Original Article

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A methodology to standardize the evaluation of root canal instrumentation using cone beam computed tomography

Cláudia Bohrer Flores[1], Patrícia Machado[1], Francisco Montagner[2], Brenda Paula Figueiredo de Almeida Gomes[3], Gustavo Nogara Dotto[4], Marcia da Silva Schmitz[4]

[1]DDS, MSc student, Federal University of Santa Maria, Brazil

[2]DDS, MSc, PhD, Adjunct Professor, Endodontic Division, Department of Conservative Dentistry, Federal University of Rio Grande do Sul, Brazil

[3]DDS, MSc, PhD, Head Professor, Endodontic Division, Department of Conservative Dentistry, Piracicaba Dental School, University of Campinas, Brazil

[4]DDS, MSc, PhD, Adjunct Professor, Endodontic Division, Department of Stomatology, Federal University of Santa Maria, Brazil

Abstract

The evaluation of root canal instrumentation is important to observe the action of endodontic instruments in the root canal walls. **Aim:** This study introduces a method to standardize the acquisition of images before and after preparing root canals by using cone-beam computed tomography (CBCT). **Methods:** Sixteen mandibular molars were included in acrylic resin blocks. Samples were inserted in a stable wood box, which was filled with plaster and served as a guide to reinsert the samples. The apparatus was used for the CBCT examination before and after cervical flaring of root canals. The software IcatVision® was used to equalize the images before and after instrumentation with two computers operating at the same time. The measurements between root canal center and the furcation area were determined. The statistical analysis was performed using the t-test for paired samples (á=0.05). **Results:** The values for dentin thickness in the risk zone before and after root canal flaring with Gates-Gliden drills were 1.096 (± 0.27) mm and 0.742 (± 0.24) (p<0.01), respectively. **Conclusions:** The proposed method assures the same positioning of the samples before and after root canal preparation. It is extremely important, as any mesiodistal or buccolingual movement can produce a different topogram for comparison procedures.

Keywords: cone-beam computed tomography, anatomy cross-sectional, image processing computer-assisted, endodontics.

Introduction

The evaluation of root canal instrumentation is necessary to determine the action of the instruments on the original canal shape[1-2] and to observe if the principles of canal preparation had been followed[3]. The thin area in the root canal wall (risk zone), vulnerable to stripping by injudicious filing[4], has been analyzed using microscopic analyses[5-6], silicone impressions[7], muffle system[8-14], Endodontic Cube[15-16], multi-slice computed tomography[17] and cone-beam computed tomography (CBCT)[18].

CBCT evaluation has shown that the exact location and anatomy of the root canal system can be assessed[19-21] and it has been validated as a tool to explore root canal anatomy[22]. Furthermore, it has been successfully used for measurements

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Correspondence to:
Francisco Montagner
Universidade Federal do Rio Grande do Sul,
Faculdade de Odontologia
Rua Ramiro Barcelos 2492, CEP: 90035-003
Bairro Bom Fim - Porto Alegre, RS - Brazil
Phone/Fax: +55 51 33085430
E-mail: francisco.montagner@ufrgs.br

before and after instrumentation of root canals and for determining the amount of dentin removed during cleaning and shaping of root canals[18].

However, a method has not been proposed to standardize the positioning of samples for obtaining images or topograms before and after root canal preparation by CBCT. It is extremely important because any displacement of the sample in both buccollingual and mesiodistal directions will not provide pre- and post-instrumentation image superimposition. Therefore, the aim of this study was to develop a methodology to standardize specimen positioning before and after image acquisition by CBCT.

Material and methods

This study was approved by the Ethics Committee of the Santa Maria University, Santa Maria, RS, Brazil.

Sixteen extracted periodontally involved mandibular molars with complete root formation were radiographed and stored in 0.1% thymol solution at 9º C. Teeth were placed under tap water for 12 h prior to use to eliminate residues of the storage solution. The teeth that exhibited previous endodontic manipulation, internal or external resorption, were excluded from the study.

