Comparison of the Vibringe System With Syringe and Passive Ultrasonic Irrigation in Removing Debris From Simulated Root Canal Irregularities

Tina Rödig, Dr. med. dent, Meral Bozkurt,* Frank Konietschke, Dr,† and Michael Hülsmann, Prof. Dr. med. dent**

Abstract

Introduction: The aim of this study was to compare the efficiency of a sonic device (Vibringe), syringe irrigation, and passive ultrasonic irrigation in the removal of debris from simulated root canal irregularities. **Methods:** Root canals with 2 standardized grooves in the apical and coronal parts were filled with dentin debris. Three different irrigation procedures were performed with NaOCl (1%) and (1) syringe irrigation, (2) Vibringe, and (3) passive ultrasonic irrigation. The amount of remaining debris was evaluated by using a 4-grade scoring system. **Results:** Ultrasonic irrigation removed debris significantly better from the artificial canal irregularities than the Vibringe System and syringe irrigation ($P < .0001$). The Vibringe System demonstrated significantly better results than syringe irrigation in the apical part of the root canal ($P = .011$). **Conclusions:** Passive ultrasonic irrigation is more effective than the Vibringe System or syringe irrigation in removing debris. The sonic device demonstrated significantly better results than syringe irrigation in the apical root canal third. *(J Endod 2010;■:1–4)*

Key Words

Debris, irrigation, root canal, sonic, ultrasonic, Vibringe System

From the *Department of Preventive Dentistry, Periodontology and Cariology, and †Centre for Statistics, University of Göttingen, Göttingen, Germany.

Address requests for reprints to Dr T. Rödig, Department of Preventive Dentistry, Periodontology and Cariology, University of Göttingen, Robert-Koch-Str. 40, 37075 Göttingen, Germany. E-mail address: troedig@med.uni-goettingen.de.

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Disinfection of the root canal system by using antimicrobial and tissue-dissolving irrigants is considered an essential part of chemomechanical debridement (1). Residual pulp tissue, bacteria, and dentin debris remain in areas that are routinely left uninstrumented after root canal preparation (2, 3). Reports on the efficacy of irrigation at different coronal-apical levels have been contradictory (4, 5). Therefore, a coronal groove was added to an existing research model (6) to evaluate debris removal not only from apical but also from coronal thirds of the root canal. Conventional syringe irrigation is still widely accepted (3), although its flushing action is not sufficient in removing debris from root canal irregularities (2, 7). Enhancement of the flushing action of irrigants by ultrasound is well-documented (8, 9) and has the potential to remove dentin debris and organic tissue from inaccessible root canal areas (10, 11). Conflicting results regarding the effectiveness of sonic or ultrasonic activation of the irrigant to remove smear layer, debris, and bacteria (12–14) have been published. Recently, the Vibringe System (Vibringe B. V. Corp, Amsterdam, Netherlands), an irrigation device that combines manual delivery and sonic activation of the solution, has been introduced. The Vibringe is a cordless handpiece that fits in a special disposable 10-mL Luer-Lock syringe that is compatible with every irrigation needle. No data on the effectiveness of this system are available at present.

The aim of the present study was to compare the efficiency of conventional syringe irrigation, the Vibringe System, and passive ultrasonic irrigation (PUI) in the removal of dentin debris.

Material and Methods

Specimen Preparation

Ten extracted maxillary lateral incisors with straight roots were decoronated to obtain a standardized root length of 17 mm. The root canals were prepared with FlexMaster (VDW, Munich, Germany) nickel-titanium rotary instruments to a working length (WL) of 16 mm and an apical size of #35/02. Between the instruments, irrigation was performed with 2 mL NaOCl (1%) by using a syringe and a 30-gauge needle (NaviTip; Ultradent, South Jordan, UT). The roots were split longitudinally into 2 halves, allowing subsequent reassembling. A modified finger spreader was inserted into an ultrasonic handpiece (Piezon Master 400; EMS, Nyon, Switzerland) to cut 1 longitudinal groove of 4.0-mm length, 0.2-mm width, and 0.5-mm depth into root canal dentin of each half. The locations of the grooves were 2–6 mm from WL in one root half (apical section) and 10–14 mm from WL in the opposite half (coronal section). This experimental design is based on a previous study (6) and has been used in several investigations concerning the removal of debris (15–17). Subsequently, digital photographs of the root halves were taken before and after irrigation from identical angles by using a microscope (MOTIC Ergonomic Trinokular Zoom Stereo Mikroskop; Motic, Wetzlar, Germany) with 30× magnification. Dentin debris was produced by mixing 100 mg dentin chips with 0.175 mL NaOCl (1%) in a standardized ratio to achieve a wet sand-like consistency. Each groove was filled with debris to simulate a clinical situation when dentin debris accumulates in uninstrumented root canal extensions. Subsequently, the root halves were reassembled and fixed by using a clamp.

