Effect of glide path preparation on apical extrusion of debris in root canals instrumented with three single-file systems: An ex vivo comparative study

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Abstract

Aim: The aim of this study was to test the effect of new protocol of glide path preparation by 20/0.04 rotary file on apical extrusion of debris when instrumenting fine curved mesial canals in mandibular molars with Self-adjusting File (SAF) and compare it to a glide path prepared by 20/0.02 hand K-file and rotary OneShape (OS) and reciprocating WaveOne (WO) file instrumentation.

Materials and Methods: Sixty mandibular molars with curved mesial roots were selected and randomly divided into three groups (n = 20) for instrumentation. In two groups, glide path was prepared using 20/0.02 K-file for instrumentation by OS (size 25/0.06 taper) and WO (size 25/0.08 taper) files; in the remaining group, 20/0.04 rotary file was used for glide path preparation and instrumented by SAF (1.5 mm). The debris extruded during instrumentation was collected in preweighed Eppendorf tubes and stored in an incubator at 70°C for 5 days. Tubes containing the dry extruded debris were then weighed. One-way analysis of variance (ANOVA) was applied to the weights obtained, followed by Tukey’s post hoc test for multiple comparison.

Results: The mean debris (g) extruded apically was 0.000651 ± 0.000291, 0.000823 ± 0.000319, and 0.000473 ± 0.000238 for Group 1 (20/0.02 + OS), Group 2 (20/0.02 + WO), and Group 3 (20/0.04 + SAF), respectively. The groups exhibited a significant difference (P < 0.01; ANOVA). Group 3 resulted in least debris extrusion compared to Groups 1 and 2 (P < 0.01; Tukey’s post hoc test).

Conclusion: Glide path prepared to size 20/0.04 and SAF 1.5 mm instrumentation produce less debris in curved mesial canals of mandibular molars, compared to glide path established by 20/0.02 and instrumentation by OS and WO files.

Keywords: Apical extrusion; glide path; instrumentation; OneShape®; Self-adjusting File; WaveOne

INTRODUCTION

The extrusion of debris formed by root canal instrumentation, which contains necrotic tissue, microorganisms, pulpal fragments, and dentin particles into the periapical region, cause postoperative inflammation.¹ All instrumentation techniques result in the extrusion of debris, even after the root canal preparation is carried out short of the apical terminus.²⁻⁸ Furthermore, advances in instrument design using different operational motions influence the amount of debris extrusion.⁹

Establishing a glide path prior motorized instrumentation creates a patent channel from the coronal access cavity to the apical terminus.¹⁰ It also helps in enhancing the
performance of the rotary nickel-titanium (NiTi) files[11,12] and reduces the extrusion of debris.[13] Most of the NiTi rotary and reciprocating files are flexible and have noncutting tips,[6,10] hence cannot be used for initial negotiation of the root canals.[14] Therefore, creating a glide path is recommended when using these file systems, especially in curved canals.[15] However, the manufacturers of single-file NiTi systems do not take into account the preliminary creation of a glide path before their use in canal preparation.[13]

With the Self-adjusting File (SAF), glide path preparation is extremely important as this file is hollow and does not possess penetrability per se.[16] The previous manufacturers’ instructions were to prepare a glide path till #20 K-file. Nevertheless, recently, Kfir et al.[10] reported that creating a glide path to #20 K-file might not be adequate for the SAF to reach the working length (WL) in curved canals. They reported that a glide path with size 20/0.04 taper rotary files successfully helped the SAF 1.5 mm file reach the WL in curved and fine canals. Consequently, manufacturer instructions for the use of SAF were changed and currently suggest the use of 20/0.04 rotary file for glide path preparation.

To the best of our knowledge, debris extrusion with the newly proposed protocol for SAF instrumentation for curved canals is yet to be reported. Hence, this laboratory study was designed to compare debris extrusion using single-file systems in curved canals after creating a glide path with 20/0.02 hand K-file for rotary OneShape (OS)® (Micro Méga, Besançon, France) and reciprocating WaveOne (WO) primary (Dentsply Maillefer, Ballaigues, Switzerland) single-file systems and 20/0.04 rotary file for SAF (ReDent Nova, Ra‘nana, Israel) instrumentation.