Coronal access was performed using a #1014 diamond bur (KG Sorensen Cotia, SP, Brazil) followed by a Endo-Z drill (Dentsply, Maillefer, Ballaigues, Switzerland). The root canal of each tooth was flushed with 2.5% NaOCl (Manipulation Pharmacy, Nova Derme, Santa Maria, RS, Brazil) and explored using a size 10 K-ûle (Dentsply Maillefer) until the apical foramen was reached. Root canal length was determining through the visualization of the #10 file tip.

The entire root apex was covered with colorless nail polish (Colorama, Procosa Produtos de Beleza Ltda, São Paulo, SP, Brazil), to avoid the penetration of acrylic resin into the root canal system. A plastic box (1.5 cm x 1.5 cm x 1.5 cm) was used as guide where the teeth were inserted. The plastic boxes were lubricated with solid Vaseline (Rioquímica, São José do Rio Preto, SP, Brazil). Each tooth was placed inside the plastic box and the self-curing acrylic resin was inserted to position the teeth, without covering the crown (Figures 1A and 1B). After 24 h, the acrylic resin was polished (Arotec, Cotia, SP, Brazil) with 200-, 400- and 600-grit abrasive paper for 30 s each (Alcar abrasivos, Vinhedo, SP, Brazil). The specimen's surface were covered with a thin layer of separating medium (Cel-Lac; S.S. White, Rio de Janeiro, RJ, Brazil).

A 10 cm x 10 cm x 3 cm wood box was made to serve as a template to insert the type III plaster (Polidental Ltda., Cotia, SP, Brazil) (Figure 1C). The internal surfaces of the wood box were covered with plastic film (Wyda, Sorocaba, SP, Brazil) to favor cast dislodgement after setting period. The plaster was then prepared and inserted in the box. The specimens were placed inside the apparatus as shown in Figure 1D. After the plaster setting, the specimens were removed. Both specimens and the spaces that were formed in the casts received a code to identify them (Figure 1E).

After 24 h, the specimens were replaced in the cast according to the codes and 3-dimensional CBCT images (GX CB-500 POWERED BY i-CAT) were obtained with exposure time of 26 s, operating at 120 Kvp and 5 mA. CBCT imaging was performed with the 0.25-mm voxel size. The reconstruction of the sections was performed.