Irrigation Procedures

Preliminary experiments had shown that a single specimen could be reused up to at least 5 times without visible damage to the root canal surface. Therefore, the 10 teeth were used repeatedly in the 3 experimental groups. The irrigation procedures were performed consecutively with a random sequence of the specimens. In group 1, irrigation was accomplished with a 10-mL syringe and a 30-gauge needle (NaviTip). In group 2, the irrigant was delivered and sonically activated via the Vibringe System by using a 30-gauge needle (NaviTip) according to manufacturer's instructions. In group 3, irrigation was performed with an ultrasonic device (Piezon Master 400) and a stainless steel K-type file size 15 (Endosonore; Maillefer, Ballaigues, Switzerland), with its power set at the ¼ of the scale. In all groups a total volume of 20 mL NaOCl (1%) was delivered. The flow rate in groups 1 and 2 was approximately 5 mL/min. In group 3, the delivery rate during PUI with a continuous flush of the irrigant was 10 mL/min. Insertion depth of the needle and the ultrasonic file was 1 mm short of WL in all groups. After irrigation the root halves were separated to take digital photographs of the canal walls. The remaining debris was removed from the grooves, followed by a complete refilling of the root canal extensions before the next irrigation procedure. All measures were carried out under a microscope at 30× magnification.

Scoring Procedure and Statistical Analysis

The amount of remaining debris in the grooves was scored under the microscope with 30× magnification by 2 calibrated dentists with a scoring system described previously (18): 0, the groove is empty; 1, less than half of the groove is filled with debris; 2, more than half of the groove is filled with debris; 3, the complete groove is filled with debris (Fig. 1). Intraobserver reproducibility and interobserver agreement were calculated. In cases of differences, both scores were included in the statistical analysis that was performed with a nonparametric analysis of variance for factorial longitudinal data and the closed testing principle (P = .05).

Results

Interobserver agreement was 90% (κ = 0.9057, confidence interval = 0.8310–0.9804), and intraobserver reproducibility was 98% (κ = 0.9843, confidence interval = 0.9626–1), with no significant influence of the observer (P = .9825). The results of the scoring procedure are presented in Fig. 2 and Table 1. There were statistically significant differences between the experimental groups (P < .0001) and the location of the groove (P < .0001). A significant interaction between the irrigation protocol and the location of the groove (P = .018) was found. For syringe irrigation and Vibringe System, pairwise comparisons demonstrated significantly better cleanliness of the apical groove (P = .005; P = .002, respectively). No difference between the grooves was detected for ultrasonics (P = .160), which removed debris significantly better than Vibringe System and syringe irrigation (P < .0001), irrespective of the location of the groove. For the coronal groove, the difference between syringe irrigation and the use of the Vibringe System was not statistically significant (P = 1). In contrast, the results for the apical groove demonstrated a significantly better performance for Vibringe System than for syringe irrigation (P = .011). Overall, the cleanliness of the apical groove was significantly superior in comparison to the coronal groove (P < .0001). None of the specimens irrigated with a syringe showed completely clean artificial root canal irregularities without any remaining debris (score 0). Debris was completely removed after irrigation with the Vibringe System in 5% of the specimens and after PUI in 92.5% of the specimens.

