motor (VDW GmbH) by using the manufacturer's recommendations. New file was used on each specimen.

Every time the instrument was withdrawn, the canal was rinsed with 2 mL 1% sodium hypochlorite (NaOCl) delivered by a 30-gauge NaviTip needle (Ultradent Products Inc, South Jordan, UT). A total of 20 mL NaOCl was used during the instrumentation procedure. Foramen patency was maintained during the instrumentation by using #10 K-file. Final irrigation was performed with 2 mL 17% EDTA, followed by 2 mL 1% NaOCl activated for 30 seconds by using an ultrasonic tip (Irrisonic; Helse Dental Technology, Santa Rosa de Viterbo, Brazil) coupled to an ultrasound device (Suprasson P5; Satelec Acteon Group, Merignac, France).

Micro-CT Imaging

Teeth were scanned preoperatively to investigate anatomic characteristics, and scanning was performed after instrumentation and obturation. Images were obtained by using a micro-CT scanner (SkyScan 1176; Bruker-microCT). To improve specimen repositioning during image acquisition, teeth were individually embedded in high-precision impression material (Speedex; Coltène, Cuyahoga Falls, OH), with the access cavities facing down. Groups of 7 teeth were positioned in a single sample holder, and the samples were brought to the carbon fiber bed of the micro-CT scanner. Specimens were scanned at 90 kV, 278 μA, 360° rotation, and a 0.5° rotation step, resulting in a voxel size of 17.42 μm. The filter used was made of copper that was 0.1 mm thick.

Images were reconstructed with a modified Feldkamp cone-beam reconstruction algorithm that was run on a computer cluster by using the NRecon software version 1.6.6.0 (Bruker-microCT), which yielded 800–900 slices per specimen. Reconstruction parameters were adjusted for noise suppression by using the fine-tuning function as follows: gaussian smoothing filter (kernel = 2), beam hardening correction of 40%, post-alignment of 0.50 to compensate for possible misalignment during acquisition, and ring artifact correction of 10.

Obturation

Specimens were divided into 2 groups (n = 12) on the basis of root canal anatomy and baseline root canal volume as shown in Table 1. One group was obturated by using the SC technique and the other by using the CWC technique. Reciproc R25 gutta-percha cones (VDW GmbH) and AH Plus sealer (Dentsply DeTrey, Konstanz, Germany) were used to fill all the root canals.

In the SC group, the gutta-percha cones with sealer were introduced to the measured working length. A heat plugger (Odous de Deus, Belo Horizonte, Brazil) was used to remove excess filling material at the canal entrance, and the cone was vertically condensed by using a cold plugger.

The gutta-percha cones with sealer were placed to working length, the coronal excess was seared off, and then the remaining material was packed down by using Elements Unit (SybronEndo, Orange, CA) to within 5 mm of the apex. Next, backfilling the canal was accomplished by using the Elements Backfill Unit until the canal orifice was reached, as described previously (16).

In both groups once root canal filling was completed, the pulp chamber was cleaned by using a cotton pellet soaked in 70% alcohol, and the canal entrance was sealed with eugenol-free temporary filling material (Coltosol; Coltène, Altstatten, Switzerland). Teeth were stored at 37°C under 100% humidity for 72 hours before post-obturation scanning.

Image Analysis

The DataViewer software version 1.5.1 (Bruker-microCT) was used to record three-dimensional image data obtained before and after obturation in axes x, y, and z.

CTAn version 1.14.4 and CTVol version 2.2.1.0 software packages (Bruker-microCT) were used to create and visualize tridimensional models and quantify root canal volume, filling material volume (gutta-percha and sealer), and voids volume. The gray scale range required to recognize each object under study was determined in a density histogram by using a global threshold method. Comparisons between the original and segmented scans were performed to ensure segmentation accuracy. In regard to filling material segmentation (gutta-percha and sealer), threshold values ranged from 185 to 205. Task lists based on arithmetic and logical operations were applied to create separate binary images of the root canal and the filling material by using a custom processing tool.

The volume of voids ($Voids_{Vol}$) was calculated by subtracting the filling material volume ($Filling_{Vol}$) from the post-obturation root canal volume ($Canal_{Vol}$):

$$Voids_{Vol} = Canal_{Vol} - Filling_{Vol}$$

The percentage volume of voids (% $Voids_{Vol}$) was calculated by using the following formula:

$$\%Voids_{Vol} = Voids_{Vol} \times 100/Canal_{Vol}$$

All analyses were conducted separately for the coronal, middle, and apical thirds of the canal.

TABLE 1. Baseline and Final Root Canal Volume (mm^3) According to Group (Mean ± Standard Deviation)

Group/region	Baseline volume	Final volume
SC		
Total	5.16 ± 1.85	9.81 ± 2.50
Cervical	2.56 ± 0.91	5.38 ± 1.47
Middle	1.89 ± 0.92	2.83 ± 1.02
Apical	0.49 ± 0.26	1.16 ± 0.49
CWC		
Total	5.42 ± 1.89	9.62 ± 1.75
Cervical	2.78 ± 1.06	5.86 ± 1.63
Middle	1.88 ± 0.83	2.84 ± 1.03
Apical	0.76 ± 0.20	0.79 ± 0.45