

Influence of Clinical Operative Technique on Debris Extrusion of Two Reciprocating Files

Ayfer Atav Ates¹, Burçin Arıcan¹, Luca Testarelli², Gianluca Gambarini³, Alessio Zanza³,
Marco Seracchiani³

¹Department of Endodontics, Istanbul Okan University, Faculty of Dentistry, Istanbul, Turkey.

²Department of Oral and Maxillofacial Sciences, University of Rome, Rome, Italy.

³Department of Oral and Maxillofacial Sciences, Sapienza University of Rome, Rome, Italy.

Correspondence: Luca Testarelli, Via Caserta 6,00161, Rome, Italy. **E-mail:** luca.testarelli@uniroma1.it

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ABSTRACT

Objective: To compare the influence of different clinical operative motions (pecking motion *vs.* MIMERACI) on apical debris extrusion using WaveOne Gold and EdgeOne Fire reciprocating files in the mesiobuccal canal of extracted molars. **Material and Methods:** Sixty mandibular molar teeth with curvature less than 20° were divided into 4 groups (n=15 each): G1A: WOG pecking Group; G1B: WOG MIMERACI Group; G2A: EOF pecking Group; and G2B: EOF MIMERACI Group. The produced debris was collected in the preweighed Eppendorf tubes and following the shaping procedures; they dried in the incubator for 5 days at 70° C. The tubes were weighed again, and the final extruded debris was measured by subtracting the pre-instrumentation from post-instrumentation weight of tubes. The canal preparation time was calculated with a digital chronometer. The obtained data were analyzed using two-way ANOVA at a 0.05 level of significance. **Results:** MIMERACI method significantly decreased the amount of debris pushed out in both instruments ($p < 0.05$). Neither instruments nor clinical motions created a statistical difference regarding the required time ($p > 0.05$). **Conclusion:** All tested instruments pushed debris out apically at some level, but MIMERACI operative technique was associated with significantly less apical debris extrusion.

Keywords: Endodontics; Root Canal Therapy; Root Canal Preparation.

Introduction

During root canal therapies, root canal filling material, irrigation solutions, bacteria, necrotic tissue remnants, dentin particles can apically extrude regardless of the instrumentation technique and rotary instruments used [1,2]. These extruded materials may trigger periapical inflammation, which may cause flare-ups, may increase post-operative pain and swelling, may negatively affect outcome [3,4].

Although every rotary or manual endodontic instrument can cause apical debris extrusion somehow, it was shown that cross-section design, kinematics, taper, tip size of the instruments affect the amount of it [5,6]. Reciprocation motion could increase the risk of pushing debris inside canals/beyond the apex since it consists of two different angles (rotating clockwise and counterclockwise), and flutes are designed to remove debris coronally only in one direction.

WaveOne Gold (WOG - Dentsply Maillefer, Ballaigues Switzerland [7] and EdgeOne Fire (EOF - EdgeEndo, Albuquerque, NM, USA) [8] have the same tip size and taper and are recommended to use with similar motion (angles and resulting speed) by their manufacturers. Both are single file techniques, working in a reverse reciprocating motion: 30° clockwise and 150° counterclockwise. The main difference between WOG and EOF is related to the manufacturing technology, with different, non-disclosed thermal treatments: Gold *vs.* FireWire heat treatment [9].

Many studies stated that reciprocation could play a critical role in increasing the risk of apical extrusion of debris, but no published studies evaluated if clinical motion could reduce this risk. For this reason, in the present study, a clinical motion, the so-called “MIMERACI”, proposed by Gambarini et al. [10], has been tested to evaluate debris extrusion. The motion works for both continuous rotation and reciprocation since the resulting motion of NiTi reciprocation is a non-continuous rotation. MIMERACI is an acronym, which means manual insertion (MI), minimal engagement (ME), remove (R), and clean flutes (AC), irrigation (I). It is a very controlled clinical motion with 1 mm step advancements in the root canal. Authors claimed that the system could cause less debris production and extrusion by minimizing files' engagement, more frequent cleaning of flutes, and increasing the fresh irrigating solution.

While there are many studies [11-13] comparing debris extrusion of conventional hand instruments with rotary files, reciprocation and rotation motions with the same or different NiTi rotary files, there is no study that evaluates the influence of clinical operative motions on debris extrusion. Moreover, WOG and EOF have not been compared to date regarding the amount of debris extrusion in any study. Therefore, this study aimed to compare the amount of apically extruded debris produced by two reciprocating NiTi instruments used with a traditional pecking motion and the MIMERACI technique. The null hypothesis was that MIMERACI technique would not affect the amount of debris extrusion compared to a traditional pecking motion independently from the used reciprocating instrument.

