Microtomography evaluation of glide path length influence on volume and apical limit of root canal fillings

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DOI: https://doi.org/10.14436/2358-2545.7.2.015-020.oar

ABSTRACT

Objective: The objective of the present study was to evaluate the influence of the glide path length on the apical volume and limit of root canal fillings using PathFile instruments. **Methods:** Thirty-four root canals from seventeen mesial roots of mandibular molars were divided into two groups based on the glide path length created using #13, #16, and #19 PathFile instruments: Group 1 (G1) – full root canal length; Group 2 (G2) – 1 mm short of the apical foramen. Next, the root canals were instrumented with the Reciproc R25 until 1 mm short of the apical foramen in both groups and filled with AHPlus and gutta-percha using the single cone technique. The volume of material used to fill the 3 mm apical portions of the canals and the distance from the filling to the apical foramen were determined through microtomography. The data were compared statistically and the Mann-Whitney test was used to evaluate differences between groups. **Results:** No statistically significant difference was observed for the volume of the material used to fill the canals between groups ($p > 0.05$). However, the distance between the apical limit of the filling material and the apical foramen was significantly different between groups G1 (0.4335 mm) and G2 (1.241 mm) ($p < 0.05$). **Conclusions:** The creation of a glide path within the root canal length favors a limit of the root canal filling closer to the apex that was statically significant, although it was not significant regarding to the volume.

Keywords: Endodontics. Root canal obturation. X-Ray Microtomography.

How to cite: Fruchi LC, Vivan RR, Alcalde MP, Andrade FB, Duarte MAH. Microtomography evaluation of glide path length influence on volume and apical limit of root canal fillings. Dental Press Endod. 2017 May-Aug;7(2):15-20.
DOI: https://doi.org/10.14436/2358-2545.7.2.015-020.oa

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» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Submitted: June 02, 2016. Revised and accepted: March 14, 2017.

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Introduction

Maintenance of the original anatomy of root canals while using rotary instruments without inflicting any damage to the tooth has been a major concern. However, the establishment of a glide path before using rotary instruments is known to address this concern.[1-5]

The glide path is the creation of root canal patency from the open orifice canal access to the apical foramen. It creates an enlargement within the root canal before instrumentation with rotary or reciprocating motion instruments, with the intention of avoiding stresses that could fracture the instruments.[6] Furthermore, the ability to reach the working length could be improved by avoiding the so-called "taper-lock effect".[2,3] The use of hand instruments to create a glide path is technically difficult and risky when compared to rotary instruments.[2,4] The manufacturer of the Reciproc instrument believes that the creation of a glide path prior to the use of reciprocating instruments is not necessary in most treatments.[7,8]

In recent years, the use of a glide path before root canal instrumentation has been studied to determine the various factors that influence root canal transportation, deformation, and torsional and fatigue stress.[2-5,9] However, there are no reports that evaluate the influence of the glide path limit with PathFile instruments (Dentsply; Maillefer, Ballaigues, Switzerland) on the apical volume and limit of the root canal filling.

The purpose of the present study was to create a glide path using PathFile instruments at different working lengths, before the use of a rotary instrument (Reciproc; VDW, Munich, Germany), and evaluate its influence on the apical volume and limit of the root canal obturation. The null hypothesis was that the length of the glide path does not interfere with the limit and apical volume of the root canal filling.

Material and Methods

The present study was conducted under the approval of the Ethics Committee of the Bauru School of Dentistry, University of São Paulo (#1.093.113). Forty human mandibular molars with curved mesiobuccal canals, donated by the Human Teeth Bank of the University of São Paulo, São Paulo, Brazil, were used in the study.

The teeth were digitally radiographed in the bucco-lingual and mesio-distal directions with an exposure time of 0.16 s using the Schick CDR X-ray digital system (Schick Technologies, Long Island, NY). This was done in order to select the teeth and divide them into two groups with similar characteristics, as the root canal length and curvature, and the Vertucci classification (II and IV), which were distributed in a balanced way to ensure the homogeneity between the groups regarding the anatomy. The chosen teeth were those which apical foramens were possible to be bypassed with slight resistance to the tip of a #10 K file instrument (Dentsply; Maillefer, Ballaigues, Switzerland). All root canal treatments and measures were made by the same skilled professional.