MATERIALS AND METHODS

Freshly extracted human mandibular molar teeth with fully formed apices and two roots were acquired. The inclusion criteria were: Teeth having curved mesial roots with two separate canals and curvature angles ranging from 20° to 40° according to Schneider.[17] Narrow canals, in which size only 15 K-files or smaller could be inserted passively to WL, were used. Root canals having no apical patency, roots with canals wider than those indicated above, and roots with evident microcracks observed under microscope magnification of ×20 were excluded from the study. Following the above-mentioned criteria, sixty samples were selected for the current study. Soft-tissue remnants and calculi on the external root surface of these samples were removed mechanically.

Sample preparation

A standard access cavity was prepared for all the samples, followed by removal of the distal root and the coronal part of each sample, using a diamond-coated high-speed bur with air–water spray at the furcation level. The cusps were flattened using a high-speed bur under water-cooling, to obtain standardization of samples with WL of 18 mm. WL in the mesial canals was determined by inserting a size 10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) until it was seen from the apical foramen and 0.5 mm was subtracted from this length. Placing a #15 K-file to the measured WL and exposing mesiodistal and buccolingual radiographs to confirm two mesial canals followed this. Samples, in which #15 K-file failed to reach the apex, were prepared to accommodate this file. The coronal third of all the samples was funneled using Gates Glidden drills (#1–#3) to gain coronal flare.

For the preparation of glide path and subsequent instrumentation, the samples were then divided into three groups. A glide path with 20/0.02 NiTi hand K-file was prepared for two groups, which were later, instrumented using OS (25/0.06) and WO primary (25/0.08) files and using 20/0.04 rotary file for a group followed by instrumentation with SAF (1.5 mm) file.

The purpose of this study was to compare debris extruding apically by newer concepts of establishing a glide path by size 20/0.02 taper hand K-file, followed by rotary OS and reciprocating WO single files, and reported concept of establishing glide path with 20/0.04 rotary file, followed by instrumentation with SAF.

Debris collection

The present study used the experimental model described by Myers and Montgomery[18] to assess the debris extruded periapically. An analytical balance (Sartorius Cubis, Göttingen, Germany) with an accuracy of 10⁻⁶ g was used to measure the initial weights of the tubes. Three consecutive weights were obtained for each tube, and the mean was calculated. Each tooth was inserted up to the cementoenamel junction, and a 27-gauge needle was placed alongside the stopper as a drainage cannula to balance the air pressure inside and outside the tubes. Then, each stopper, with the tooth and the needle, was attached to its Eppendorf tube, and the tubes were fitted into vials. The same operator trained to use all the file systems efficiently carried out the instrumentation. The Eppendorf tube was covered with a silver foil to prevent the operator from seeing the apex during instrumentation [Figure 1].

Glide path preparation and instrumentation

Group 1: 20/0.02 + OneShape®

The glide path for mesial root canals of the twenty samples in this group was prepared with NiTi 20/0.02 hand K-file (Dentsply Maillefer, Ballaigues, Switzerland) until the hand file loosely fitted into the canal. The samples then received a final instrumentation with the OS® (25/0.06) rotary single-file system according to the manufacturer’s...
instructions, using a gentle in-and-out motion with a torque-controlled endodontic motor (X-Smart Plus, Dentsply Maillefer, Ballaigues, Switzerland) at 400 rpm and a torque of 4 N cm. These files were used in a brushing motion with minimal apical pressure. On meeting obstruction, the file was removed, the canal was irrigated, recapitulated, and the file was reintroduced into the canal. The instrumentation was continued till the file reached full WL and rotated freely.

**Group 2: 20/0.02 + WaveOne**
The glide path for the samples in this group was created as in Group 2 till #20 K-file. Then, final instrumentation was carried out using a preprogrammed reciprocating endo motor (X-Smart Plus, Dentsply Maillefer, Ballaigues, Switzerland) with a WO primary (25/0.08) reciprocating file in a pecking motion. The instrument was progressed to the apical third using minimal apical pressure. On meeting an obstruction or after three pecks, the file was withdrawn and the flutes of the instrument were cleaned; the canal was irrigated, recapitulated, and the file was reintroduced into the canal. Instrumentation was done until the WO file reached the apex.