Material and Methods

Selecting Samples

Freshly extracted one hundred fifty human mandibular first molar teeth were collected. The teeth used in the present study were extracted for periodontal mobility of Class 3 on Miller Classification [14], or orthodontic reasons. The teeth were stored inside a jar full of 2.6% sodium hypochlorite (NaOCl) for 2 h then carried to a jar with 10% buffered formalin phosphate until usage. Digital radiographs were taken in two different directions. The curvature of the mesial root was calculated with Schneider's method [15] by using AutoCAD Software (Autodesk Inc., San Rafael, CA, USA). Only those have a degree of curvature less than 20°

and length more than 15 mm of mesial roots with two separate canals were used in this study. The teeth with open apex, resorption, or calcification and had root canal treatment before were omitted. The mesial roots of sixty teeth that met these criteria were separated with a high-speed diamond bur and then the coronal part was removed to get a 14 mm root length. The teeth surfaces were cleaned from soft and hard tissue remnants. A size #10 K-file was inserted into the mesiobuccal canals to check canal openings and measure the working length (WL) by subtracting 1 mm from the length that tip of the instrument seen in the major foramen. When #10 K-file loose at WL, this sample was discarded. An operating microscope (Moller Spectra 500, Moller-Wedel GmbH, Wedel, Germany) was used during these procedures. The samples were randomly divided into two groups with two subgroups (www.randomizer.org) (n=15 each) and numbers were given to each.

Experimental Design

Sixty Eppendorf tubes were weighed without cover, and this was done three times by an electronic balance (Sartorius AG, Göttingen, Germany) having an accuracy of 0.00001 g. The average values were recorded for each one. A study design by Myers and Montgomery [16] was used for the measurement of debris extrusion with some modifications (Figure 1). Each tooth was inserted into the hole, which was prepared on the cover and supported with cyanoacrylate to stabilize it. A 27 G needle was used to balance the air pressure of the inside and outside environment. The prepared covers with root and needle fitted to the Eppendorf tubes. The Eppendorf tubes were placed inside the glass vials filled with water at a controlled temperature of 37° C, as confirmed with an electrode thermometer - MN35 Digital Mini Multimeter (Extech Instruments, Waltham, MA, USA). The glass container was coated with aluminum foil to avoid bias.

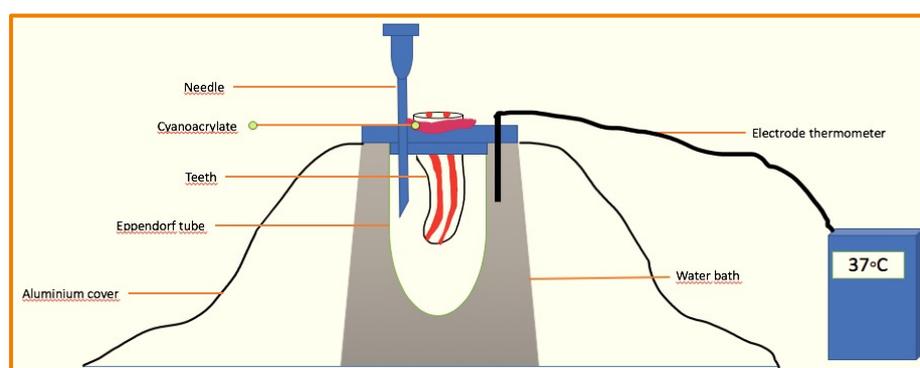


Figure 1. Schematic representation of the testing device.

Shaping Procedures

The two reciprocating files were operated with the same *WaveOne All* - and with the same endodontic VDW Gold (VDW, Munich, Germany). The files were used with different clinical motions.

- Group 1A: WOG / Traditional pecking method - The shaping procedures were performed applying only gentle inward pressure to the file. The instrument was used with a 2-3 mm amplitude with slow, in-and-out pecking motion (one peck) until WL was reached. The debris on the instrument was cleaned with sterile gauze after every 3 pecks.
- Group 1B: WOG / MIMERACI - The WOG files were operated with a clinical motion called MIMERACI described by Gambarini et al. [10] in a previous study. In this method, after each 1 mm progression in the canal, the file was removed, cleaned with sterile gauze, the root canal was irrigated and the file was reinserted into the canal. This procedure was repeated until WL was reached by WOG# 25 file.