The crowns of the teeth were flattened to a length of 16 mm with the aid of a diamond disc (FKG, Dentaire, Switzerland). The patency and working lengths of the root canals were established by inserting the tip of a #10 K file until the apex and observing them with an operatory microscope at 8X magnification (Alliance, São Paulo, Brazil). PathFiles (Dentsply; Maillefer, Ballaigues, Switzerland) #13, #16, and #19 files were used to make the glide paths.

The teeth were divided into two groups based on the length of insertion: Group 1 (G1) – PathFiles files were inserted until the full length of the canal: Group 2 (G2) – PathFiles files were inserted until 1 mm before the full canal length, which correspond to 1 mm below the patency.

The PathFiles were used with VDW electric motors (VDW, Munich, Germany) at a speed of 300 rpm and a torque of 60 g/cm. Subsequently, all teeth were instrumented with R25 Reciproc files (VDW) until the working length, established at 1 mm short of the full canal length, corresponding to 1 mm from patency. The Reciproc instrument was used with the corresponding VDW electric motor as per the Reciproc program; with three in and out pecking motions using light apical pressure until it reached the working length. During the glide path formation and root canal instrumentation, 2.5% sodium hypochlorite (Formula & Ação Farmácia, São Paulo, SP, Brazil) was used as an irrigant. Final irrigation was done with 1 ml of 17% EDTA (Formula & Ação Farmácia, São Paulo, SP, Brazil) for 1 minute followed by a final rinse with 2 ml of 2.5% sodium hypochlorite. The canals were then

dried with R25 paper points and filled with R25 single cones (VDW) and AH Plus sealer (Dentsply) using the single cone technique. The teeth were again digitally radiographed in the bucco-lingual and mesio-distal directions with an exposure time of 0.16 s using the Schick CDR X-ray digital system (Schick Technologies, Long Island, NY) in order to evaluate the quality of the root canal filling.

The crowns were temporarily sealed with Citodur (Dorident, Wien, Austria) temporary restorative material and stored at 37°C and 100% humidity for three months.

After the storage period, the teeth were mounted on a custom attachment and scanned in a micro computed tomography system (micro-CT) (SkyScan 1174; Bruker-microCT, Kontich, Belgium) using the following voxel parameters: 50 kV, 800 µA, and an isotropic voxel size of 39 µm. Other parameters used were 360° rotation, 0.8° step rotation and 0.5 mm aluminum filter. The samples were reconstructed with the NRecon software version 1.6.3 and the axial cross sections were obtained with parameters of Beam Hardening Correction of 30 %, Ring Artefact Correction of 4.

Subsequently, 17 teeth, 9 teeth from G1 (n = 18 root canals) and 8 teeth from G2 (n = 16 root canals), presenting Vertucci type IV canals (two independent canals with a mean curvature angle of 24° and mean length of 10.75 mm) were chosen for analysis. The other 23 teeth were excluded because they were either corresponding to Vertucci type II or due to anatomic discrepancies between groups.

Volumetric analyses of the 3D models were made with similar parameters with the CTAn v. 1.12 software (Bruker-microCT), divided into three segments of 3 mm each, which corresponded to the apical, middle and cervical portions. The angle of the root canal curvature was measured as described by Schneider.[10] The volume of the filling material in the 3 mm apical close to the foramen was calculated from the binarized area inside the region of interest. The canal lengths and distance of the filling material to the apex were measured through the path measure tool of CTAn v. 1.12 software (Bruker-microCT)), in bucco-lingual and mesial-distal views. The longer distances found were considered. The softwares Data Viewer v. 1.5.1 64-bit (Brucker-microCT) and CTVol v.2.3.1 (Bucker-microCT) were used for qualitative evaluation.

Statistical analysis was performed using the Prism 6.0 software (GraphPad Software Inc., L Jolla, CA, US). The normality of the data was analyzed by the Shapiro-Wilks test, and due to the absence of normality, the Mann-Whitney test was used to compare the groups regarding the volume of the filling material in the apical third and length from the end of the filling material to the apical foramen. The significance level was established at 5%.

