Bacterial Removal Promoted by 2 Single-file Systems: Wave One and One Shape

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Abstract

Introduction: Different single-file systems are available for endodontic treatment; however, comparative studies are scarce. Thus, the present study evaluated bacterial reduction promoted by 2 single-file systems: Wave One (Dentsply Maillefer, Ballaigues, Switzerland) and One Shape (Micromega, Besancon, France). **Methods:** Forty-five distobuccal root canals of upper molars sterilized with ethylene oxide were infected with *Enterococcus faecalis* for 21 days, and then root canal initial bacterial sample was collected with paper cones and plated on M-enterococcus agar. The specimens were randomly divided into 3 groups according to instrumentation (n = 15): Wave One, One Shape, and the crown-down manual technique (control group). The other 6 specimens without contamination were control asepsis. After instrumentation, samples were collected with the use of scraping and paper cones. The bacterial reduction was calculated, and then intragroup analysis was performed using the paired t test and intergroup analysis using analysis of variance (both at 5% significance). **Results:** All techniques significantly reduced the number of bacteria in the root canal ($P < .05$), with no significant difference between them ($P > .05$). The aseptic control group did not show any bacterial growth. **Conclusions:** It can be concluded that the single-file systems Wave One and One Shape significantly reduce the bacterial number in the root canal and that there is no significant difference in their bacterial reduction abilities. *(J Endod 2014;40:1995–1998)*

Key Words

Endodontics, *Enterococcus faecalis*, root canal instrumentation

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0099-2399/$ - see front matter

http://dx.doi.org/10.1016/j.joen.2014.07.024

The development of new endodontic technologies is aimed at increasing ease and practicality; however, the basic principles of cleanliness and bacteria removal should also be considered because the development of periapical pathology is directly related to attacks emanating from necrotic tissues and bacteria (1). In particular, *Enterococcus faecalis* has been the focus of endodontic research because of its high resistance to conventional endodontic treatments (2) and low nutrient requirements (3). One of the steps of endodontic therapy is the removal of bacteria from the root canal, and it is linked to the mechanical action of endodontic instrument. During this stage, more than 90% of bacterial reduction is achieved (4–7). Many instrumentation systems have emerged to facilitate this medical procedure by reducing working time, stresses on both the operator and the patient, and the number of files for instrumentation (8–12). This study was focused on 2 single-file systems that have fundamental differences. The Wave One system (Dentsply Maillefer, Ballaigues, Switzerland) uses a reciprocating motion, and the shape of the instrument varies along its axis; the midportion and the nearest part of the cable have a triangular shape with convex sides, and the region closest to the tip of the instrument is concave. The One Shape system (Micromega, Besancon, France) is a second single-file system that uses automated movement by continuous rotation. The shape of the instrument is varied along its active region; there are 3 cutting angles from the tip of the instrument to 2 mm along its length, the middle of the instrument transitions to 2 cutting angles, and the region closest to the cable has 2 cutting angles.

Research on the Wave One system has shown favorable performance of the instrument with respect to preparation (9) and bacterial reduction (6); however, the Wave One system has also been shown to produce a greater amount of debris; a smear layer in the canal (9, 13); and, possibly, extrusions (14). There are few studies on the One Shape system, but there are manufacturer comments related to its design that state it avoids compressing the dentin during preparation and, consequently, results in better cleaning.

Taking into account the increasing interest in single-file instruments and the peculiar characteristics related to their design and movement, the aim of this study was to evaluate the bacterial reduction achieved by these 2 single-file systems, Wave One and One Shape, in canals infected with *E. faecalis*.

Materials and Methods

After approval by the Ethical Committee of the School of Dentistry, University of São Paulo (544573), 51 distobuccal root canals of upper molars were sectioned on the cementoenamel junction using a fine steel disc at low speed. Then, they were standardized to 12 mm and instrumented to a working length of 11 mm up to a #15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) under irrigation with distilled water. The root canals were filled 17% EDTA (Fórmula & Ação, São Paulo, Brazil) for 3 minutes to remove the smear layer and washed with 5 mL distilled water.

The apex was covered with composite resin (3M, Saint Paul, MN), and the external root surface was sealed using epoxy resin (Araldite; Brascola, Joinvile, Brazil). The specimens were then fixed onto 24-well polystyrene microtiter plates using acrylic resin and were sterilized using ethylene oxide (Acecil, Campinas, Brazil).

A suspension of *E. faecalis* (American Type Culture Collection 29212) in tryptic soy broth (TSB; Difco, Le Pont de Claix, France) was prepared and standardized to 4 on the McFarland scale, and then 45 root canals were contaminated with the *E. faecalis* suspension using an insulin syringe. Six other root canals were filled with TSB. The specimens were incubated at 37°C for 21 days, and the root canal contents were replaced with fresh TSB every 48 hours.