Discussion

The design of the present study is comparable to that described by Lee et al (19) and has been used in several other investigations (15, 17,

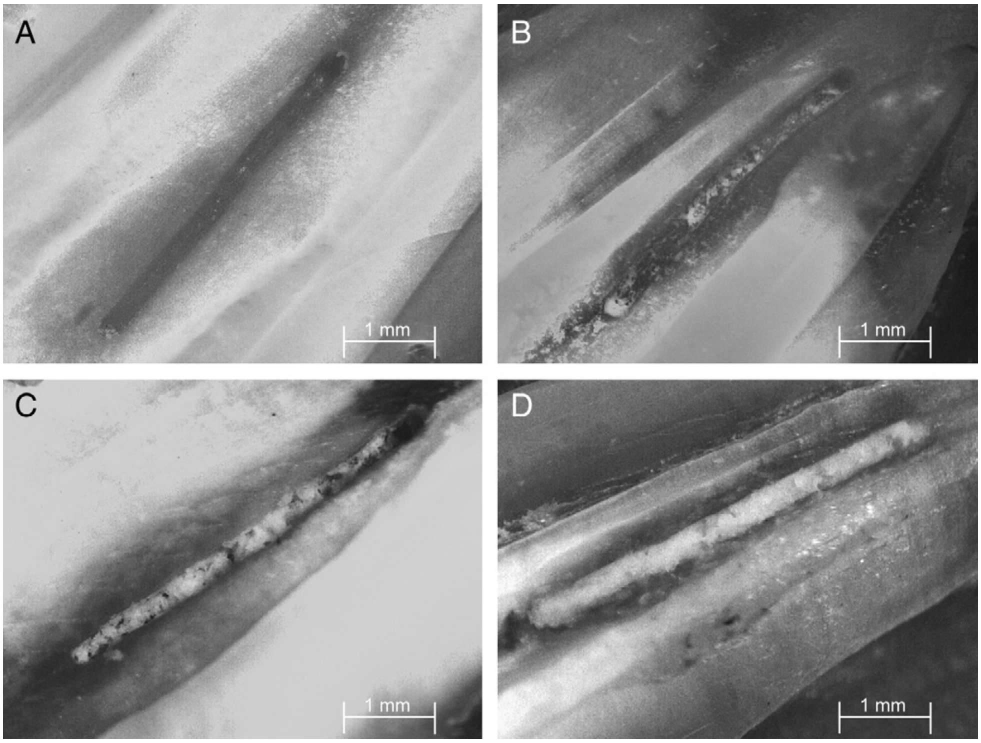

Figure 1. Standardized debris score for grooves according to van der Sluis et al (18). (*a*) Score 0: the groove is empty; (*b*) score 1: less than half of the groove is filled with debris; (*c*) score 2: more than half of the groove is filled with debris; (*d*) score 3: the complete groove is filled with debris. Original magnification, ×30.

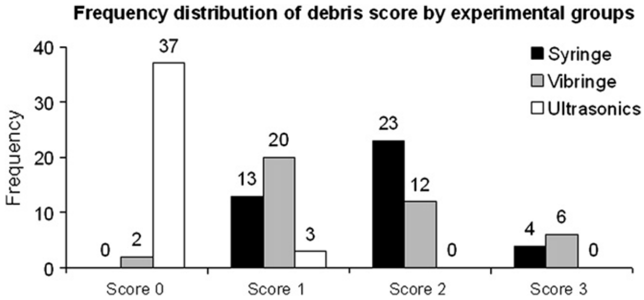

Figure 2. Frequencies of pooled evaluations for investigator and root half. Readings were generated from 20 root halves per group scored by 2 observers, resulting in 40 readings per irrigation procedure (40 grooves).

18, 20). The advantage of the groove model is the standardized size and location of the grooves, allowing a consistent evaluation with high intraobserver reproducibility and good interobserver agreement. Because the needle tip and the ultrasonic file do not have a physical effect on the debris in the groove, the flushing action of the irrigant is the main factor for debris removal. The major disadvantage of this model is that the standardized grooves do not represent the complexity of a natural root canal system. Therefore, it might be easier to remove dentin debris from artificial grooves than from isthmuses or oval extensions *in vivo*, resulting in an overestimation of the removal efficiency of different irrigation techniques.