**Group 3: 20/0.04 + Self-adjusting File**
The glide path was prepared with 20/0.04 rotary file (ProFile; Dentsply Maillefer, Ballaigues, Switzerland) for mesiobuccal root canals of the twenty samples in this group. The file was operated with minimal apical pressure for 3–4 pecks until it reached WL. After the glide path was prepared, the ability of the 1.5 mm SAF to reach WL was verified (Kfir et al. 2015). The samples received final instrumentation using the 1.5 mm diameter file with the SAF system (SAF Pro System; ReDent Nova, Ra’anana, Israel). The SAF file was operated in the canal with an in-and-out manual motion for 4 min, with 0.4-mm amplitude and 5000 vibrations/min, and continuous irrigation was done utilizing bi-distilled water with 0.4-mm amplitude and 5000 vibrations/min, employing a VATEA peristaltic pump (ReDent Nova, Ra’anana, Israel) at the rate of 4 ml/min. As a final rinse, a volume of 3 ml bi-distilled water was used for 3 min.

**Irrigation for the rotary/reciprocating files**
After meeting obstruction (rotary) or after three pecks (reciprocating), 2 mL of bi-distilled water was used as an irrigant. The irrigation needle (NaviTip 31-gauge; Ultradent, South Jordan, UT) was introduced as deep as possible into the canal but not deeper as the predetermined WL minus 1 mm. For all the groups, the ethylenediaminetetraacetic acid gel was used as a lubricant throughout the instrumentation procedure.

Following instrumentation, the teeth were removed from the tube and debris adhering to the root surface was collected in the centrifuge tube by washing off the apical area of the tooth with 1 ml distilled water. Before weighing the dry debris with an electronic balance, the centrifuge tube was stored in an incubator at 70°C for 5 days, to allow the moisture to evaporate.

**Statistical analysis**
The raw pooled data of the weights were statistically analyzed by means of the D’Agostino–Pearson test for normal distribution and test for homogeneity. This was followed by application of one-way analysis of variance and Tukey’s post hoc test to determine the significant group (SPSS ver. 20, SPSS Inc., Chicago, IL). *P* < 0.05 was considered to indicate a significant difference in all tests.

**RESULTS**
The mean debris (g) extruded by the three instrumentation protocols was 0.000691 ± 0.000281, 0.000723 ± 0.000319, and 0.000473 ± 0.000238 for Group 1 (20/0.02 + OS), Group 2 (20/0.02 + WO), and Group 3 (20/0.04 + SAF), respectively [Graph 1]. The SAF group after glide path preparation with 20/0.04 rotary file was associated with significantly less debris extrusion apically (*P* < 0.01), whereas no significant difference was observed among OS and WO groups when glide path was created by 20/0.02 hand K-file in curved canals (*P* > 0.05) [Table 1].

**DISCUSSION**
To the best of our knowledge, the apical extrusion of debris by the new protocol of glide path preparation for SAF is yet to be reported in literature. In the current study, all the three instrumentation protocols resulted in debris extrusion. The extrusion of debris was significantly less in samples with a glide path established by 20/0.04 rotary file and instrumented by SAF (1.5 mm), compared to a glide path established by 20/0.02 hand K-file and OS (25/0.06) and...
WO (25/0.08) instrumentation ($P < 0.01$). Furthermore, the reciprocating WO instrumentation did not differ in the amount of debris extrusion apically ($P > 0.05$).

A reduction in debris extrusion during canal preparation is desirable to help reduce postoperative pain following root canal treatment.\cite{8,19,20} Single and straight roots have been commonly used in numerous studies to evaluate the amount of debris extrusion during instrumentation.\cite{19} However, it has been reported that the incidence of postendodontic pain is significantly higher while treating molar teeth.\cite{21} Hence, in the present study, curved canals of molar teeth were used.

Sodium hypochlorite is used in routine endodontic procedures for irrigation. However, crystals formed when using sodium hypochlorite in such studies, dry out and cannot be separated from debris and adversely affect the reliability of the experimental methodology.\cite{16} Therefore, distilled water was used as an irrigant to prevent misleading weight measurements as a result of possible crystallization of sodium hypochlorite solution.