After the incubation period, the root canals were filled with distilled water. Next, initial samples were collected using 3 sterilized #15 paper points (Dentsply Maillefer) inserted for 1 minute each. The points were then stored in tubes containing 500 μL peptone water, and serial dilutions were prepared. Different dilutions were plated in triplicate on m-Enteroccocus agar culture medium (Difco, Le Pont de Claix, France) and plates incubated at 37°C for 48 hours for bacterial count in colony-forming units (CFUs)/mL.

The contaminated specimens were divided into the following 3 groups ($n = 15$):

1. The Wave One Group was prepared using the Wave One Primary file with the motor in reciprocating motion (Dentsply Maillefer), gently penetrating the cervical third using 3 pecking motions in the apical direction. Then, the root canal was explored up to the working length using a #15 K-file. This kinematics was performed until reaching the full working length.
2. The One Shape Group was prepared using the One Shape file with a motor in continuous rotation motion (Dentsply Maillefer) at 400 rpm and a torque of 4 Ncm. Three in-and-out motions were gently performed in the apical direction. Then, the root canal was explored up to the working length using a #15 K-file. This kinematics was performed until reaching the full working length.
3. The manual group (ie, the positive control) was prepared using the crown-down manual technique. The cervical and middle thirds were straightened with Gates-Glidden drills #1, #2, and #3, and the root canals were instrumented at the working length up to a #35 K-file (6).

Irrigation during instrumentation was performed with a total of 10 mL distilled water using a syringe and 29-G NaviTip (Ultradent Products, South Jordan, UT) to within 2 mm of the working length. In groups 1 and 2, irrigation was performed each time after withdrawing, and in group 3, irrigation was repeated with each exchange of instrument.

The aseptic control group consisted of 6 specimens not contaminated and instrumented according to each group. After the final irrigation using an additional 5 mL distilled water, scraping using a Hedstroen file #25 was done for the determination of postinstrumentation CFU/mL (S2). Briefly, the file was introduced into the canal up to the working length, with pulling strokes on all the root canal surfaces. The file was cut off below the handle and dropped into a tube containing 500 μL peptone water. Additionally, 3 sterilized #15 paper points were inserted into the root canal for 1 minute each and then stored in the same tubes of the file.

The log transformation of each CFU/mL count was performed, and statistical tests were applied. The paired *t* test was used for intragroup analysis, and intergroup analysis was performed using analysis of variance test. The level of significance for all analyses was set at $P < .05$.

Results

All the techniques were able to significantly reduce the number of bacteria in the root canal with a percentage higher than 92% ($P < .005$). Both single-file systems were similar to the manual control group, with no significant difference between them ($P > .05$).

TABLE 1. Bacterial Reduction and Counts of *Enterococcus faecalis* (in log) before and after Instrumentation

Groups*	Before† mean ± SD	After† mean ± SD	Bacterial reduction Mean ± SD	Bacterial reduction %
Wave One	6.56 ± 0.27	5.03 ± 0.70	6.54 ± 0.26	95.6
One Shape	6.50 ± 0.26	4.82 ± 0.46	6.48 ± 0.26	96.5
Manual	6.46 ± 0.26	5.27 ± 0.32	6.43 ± 0.26	92.7

SD, standard deviation.

*No significant difference according to analysis of variance statistical test ($P > .05$).

†Significant difference according to the paired *t* test ($P < .05$).

The aseptic condition during the experiment was proven by the absence of bacterial growth in the uncontaminated samples and prepared according to each group. Table 1 shows the log CFU/mL of *E. faecalis* before and after instrumentation as well as the bacterial reduction after preparation.

Discussion

Mechanical removal of microorganisms in the root canal is associated with the cutting of dentin. Therefore, every procedure that involves dentin removal and, as a result, the shaping of the root canal itself directly acts to reduce bacteria. However, the influence of those procedures on radicular anatomy caused by the incident forces on the instruments may result in deformities (15) and, resultantly, in noninstrumented areas (8, 16). Microbiological analyses differ from the methods of bi- or tridimensional computerized observation (17) and can allow for more significant disinfection because bacterial reduction occurs regardless of the shaping of the root canal by the instruments. Thus, the shaping ability of rotary systems has been shown to generate a significant level of bacterial reduction (4, 5, 7, 18–20). Furthermore, studies on the reciprocating single-file systems have had similar results (6, 17, 21), as was confirmed by the present study. However, there are few studies on the single-file systems that use continuous movement, and more are necessary to critically assess those systems.