- Group 2A: EOF / Traditional pecking method - EOF Primary file (#25.06) was used with in-and-out motion advancing the file 2-3 mm with each stroke until reaching the WL. The instrument was cleaned each time, as explained in Group 1A.
- Group 2B: EOF / MIMERACI - EOF files were used with *Waveone All* program and all shaping procedures were performed as described in Group 1B.

In all groups, apical patency was checked with #10 K-file to avoid apical blockage with debris. Single experienced endodontics who calibrated to the MIMERACI technique was performed all shaping procedures. A total of 12 mL bidistilled water was used for irrigation. Each file was used for 3 canals and then discarded. Irrigation was performed using a syringe and a side-vented 30G needle (NaviTip - Ultradent Products, Inc., South Jordan, UT, USA) in a back-and-forth motion and positioned 3 mm short of the WL. The required time was calculated with a digital chronometer during shaping and irrigation procedures.

After finishing root canal preparations, the cover with drainage syringe and root was removed. The debris around the root apex was cleaned with 1 ml bidistilled water inside the Eppendorf tube. To evaporate the bidistilled water, the collection combination inside the tubes was dried at a temperature of 70° C for 5 days [17]. The Eppendorf tubes were weighted three times with the abovementioned electronic balance and then average weight recorded. Then, for each sample, the tare was subtracted from the final measurements to get the values. All measurements were done by a second examiner who was blinded to group contents.

Data Analysis

The data obtained were analyzed with two-way ANOVA at 0.05 level of significance using Minitab Statistical Software, version 18 (Minitab, LLC, State College, PA, USA).

Results

No instrument fracture occurred during instrumentation. The mean weight and standard deviation of the amount of apically extruded debris for each group were shown in Table 1. There was statistically no significant difference between WOG and EOF when used according to the manufacturer instructions (pecking) or MIMERACI technique ($p > 0.05$). When two clinical motions were compared, MIMERACI method significantly decreased the quantity of debris extruded for both instruments ($p < 0.05$). No correlation was found among the required time and the other variables ($p > 0.05$) (Table 2).

Table 1. The mean and standard deviations of the amount (gr) of extruded debris according to both instruments and instrumentation methods.

| Groups | A (Traditional Pecking) | | B (MIMERACI) | | p-value |
|---------------|-------------------------|----------|--------------|----------|---------|
| | Mean | SD | Mean | SD | |
| Group 1 (WOG) | 0.000853 | 0.000471 | 0.000324 | 0.000364 | 0.734 |
| Group 2 (EOF) | 0.000842 | 0.000687 | 0.000252 | 0.000246 | |
| p-value | | | | | 0.000 |

Table 2. The mean and standard deviations of the operating time (seconds).

| Groups | A (Traditional Pecking) | | B (MIMERACI) | | p-value |
|---------------|-------------------------|-------|--------------|------|---------|
| | Mean | SD | Mean | SD | |
| Group 1 (WOG) | 126.87 | 10.44 | 128.07 | 9.07 | 0.727 |
| Group 2 (EOF) | 127.93 | 8.46 | 128.67 | 8.97 | |
| p-value | | | | | 0.685 |

Discussion

The standardization of experimental design and teeth are required factors to have valid results in apical debris extrusion studies. Unlike other studies [2,18,19] in which single-rooted teeth were used, mandibular molar teeth with mature apices were chosen in the present study. Besides, anatomical differences such as curvature degrees and working lengths of teeth were also standardized. Due to the standardization of apical foramen diameter is indispensable for the extrusion studies [20], we discarded the samples when #10 K-file pass through easily from the apex during the WL determination. Because the amount of extruded debris was extremely low, the tubes were weighed three times using microbalance with an accuracy of 10⁻⁵. Moreover, the previously tested debris collection method, which is reliable, easy, cheap, and repeatable, was imitated in this study with some modifications. To mimic in vivo conditions, all the root canal shaping procedure of the mesiobuccal canal was performed at body temperature.

There are numerous publications that evaluate the clinical relevance [21,22] of debris extrusion and compare the debris extrusion caused by various instruments and motors motions [2,17,19]. To the authors' knowledge, this is the first study evaluating differences between WOG and EOF regarding apical debris extrusion. Although WOG and EOF have similar designs regarding the same tip size, taper, and cross-section, they have different heat processes and alloy, which may affect their clinical performance mainly in curved canals. EOF Fire-Wire heat treatment was shown to improve flexibility and fatigue when compared to WOG [9]. However, in the present study, no statistically significant difference was observed between the two tested instruments on the amount of extruded debris, both using traditional pecking motion and MIMERACI. A possible explanation is that severe canal curvatures were not included in the study since the main goal was to evaluate the influence of the instrumentation technique, minimizing factors related to anatomy.

