Evaluation of the preparation of root canals with two different systems using micro-computed tomography

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ABSTRACT

Introduction: Root canals with long oval cross section make it difficult for rotating tools, which can not be adapted to the walls in its entire extension. The Reciproc single-file system (VDW, Munich, Germany) was developed for the root canal preparation by the reciprocal motion technique. The reciprocal motion relieves the instrument stress, reducing the risk of cyclical fatigue, caused by the tension and compression. **Objective:** The objective of this study was to evaluate, *ex vivo*, the long oval root canals preparation of lower molars with Reciproc system, comparing it to the preparation with complete rotating tools, BioRaCe, by means of micro-computed tomography. **Methods:** The distal roots of thirty lower molars were used and randomly divided in two groups: G1, Reciproc R40; and G2, BioRaCe. Teeth were scanned by a SkyScan 1172, before and after the root canals preparation. The images obtained were imported, reconstructed and, then, analyzed for comparison of changing in the volume of root canal. **Results:** The results were subjected to Mann-Whitney non-parametric statistical test, for the volume analysis. The root canal preparation resulted in increased volume, with significant difference between groups (p < 0.5). **Conclusion:** The Reciproc system removed more dentin from the walls than the BioRaCe one.

Keywords: Dental instruments. Root canal preparation.

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Introduction

The anatomical complexity of root canals, such as canals with oval cross section, long oval (different from the circular one), still represents a challenge for the adequate preparation of wall surfaces of these canals.[1-4] There is a tendency, in such cases, in keeping the non-prepared and contaminated areas of the root canal. In canals with these anatomical conditions, literature reports several studies showing that both manual instrumentation and the continuous rotary instrumentation have left untouched areas.[3,5-8] Not removing the debris on the walls of root canal may compromise the success of endodontic therapy.[9,10]

In the conventional rotating systems, we face a difficulty in instrumenting canals with cross section different from circular ones, once there is a tendency in centralizing the tool, working less in the poles of these canals.[2,4] Searching for a more adequate action of these instruments, it is recommended the brushing movement of the instrument, which rotates continuously, into the poles so that these areas are also reached. Recently, new systems propose instruments with reciprocal motion.[10-13]

Micro-computed tomography (µCT) has got important significance in Endodontic researches, for being a non-invasive method, allowing the three-dimensional analysis of the root canal system,[14-21] as in the evaluation of the instrument action in the canal wall.

The objective of the present study was to evaluate, *ex vivo*, the preparation of long oval canals of lower molars, performed by two mechanical systems: Reciproc, with reciprocal motion; and BioRaCe, with continuous rotary instrumentation. As quality criteria of the preparation, volume changes were evaluated after using each system, with micro-computed tomography.

Material and Methods

Teeth selection

After approval of the Research Ethics Committee of the School of Dentistry of the São Paulo University (FOUSP), thirty extracted lower molars were selected, donated by the Human Teeth Bank (FOUSP). The distal root of these teeth was used.

The teeth had a single canal in the distal root and

the angle of curvature was inferior to 20°.[22] When the buccolingual diameter was, at least, 2.5x bigger than the mesiodistal at 5 mm of the root apex, to canals were classified as long ovals.[23,24] These measures were carried by an digital image processing system, Image Tool (University of Texas Science Center, California, USA).

After the surgical access, the root canal were explored with a manual #10 K-file, and the actual working length (AWL) was determined when the end of the instrument was observed through the apical foramen, with the aid of an operating microscope (Alliance, São Paulo/SP), with 8x magnification, pulling back 1 mm.

Teeth were distributed randomly in two experimental groups: G1, Reciproc R40 (n = 15); and G2, BioRaCe (n = 15).

The samples scanning was carried before and after canal preparation, using the device SkyScan 1172 (Kontich, Belgium), with 100 kV, 100 µA, and isotropic resolution of 11. 88 µm. The objects rotate at 180°, with 0.4° of rotating speed. Total time for image scanning was 49 minutes and for image reconstruction was 13 minutes, totalizing 1 hour and 2 minutes for completion.

Canal preparation

Root canals preparation, in all experimental groups, was carried by a single operator.