Creating a glide path in the canals being instrumented enhances the performance of NiTi instruments.\cite{11} Zanette et al.\cite{22} reported that glide path preparation allows the preservation of a pathway to the entire WL, preventing procedural errors such as ledge formation and apical transportation.\cite{23} Procedural errors are especially likely to occur during preparation of curved root canals. Apical transportation and irregular foramen widening are associated with a high rate of extrusion of debris.\cite{24} Berutti et al.\cite{23} also determined that the creation of a glide path before any NiTi rotary or reciprocating motion instrumentation appears to be appropriate for safely shaping the canal. In the current study, glide path with 20/0.02 hand K-files was achieved for rotary and reciprocating groups. Bürklein et al.\cite{26} evaluated the amount of apically extruded debris using several systems (Reciproc, OS\textsuperscript{®}, Mtwo and F360) and concluded that the reciprocal motion produced significantly more debris extrusion, compared to all other systems. Whereas Topçuoglu et al.\cite{13} reported no difference was observed between single-file systems (rotary and reciprocating) when a glide path was prepared during instrumentation of curved canals. In the current study also, no difference was seen in the amounts of debris extruded apically by OS and WO files when a glide path was prepared using 20/0.02 hand K-files.

Continuous rotary movement of the files could improve coronal transportation of dentine chips and debris by acting like a screw conveyor.\cite{29} This may explain the reduced extrusion in the SAF group as the glide path was prepared with rotary 20/0.04 file. WO files have a modified triangular cross-section, resulting in decreased cutting efficacy and smaller chip space resulting in auguring the formed debris after instrumentation, periapically.\cite{8,25} The WO files also exhibit a larger taper of 0.08 at the apical 3 mm, which may have attributed to excessive debris formation apically, and their extrusion periapically in the current study.\cite{6,8} The reciprocating files are associated with higher debris extrusion apically.\cite{6,16,20,25} However, in a study comparing the influence of glide path preparation on WO primary reciprocating file instrumentation, stated “fewer pecking motions were needed to reach full WL with WO single files when a glide path was created.”\cite{12} This may be the reason for the reduced debris extrusion in the WO group with a glide path prepared making it comparable to the rotary OS groups.

The previous studies have reported less debris extrusion associated with SAF compared to rotary and reciprocating files;\cite{6,7} however, to the best of our knowledge, the apical extrusion of debris resulting from the recently developed protocol of creating a glide path by 20/0.04 rotary file and instrumentation with SAF is not reported. In a recent study, Pawar et al.\cite{6} also reported similar results where WO extruded higher debris compared to SAF. In their study, they used wide straight single-canaled mandibular premolar teeth that did not require a prior glide path preparation. In the current study, we used fine mesial root canals of mandibular molars to test a new protocol of glide path preparation before SAF instrumentation. In other studies also, using a similar methodology, the reciprocating files are reported to extrude more debris.\cite{6,9,20}

| Table 1: Weight of apically extruded debris (g) |
|-----------------------------------------------|
| Groups                                      | $n$ | Mean±SD                 |
| Size 20/0.02 taper + OS                     | 20  | 0.000691±0.000281\textsuperscript{b} |
| Size 20/0.02 taper + WO                     | 20  | 0.000723±0.000319\textsuperscript{b} |
| Size 20/0.04 taper + SAF                    | 20  | 0.000473±0.000238\textsuperscript{b} |

Values with different superscript were statistically significant difference with $P<0.01$. OS: OneShape, WO: WaveOne, SAF: Self‑adjusting File, SD: Standard deviation

Graph 1: Amount of the weight of apically extruded debris in the three groups tested (mean and standard deviation). Value marked with similar symbols denotes no difference in extrusion of debris apically in the three groups tested.
SAF, a single-file system, is devoid of any central metal core and any cutting edge or flutes instead has an abrasive surface and removes dentin as a thin powder that is readily suspended in and carried out with the irrigant. The SAF is operated with a transline in-and-out vibratory motion and continuous irrigation. This continuous flow of irrigant does not build up any pressure in the canal as the metal meshwork allows the free escape of irrigant. In the narrowest apical part of a canal prepared up to a #20 K-file, the SAF when fully compressed has a rectangular form, thus leaving more than 38% of the canal cross-section free for backflow of fluid and suspended delicate dentinal debris.[16] In the apical third, the SAF system created cleaner inner canal walls when compared to the rotary system.[6,16]

**CONCLUSION**

A glide path prepared by 20/0.04 rotary file and further instrumentation of mesial canals of mandibular molars by SAF 1.5 mm results in less debris extrusion apically. Furthermore, samples instrumented by OS rotary and WO reciprocating file system, after glide path prepared by 20/0.02 hand K-file, were associated with the similar amount of debris extrusion.

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**Conflicts of interest**

There are no conflicts of interest.

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