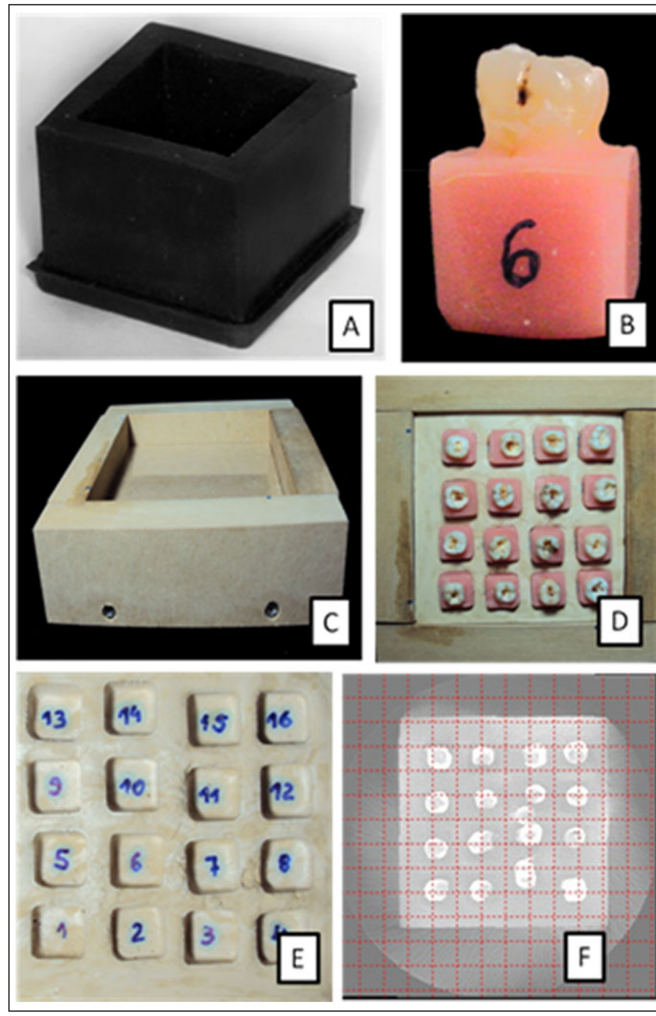

Fig.1. Sample preparation and imaging acquisition: A) Plastic cube; B) Specimen embedded in acrylic resin; C) Wood mould; D) Specimen embedded in gypsum; E) Numbering of specimens in the corresponding depression; F) Mould of gypsum aligned through the rotation tool.

Cervical instrumentation of the root canals was performed with size 1 and 2 Gates-Glidden I (Dentsply, Maillefer) under irrigation with 2.5% NaOCl.

The specimens were then replaced on the apparatus and a new CBCT imaging acquisition was performed as previously described. IcatVision® software (Dental Imaging System, Salt Lake City, UT, USA) was used to equalize the images before and after instrumentation. The images were aligned, observing the axial vision, through the rotation tool (Figure 1F). The MPR Screen was selected for measuring. The "zoom" tool was applied to allow a better visualization of the tooth. The vertical (blue and red) and horizontal (green) bars were used as reference to align the images. The tool "distance" (on coronal section) was employed to determine the measure from the highest point of the furcation area up to 2 mm apically. Then, the horizontal bar was adjusted 2 mm from furcation area (Figure 2A), generating an image in the axial section. The distance from the center of the root canal to the furcation area were determined (Figures 2B and 2C).

Statistical analysis was carried out in the BioEstat 5.0 (Fundação Mamirauá, Belém, PA, Brazil), and the t-test for paired samples was used for the comparison between groups ($p<0.01$).

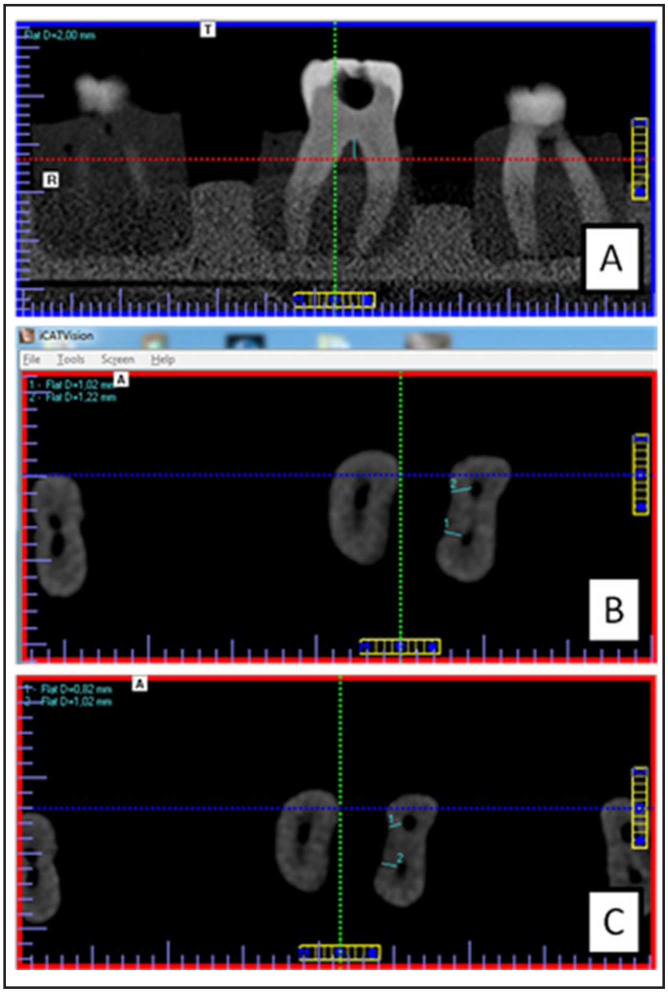

Fig. 2. Data acquisition and processing: A) Measurement from the highest point of the furcation area to 2 mm apically; B) Measurement of the risk zone before cervical preparation; C) Measurement of the risk zone after cervical preparation.