G1: Reciproc R40
(Reciprocal motion system)

In this group, distal roots were used, which allowed the introduction of a manual #20 K-file, passively until the AWL, as criteria for selection of the R40 instrument for their preparation. No manual instrument was used to create a free path, following the manufacturer's instructions. The activation of the R40 instrument happened with the electric motor Silver Reciproc VDW (VDW, Munich, Germany), adjusted for reciprocal motion, coupled to the handpiece Siron 6:1 (Sirona Dental Systems GmbH, Bensheim, Germany). This instrument operated in a reciprocal motion of 10 cycles per second, taking 3 cycles to rotate 360°.[12] After the AWL determination, the root canals were prepared as following:[12,13] Slow brushing movement of the activated instrument inside and out of the

root canal, small amplitude and light apical pressure; continuation of the canal preparation until reaching around 2/3 of the working length, and advancing the instrument to the AWL established. Always verifying if any obstruction occurred, with a manual #10 K-file. Each time the instrument was removed, new chemical substance was placed, using 3 ml of 1% NaCl, associated to Endo-PTC gel.[25]

Once Reciproc is single-use, fifteen instruments were used, thus, avoiding any influence on the obtained results. Final irrigation was performed with 5 ml of 17% EDTA, followed by more 5 ml of 1% NaCl.[25,26] Then, the canals were aspirated with Capillary tips and dried with sterile paper points. Pulp chambers were sealed with temporary sealing material.

G2: BioRaCe (n = 15)

Root canals selected for this group were, Initially, manually prepared with #8, #10 and #15 files in the working length and, then, with BioRaCe files, with the electric motor Silver Reciproc VDW adjusted to complete rotary motion, 500 rpm. The first rotary file BRO (25/0.08) prepared the 4-6 mm of the cervical third, a BR1 (15/.05), BR2 (25/.04) and BR3 (25/.06) were for the AWL. BR3 reached easily the AWL, so BR4 (35/.04) and BR5 (40/.04) carried the final apical preparation.[10,27]

The instruments were used back-and-forth, brushing against the walls of the root canal.

At each file change, 3 ml of 1% NaCl was used as irrigation substance, associated to Endo-PTC gel.[25] Recap was performed with #10 K-files in the AWL, at every instrument change.

The final irrigation, aspiration and sealing were carried out as described for the Reciproc group.

In order to avoid the instrument fracture, interference on the preparation quality and being in accordance with the studies reported in literature,[27,28] each set of BioRaCe was used three times.

Evaluation of the canal preparation

Images were reconstructed and evaluated from the root apex to the cementoenamel junction, in, around, 400 slices for specimen.[16]

The software CTan v 1.12.0.0 (SkyScan) allowed the 2D/3D volumetric analysis of the images. This analysis was carried according to recent works found in literature,[8,19,20,21,29-32] and the root canal volume change was calculated subtracting the values from the canals before preparation. The increase percentage (%Δ) was calculated using the values from before (A) and after (D) the preparation, according to the formula:[31]

$$\%\Delta = (A*100/D)-10$$

RESULTS

Facing the abnormality of samples distribution, non-parametric tests were chosen. For the analysis between groups, the Mann-Whitney test was applied in the volume increase comparison.

Three-dimensional evaluation of the volume change in the root canal

None of the instruments were broken during the root canal preparation.

In the groups of specimens prepared by Reciproc, the initial volume of total root canal varied from 2.70 to 13.31 mm³.

The distal root canal preparation resulted in the increased volume with significant difference between the groups (p < 0.5). The average of this increase in all roots from the Reciproc was of 2.52 mm³, while in BioRaCe it was 2.24 mm³. The percent average of volume increase was of 27.52% and 26.31%, respectively, for the Reciproc and BioRaCe systems, without statistically significant difference.

The morphometric changes of the root canal volume increase, in mm³, are presented in Table 1.

Different capital underlined letters between systems shows statistically significant difference.

Discussion

Endodontics comprises correct diagnosis and treatment of pulp diseases and its consequences in adjacent periapical tissues. The efficient preparation and cleaning of the root canal represent a crucial step to reach the objectives of the root canal treatment.[33]

One of these objectives is the removal of the infected dentin layer, which is especially difficult in the preparation of root canals with cross-section different from the circular one: Oval, long oval or flat. The infected recesses are potential retainers of bacterias,

Table 1. Morphometric absolute (Δ) and percent (%Δ) volume changes (mean ± standard deviation) of the root canal for the systems Reciproc and BioRaCe.