Results

Table 1 presents the median, minimum and maximum values of apical volumes of the filling material, and apical lengths (distance from the end of the filling material to the apical foramen). The volumes of filling material did not significantly differ between the two groups ($p > 0.05$). On the other hand, a significant difference was observed for the lengths of the canal filled, between the groups, G1: 0.4335, 0 – 1.69 mm; G2: 1.241 mm, 0 – 2 mm ($p < 0.05$).

Table 1. Median, maximum and minimum values of the apical volumes and apical lengths (distance from the end of the filling material to the apical foramen) for the two groups (G1 and G2).

	Apical volumes (mm^3)		Apical lengths (mm)	
	G1	G2	G1	G2
Median	0.7581[a]	0.4388[a]	0.4335[a]	1.241[b]
Minimum	0.2235	0.2072	0	0.0000
Maximum	1.008	1.062	1.69	2.000

G1: the glide path length was created along the full canal length; G2: the glide path length was created until 1 mm short of the full canal length. Different letters indicate the statistical significance differences ($p < 0.05$).

Discussion

The null hypothesis was rejected since the apical limit of the glide path influenced the apical limit of the root canal filling. Several studies have reported the importance of creating a glide path before instrumentation, and its influence on the fatigue and torsional resistance, as well as deviation and/or preservation of the root canal anatomy.[2-4,11] One study reported that pre-flaring or creation of a glide path before instrumentation using Reciproc instruments is not necessary in most root canal treatments.[8] However, in the present study, the apical limits of the root canal filling ranged between 0 and 1.69 mm for all teeth in G1, and 0 and 2 mm in G2. The teeth from G1 presented an apical limit of filling closer to the foramen, when compared with those from G2 (mean difference of 0.60 mm) (Fig 1).

In this study the canals were instrumented to the same master apical file size and were filled with a corresponding single cone obturation technique. In this situation the volume of filling material in the apical region would be the same. In the present study, Reciproc files reached the working length easier and with more precision in G1 than in G2, probably due to the bigger preflaring that the PathFile made near the apical foramen in G1. It could make difference in the volume and length of the filling material between groups. Most sealers and gutta-percha cannot be differentiated through micro-CT; furthermore, they were considered as the same unit.[12] Therefore, achieving patency at the full canal length avoided the vapor lock effect, allowing better irrigation of the apical region[13] which could allow the filling material (sealer and/or gutta-percha) to reach the apical area easier.