The results indicated that PUI removed significantly more debris from root canal irregularities than the sonically activated Vibringe System and syringe irrigation. A more effective removal of debris with ultrasonic irrigation compared with sonic activation has been demonstrated (12, 14, 16), which could be due to the higher driving frequency of ultrasound (30 kHz) in comparison to the sonic device (150 Hz). Therefore, the flow velocity and the cleaning efficiency are lower for sonically activated irrigation (14, 21), resulting in less effective delivery of irrigant to the root canal extensions. The general consensus that ultrasonic irrigation is more effective than syringe irrigation in removing remnants of debris (11, 19, 22) is confirmed by the results of the present study.

The percentages of complete debris removal (score 0) for sonic and ultrasonic irrigation were 5% and 92.5%, respectively. These results are in agreement with a recent study that reported on 5.5%–6.7% completely clean root canals after sonic irrigation and 89% after ultrasonic irrigation (16).

In this study, the flow rate was approximately 5 mL/min for conventional manual or sonically activated irrigation and 10 mL/min for PUI. During PUI with a continuous flush, the volume and flow rate of the irrigant that enters the apical part of the root canal cannot be standardized (23). Although irrigant flow rate is considered a highly significant factor determining flow pattern in fluid dynamics (24), it is unknown whether it influenced the performance of ultrasonic irrigation.

Controversy exists regarding the removal of debris from different parts of the root canal. Debris removal from the coronal part is considered to be easier than from the apical part (14), whereas other authors found no differences among root canal thirds (25). In this study, a previously described tooth model (6) was modified to determine root canal cleanliness at apical as well as coronal levels. The overall evaluation revealed that cleanliness of the apical groove was superior to cleanliness of the coronal groove. All irrigation devices were placed 1 mm short of WL in close proximity to the location of the apical groove. Therefore, the introduction depth of the needle tip and the distance to the grooves seem to play an important role in the removal of debris, reinforcing the benefit of the physical flushing action (4, 26). Although a final irrigation protocol with apical cleaning as the main goal was tested, both grooves were filled with standardized amounts of debris. It might be speculated that the coronal third is flushed more often with NaOCl during the clinical procedure, resulting in better debridement coronally.

The Vibringe System performed similarly to conventional syringe irrigation in the coronal part but removed significantly more debris in the apical part. A possible explanation is that the oscillation amplitude of the sonically activated irrigation needle is higher at the tip than at the attached end (16, 27), resulting in an increased fluid velocity. In the coronal part the larger distance of the needle or file tips to the groove seems to reduce the efficacy of the agitation of the irrigant.

In conclusion, the present study showed that none of the tested irrigation devices were able to completely remove debris from artificial extensions in straight root canals. PUI removed significantly more debris than syringe irrigation or a sonically activated device (Vibringe). The Vibringe System performed significantly better than conventional syringe irrigation in the apical part of the root canal.

TABLE 1. Frequency Distribution of Debris Score by Experimental Groups and Location of the Groove

		Score			
Group	Location of the groove	0	1	2	3
Syringe	Coronal	0	3	13	4
	Apical	0	10	10	0
Vibringe	Coronal	0	5	9	6
	Apical	2	15	3	0
Ultrasonics	Coronal	17	3	0	0
	Apical	20	0	0	0

Readings were pooled for both observers.

Score 0: groove is empty; score 1: less than half of groove is filled with debris; score 2: more than half of groove is filled with debris; score 3: complete groove is filled with debris.

References

1. Haapasalo M, Endal U, Zandi H, Coil J. Eradication of endodontic infection by instrumentation and irrigation solutions. Endodontic Topics 2005;10:77–102.
2. Wu MK, Wesselink PR. A primary observation on the preparation and obturation of oval canals. Int Endod J 2001;34:137–41.
3. Peters OA. Current challenges and concepts in the preparation of root canal systems: a review. J Endod 2004;30:559–67.
4. Huang TY, Gulabivala K, Ng YL. A bio-molecular film ex-vivo model to evaluate the influence of canal dimensions and irrigation variables on the efficacy of irrigation. Int Endod J 2008;41:60–71.
5. Wu MK, Wesselink PR. Efficacy of three techniques in cleaning the apical portion of curved root canals. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995;79:492–6.
6. Lee SJ, Wu MK, Wesselink PR. The efficacy of ultrasonic irrigation to remove artificially placed dentine debris from different-sized simulated plastic root canals. Int Endod J 2004;37:607–12.
7. Cunningham WT, Martin H, Forrest WR. Evaluation of root canal debridement by the endosonic ultrasonic synergistic system. Oral Surg Oral Med Oral Pathol 1982;53:401–4.
8. Stock CJ. Current status of the use of ultrasound in endodontics. Int Dent J 1991;41:175–82.
9. van der Sluis LW, Versluis M, Wu MK, Wesselink PR. Passive ultrasonic irrigation of the root canal: a review of the literature. Int Endod J 2007;40:415–26.
10. Gutarts R, Nusstein J, Reader A, Beck M. In vivo debridement efficacy of ultrasonic irrigation following hand-rotary instrumentation in human mandibular molars. J Endod 2005;31:166–70.
11. Passarinho-Neto JG, Marchesan MA, Ferreira RB, Silva RG, Silva-Sousa YT, Sousa-Neto MD. In vitro evaluation of endodontic debris removal as obtained by rotary instrumentation coupled with ultrasonic irrigation. Aust Endod J 2006;32:123–8.