System		Volume
Reciproc	Δ	2.52 ± 1.66[A]
	%Δ	27.52 ± 18.98
BioRaCe	Δ	2.24 ± 1.96[B]
	%Δ	26.31 ± 18.39

which may compromise the success of the endodontic treatment.[9,10] In the attempt of extending the root canal preparation to other directions for the inclusion of such areas, it may lead to complications, such as perforations, on the canal danger zone.[2,4]

Due to this situation, several techniques of preparation and instruments have been studied and reported in literature, on an effort to solve the difficulty in preparing these canals, especially the long-oval ones.[8,10,11,12,34]

The technological advancement allowed the improvement of evaluation tools for root canal preparation, of resolution of images obtained without invasion; and CT came as a method of evaluation for research in Endodontics, allowing the detailed reproduction of internal and external anatomy of the tooth, as well as the evaluation of the instrument action on the root canal, without compromising the sample.[14-18] Once the information is stored, it is available for future evaluations, i.e., the original information of the healthy tooth is not lost. In the present work, the isotropic resolution of the microtomography was of 11.88 μm, which increases the sensibility of the device, reduces the artifact and results in a better contrast and detailing of the image.

The present study evaluated the quality of preparation of long oval root canals performed by two mechanical systems: Reciproc and BioRaCe, using micro-computed tomography. As quality criteria of the preparation, the volume was analyzed.

Trying to investigate the possibility of new instruments and techniques improving the preparation of oval canals, the system BioRaCe was selected to be the control group in the comparison of results obtained with the Reciproc system.

The Reciproc single-file system is fabricated from a special alloy NiTi "M-wire", created by an innovative process of thermal-treatment, providing greater flexibility and resistance to cyclic fatigue, combined to reciprocating movement (150° counterclockwise/30° clockwise) with instrument relief in clockwise movement.[35,36,37] Its "S" shaped cross section, according to the manufacturer, allows progression in apical direction. On the other side, the instruments of BioRaCe system with continuous rotary movement present triangular cross section, electrochemical surface finishing and variable helical angle in order to avoid the screwing effect on the root walls.[28]

The instrument selected by Reciproc was R40, due to the passive insertion of a #20 file until the AWL in the distal canal of teeth included in the study, and it was used back-and-forth, and brushing laterally to allow the preparation of all walls with long oval cross section.[12] In the BioRaCe system, the preparation was performed with a sequence from BR0 to BR5.[10,27] The instruments were also used back-and-forth and laterally against the root canal walls.

It is important to emphasize that the apical preparation of Reciproc (R40) and BioRaCe (BR5) were equivalent for both having #40 diameter (D0), thus allowing the comparison between them.

The same parameters of microtomography were used for obtaining and reconstructing images after the root canal preparation, for the postoperative readings and posterior comparison of results.

The volume of interest of reconstructed images after scanning was from the root apex to the cementoenamel junction, in approximately 400 slices for specimen.[16,37]

The quality of the preparation was evaluated quantitatively by the volume increase parameter accessed by the μCT. The volume analysis was carried according to recent works found in literature and the root canal volume change was calculated subtracting the values from the canals before preparation.

The percentage of volume increase was calculated using the measurements from before and after the root canals preparation, with the Versiani et al[31] formula.

The evaluation considered the entire root canal. The pre- and post-preparation images, in this case, were not superimposed. The parameter is evaluated individually by the exact determination of the volume of interest.[8,20,29]

Regarding the increase, in the analysis between groups there was statistically significant difference, which disagreed of the reports from other studies.[8,19,32] The Reciproc system was able to remove more dentin than BioRaCe.

As for the percentage of volume increase, the value for the Reciproc system was 27.52% and 26.31% for BioRaCe, with no significant difference in this case (p > 0.5). It means, in the percent evaluation of what really represents the action of the instrument in the root canal surface, there was no statistically significant difference between systems.

Of course, the high cost of the X-ray micro-CT is an obstacle to the better use of this tool in Brazilian researches, but the high correlation of images obtained with the real object and the values from analysis only possible with this tool with overcome all the obstacles. Due to the obtained results, further studies are suggested, assessing and comparing different techniques and/or endodontic instruments, regarding the quality of the canals preparation, exploring other parameters besides the root canal volume.

Conclusion

Based on these results obtained here, it was concluded that:

1) The evaluated systems behaved differently on the quality of preparation, when compared to the volume increase.

2) The Reciproc system promoted greater increase in the entire extension of the canal, when compared to the BioRaCe system.

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