Results

The values for dentin thickness in the risk zone before and after cervical flaring with Gates-Gliden drills were 1.1373 (± 0.2851) mm and 0.7573 (± 0.2663), respectively. There was statistically significant difference between groups. The values showed a small dentin thickness after cervical flaring with Gates-Gliden drills (Figure 3).

Discussion

CBCT allows evaluating root canal preparation without cutting off the specimens and loosing the root canal structure

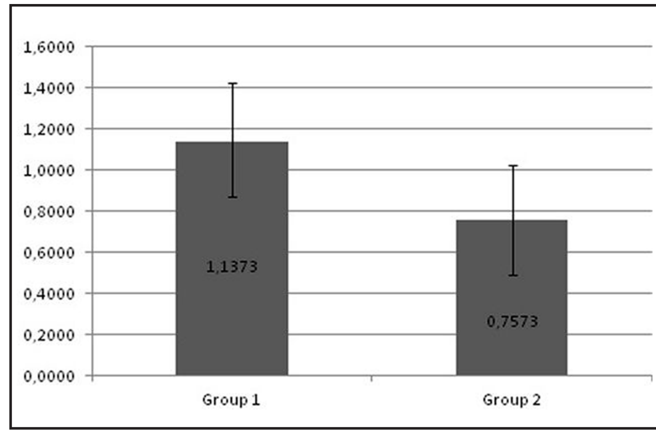

Fig. 3. Mean values and standard deviations for the distances between the root canal center and the furcation area for Group 1 (before Gates-Glidden preparation) and for Group 2 (after Gattes-Glidden preparation) samples.

material during sectioning[18-23]. The methodology proposed in this study permits standardizing specimen positioning for acquisition of CBCT images before and after cervical flaring. We used squared gypsum pattern in order to align the samples through the horizontal and vertical bars of the software IcatVision®. The images before and after preparation were superimposed. In addition, we used two computers to evaluate the pre- and post-instrumentation images, which were standardized and measured in the software. Thus, there were no other image manipulation programs for generating distortion attempt to superimpose images of the same size before and after preparation. In addition, the "zoom" tool was employed in order to best measure the specimens.

Dentin thickness in the risk zone after the action of instruments for cervical flaring can be evaluated by different methodologies. Methods that use cross-sections of the sample do not provide an adequate stabilization for the tooth structure[16]. This study suggested a standardizing methodology for acquisition of CBCT images. Assessment of the risk zone could be carried out by micro-computed tomography (µCT), but it is time-consuming, expensive and not always available in all research centers.

Several methods have been proposed for standardization of imaging acquisition. Bramante (1987)[24] suggested a method in which images obtained from root slices were superimposed to detect alterations that were produced after root canal preparation. Zaia et al. (2000)[25], Wu (2005)[26] and Sauáia et al. (2010)[23] modified the previously described methodology and suggested to include the teeth in acrylic resin. Coutinho Filho et al. (2008)[14] used a plastic tube and a metallic strip to guide the slices repositioning. Our study also adopted this protocol in order standardize the position of each section to evaluate the same sample before and after root canal preparation. However, the squared-shaped samples inside acrylic resin blocks were placed in a box with plaster to guarantee their perfect repositioning. CBCT was also adopted to avoid sample sectioning, ensuring that a significant loss of dental structure did not occur.

It is feasible to conclude that the use of the present methodology allows comparing specimens before and after root canal instrumentation, since image superimposition was obtained after acquisition of CBCT images.

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