To date, no file system was found to prevent totally the debris transportation to the apical area and their extrusion. According to Caviedes-Bucheli et al. [23], the instrument's design has an influence on apical debris extrusion. In the present study, two similar designs were selected to minimize its possible impact on debris: WOG and EOF have similar parallelogram cross-sections and the same dimensions (tip size and tapers). Both systems caused very low and similar debris extrusion.

Many researches have shown the quantity of debris extrusion by different files [18,19,24], but no study was focused on different clinical operative motions. In the present study, WOG and EOF were used according to manufacturers' instructions (pecking motion) and with MIMERACI technique. Results showed that the latter method produced significantly less debris extrusion with both instruments. Therefore, the null hypothesis was rejected.

Gambarini et al. [10], who proposed MIMERACI clinical motion in 2017, reported that this technique has three main advantages: the manual insertion and the minimal (1 mm) progression towards the apex allow a controlled engagement and controlled production of debris, avoiding overfilling of flutes; this progression in steps should be repeated a few times until reaching the working length; after each step (a small progression into the canal just 1 mm deeper than manual insertion), the instruments should be removed and flutes cleaned outside the canal, minimizing the risk of pushing debris inside or being push out apically; Irrigation after each step improves cleaning, debris removal and reduce, together with the 1 mm progression, the risk of canal blockage from an excessive amount of debris.

Gambarini et al. [10], using Twisted File Adaptive instruments (SybronEndo, Orange, CA, USA) reciprocating instruments, showed that MIMERACI technique had better clinical results (reducing post-

operative pain) when compared to traditional pecking motion. Considering the relation between debris extrusion and post-operative pain, the present study results could be a confirmation of those findings.

Recent studies [2,20] conducted with different instrumentation systems concluded that faster shaping procedures like single-file techniques could cause more debris transportation than sequenced file systems. Our results showed that if a single file is properly used with a more controlled technique (MIMERACI), significantly less debris can be produced without losing the advantage of a faster shaping procedure. No statistically significant difference in instrumentation time was found when the two different clinical operative motions were used, independently from the used instrument.

In clinical endodontics, NaOCl is a widely used irrigation solution for removing organic tissue. However, in the present study, to avoid the crystallization of sodium, which may cause debris mismeasurements due to remained sodium crystals after evaporation, bidistilled water was used [25,26]. The proximity of the irrigation needle to the apical construction increases the effectiveness of irrigation as well as the possibility of undesirable periapical over extrusions. Thus in all cases, the side-vented needle was placed 3 mm beyond the working length to deliver irrigant and prevent the possibility of irrigant extrusion caused by open-ended needle [27].

Despite all the aforementioned precautions, the authors are confronted with several limitations. The biggest problem was to mimic the *in vivo* conditions. *In vitro* studies, it is not possible to standardize the microhardness of dentin, which differs among the teeth that may affect the produced and extruded debris [28]. And also, the results should not be generalized to clinic conditions directly because of the lack of pulpal, periodontal tissues, and back-pressure of periapical tissues in this experimental design [29,30]. In addition, the ambient air and humidity may have an impact on the measurements of the extruded debris, which is quite low [31]. All these factors make it difficult to reflect the experimental study results to the clinic. Moreover, further *in vivo* and *in vitro* studies will be needed to better evaluate the influence on debris extrusion of the MIMERACI technique and stress generated during instrumentation to complete the evaluation on the technique [32,33].

Conclusion

Within the limitation of this *in vitro* study, the influence of different clinical motion on apical debris extrusion was demonstrated. The MIMERACI technique caused significantly less debris extrusion, independently from the different tested reciprocating instruments, without negatively affecting instrumentation time.

Authors' Contributions

| | | | |
|-----|---|---|--|
| AAA |  | https://orcid.org/0000-0003-0270-8646 | Writing - Original Draft. |
| BA |  | https://orcid.org/0000-0001-5757-0571 | Conceptualization, Methodology and Investigation. |
| LT |  | https://orcid.org/0000-0003-3904-3000 | Methodology and Writing - Review and Editing. |
| GG |  | https://orcid.org/0000-0002-5645-1965 | Formal Analysis, Data Curation and Project Administration. |
| AZ |  | https://orcid.org/0000-0002-2062-8140 | Investigation. |
| MS |  | https://orcid.org/0000-0001-6104-921X | Writing - Review and Editing. |

All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

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None.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

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