The plate culture method is a methodology used frequently in bacterial reduction studies (4–7, 17–27). Furthermore, scraping was used after preparation to collect the smear layer, biofilm remnants, and noninstrumented areas that could influence the results (6, 18, 20, 21, 24). The culture technique has limitations because low amounts of viable but uncultivable bacteria cannot to be detected. However, our results show that a sufficient amount of bacteria can be detected with this method in this study, and we focused on a known bacterium, *E. faecalis*. Molecular methods have been suggested as the most sensitive bacterial detection tests; however, Alves et al (21) obtained similar results using the molecular polymerase chain reaction and plate culture techniques. Lin et al (28) suggested observing the biofilm by scanning electron microscopy, but this method does not guarantee the observation of the full depth of the biofilm structures and their viability.

Among the dental groups, the molars deserve special attention because they require the greatest amount of endodontic treatments, and the greatest incidence of persistent apical periodontitis occurs in the molars (29). Therefore, to simulate clinical reality, this study was performed on a molar root, the distobuccal root (5, 6). This allowed for the standardization of specimens; the specimens had similar anatomy, no curvatures, and a diameter able to be shaped by a #30 or #35 instrument. The buccal-mesial roots do not have those characteristics; they have variable curvatures, flattening, and the presence of a fourth

canal. The palate root canal is broader and is difficult to isolate, which compromises the collection of specimens. The premolars, although they have been widely used in other studies (4, 7, 22, 23, 25), were not used here because of the large diameter of their root canals. That characteristic could compromise the disinfection because of the limited shaping ability of the Wave One Primary files (25.08) and One Shape (25.06) systems in wider canals.

The manual technique was used as a control because it is a technique that is still widely used by clinicians. Apical preparation with a 35.02 file is traditionally performed during the manual preparation of the buccal root canals of the upper molars. It should also be mentioned that preparation using automated instrumentation shapes the apical region differently from manual preparation. With automated shaping, gutta-percha cones of larger caliber than with automated shaping can be used. For example, automated shaping with 25.08 rotary files easily allows the use of cones with an apical diameter of 35. Thus, for the automated final preparation, the diameter of the preparation and not the last instrument used should be evaluated. Furthermore, previous studies found no significant difference in bacterial reduction using instruments with different tapers and diameters (4–6, 19, 26). This is consistent with our results; we found no difference in the apical diameter between the automated techniques using instruments with an apical diameter of #25 and the manual technique using a final instrument of #35.

The bacterial reduction found for the single-file systems was 95.6% for Wave One and 96.5% for One Shape, and there was no significant difference between the bacterial reduction values using the single-file systems and the manual technique. This trend was expected because of the canal enlargement that is achieved by both the single-file and manual systems. These results are consistent with our previous study, which showed a bacterial reduction of 95.1% using the Wave One system and no significant difference between the reduction achieved by the Wave One system and the manual technique (6). However, Ferrer-Luque et al (27) observed a bacterial reduction of 98.27% using the same reciprocating system. These subtle percentage differences across studies are justified by methodological models. The second author studied premolars, and there was no scraping for the final collection.

The results of this study did not show a difference in bacterial removal ability between the reciprocating motion and continuous rotation techniques but, rather, indicated that they were equally effective at bacterial removal because of their similarity in canal enlargement. However, this study was performed on the distobuccal root canal of the upper molar; thus, other root canals with oval cross-sections should also be evaluated in the future.

None of the samples showed 100% bacterial reduction, but the index was high, greater than 95%, which is in agreement with the literature that states that most bacteria are removed by mechanical action (5–7, 27). However, Nakamura et al (7) and Ferrer-Luque (27) observed 100% bacterial reduction in the immediate postinstrumentation collection samples when using 5.25% sodium hypochlorite, which indicates that it enhances bacterial reduction. However, sodium hypochlorite was not used in this assay because of the aim of comparing only the performance of the 2 systems without the influence of an antibacterial substance. Moreover, 100% bacterial reduction does not indicate the absence of bacteria; rather, it indicates a very low amount of bacteria that cannot be detected by culture methods. Studies using scanning electron microscopic and histobacteriologic analysis have shown that it is not possible to completely eliminate biofilms after instrumentation using 3% or 5% sodium hypochlorite (28, 30).

Thus, it can be concluded that the single-file systems Wave One and One Shape significantly reduce the bacterial number in the root canal and that there is no significant difference in their bacterial reduction abilities.

Acknowledgments

The authors thank Acecil for ethylene oxide sterilization.
The authors deny any conflicts of interest related to this study.

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