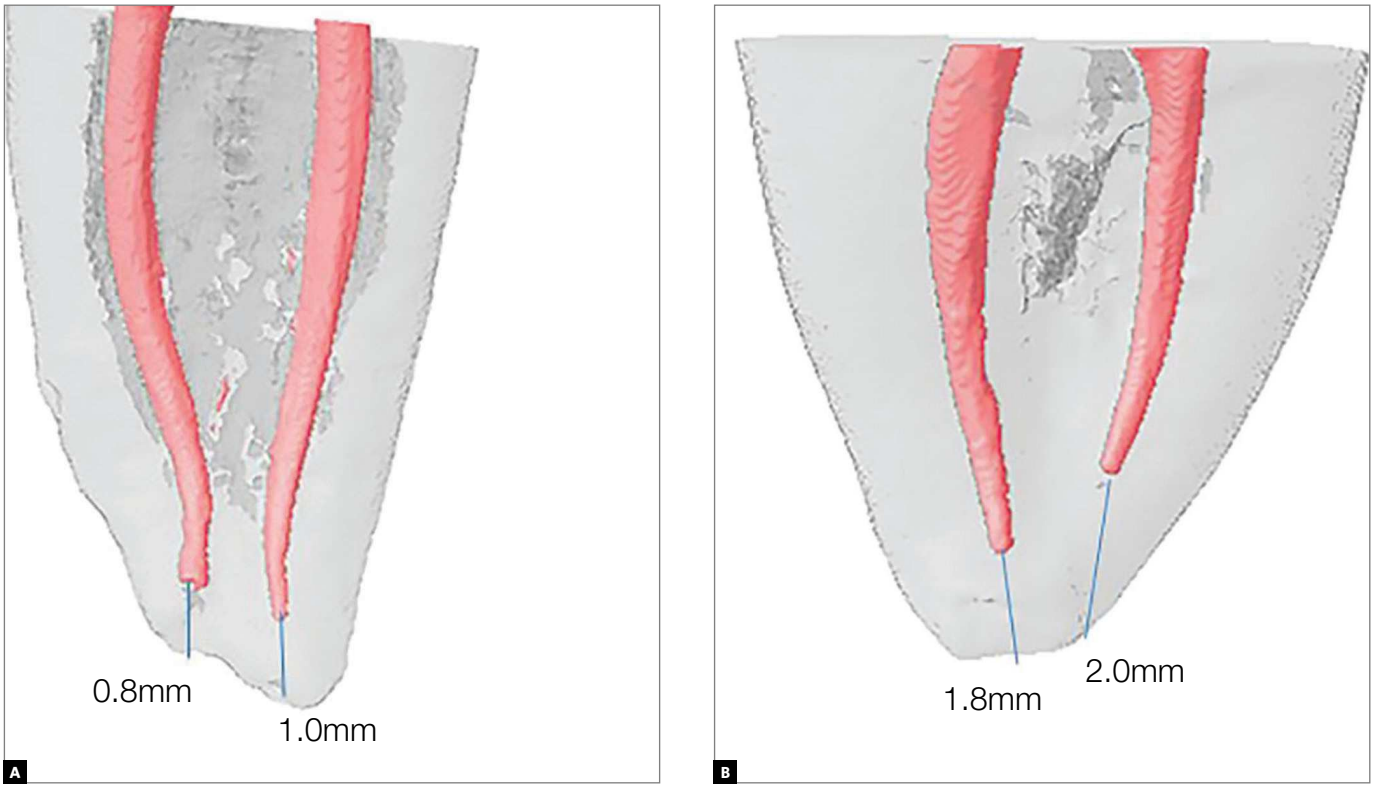

Figure 1. Micro-computed tomography reconstructions of representative samples from Group 1 (**A**) and Group 2 (**B**). The filling material in the canal using PathFile instruments along the full canal length (**A**), and 1 mm shorter from the full canal length (**B**).

In G1 the instruments are in contact with a greater surface area of the root canal walls. Clinically it could lead to better cleaning and disinfection, which can favor the predictability of the success of the root canal treatment.[14,17] and, according to the present study, a better limit of the filling. Although the limit of the instrumentation and the filling material is controversial, several studies showed that these limits should be within 2 mm from the radiographic apex, at or short of the apical constriction.[16-18] Therefore, the relevance of this study evaluating the volume and length of filling material between groups with the glide path in different lengths is justified.

In the present study, the working length was determined by observing the tip of the instrument at the root apex with the aid of an operatory microscope.

In clinical settings, the determination of the working length using electronic foramen locators is a reliable method, with the added advantage of reducing radiographic exposure.[19,20]

The full length of the canals, curvature degrees, filling material volume, and the distance between the final limit of the filling material inside the canals to the apical foramen were evaluated by micro-CT, which is an excellent method for the evaluation of root canals.[21] The volume of the filling material has also been evaluated through microtomography.[22,23]

Studies on root canal deviation, thickness of the remaining dentin, and centering ability with or without the creation of a glide path[24,25] have reported that glide paths favor lesser root canal deviation as well as centering of the root canal instrumentation.

In this study the results showed that the creation of a glide path within the root canal length favors a limit of instrumentation and filling closer to the apex. Regarding the volume of filling material, the glide path within the root canal length (G1) showed greater volume than the group where it was 1 mm short of the foramen (G2), although it was not statistically different. Further studies should be conducted in order to better understand the influence of the glide path limit on the extrusion of debris.

Within the limits of the present study, it was concluded that the use of PathFiles for the creation of a glide path along the full length of the root canal, before the use of Reciproc R25 instruments, enabled the limit of the root canal filling to be located closer to the apex.

Acknowledgements

This study was supported by State of São Paulo Research Foundation, FAPESP (2015/03829-1).

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