12. Stamos DE, Sadeghi EM, Haasch GC, Gerstein H. An in vitro comparison study to quantitate the debridement ability of hand, sonic, and ultrasonic instrumentation. J Endod 1987;13:434–40.
13. Jensen SA, Walker TL, Hutter JW, Nicoll BK. Comparison of the cleaning efficacy of passive sonic activation and passive ultrasonic activation after hand instrumentation in molar root canals. J Endod 1999;25:735–8.
14. Sabins RA, Johnson JD, Hellstein JW. A comparison of the cleaning efficacy of short-term sonic and ultrasonic passive irrigation after hand instrumentation in molar root canals. J Endod 2003;29:674–8.
15. van der Sluis LW, Wu MK, Wesselink PR. The efficacy of ultrasonic irrigation to remove artificially placed dentine debris from human root canals prepared using instruments of varying taper. Int Endod J 2005;38:764–8.
16. Jiang LM, Verhaagen B, Versluis M, van der Sluis LW. Evaluation of a sonic device designed to activate irrigant in the root canal. J Endod 2010;36:143–6.
17. van der Sluis LW, Wu MK, Wesselink PR. A comparison between a smooth wire and a K-file in removing artificially placed dentine debris from root canals in resin blocks during ultrasonic irrigation. Int Endod J 2005;38:593–6.
18. van der Sluis LW, Wu MK, Wesselink PR. The evaluation of removal of calcium hydroxide paste from an artificial standardized groove in the apical root canal using different irrigation methodologies. Int Endod J 2007;40:52–7.
19. Lee SJ, Wu MK, Wesselink PR. The effectiveness of syringe irrigation and ultrasonics to remove debris from simulated irregularities within prepared root canal walls. Int Endod J 2004;37:672–8.
20. van der Sluis LW, Wu MK, Wesselink P. Comparison of 2 flushing methods used during passive ultrasonic irrigation of the root canal. Quintessence Int 2009;40:875–9.
21. Ahmad M, Pitt Ford TR, Crum LA, Walton AJ. Ultrasonic debridement of root canals: acoustic cavitation and its relevance. J Endod 1988;14:486–93.
22. Cheung GS, Stock CJ. In vitro cleaning ability of root canal irrigants with and without endosonics. Int Endod J 1993;26:334–43.
23. van der Sluis LW, Gambarini G, Wu MK, Wesselink PR. The influence of volume, type of irrigant and flushing method on removing artificially placed dentine debris from the apical root canal during passive ultrasonic irrigation. Int Endod J 2006;39:472–6.
24. Tilton JN. Fluid and particle dynamics. In: Perry RH, Green DW, Maloney JO, eds. Perry's chemical engineer's handbook. 7th ed. New York: McGraw-Hill; 1999:1–50.
25. Munley PJ, Goodell GG. Comparison of passive ultrasonic debridement between fluted and nonfluted instruments in root canals. J Endod 2007;33:578–80.
26. Abou-Rass M, Piccinino MV. The effectiveness of four clinical irrigation methods on the removal of root canal debris. Oral Surg Oral Med Oral Pathol 1982;54:323–8.
27. Ahmad M, Pitt Ford TJ, Crum LA. Ultrasonic debridement of root canals: acoustic streaming and its possible role. J Endod 1987;13:490–9.