Influence of a Passive Sonic Irrigation System on the Elimination of Bacteria from Root Canal Systems: A Clinical Study

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Abstract

Introduction: The present investigation evaluated the ability of a new passive sonic irrigation (sonic group) system (EndoActivator) to eliminate cultivable bacteria from root canals *in vivo* and compared it with that of standard syringe irrigation (control group). **Methods:** Data were obtained by using bacteriologic sampling of root canals treated by endodontic residents. Sampling results from 1 session of treatment were then compared with results obtained after intervisit calcium hydroxide disinfection and a second session of treatment. **Results:** There was no significant difference in the ability of sonic group and control group to eliminate cultivable bacteria from root canals ($P > .05$). A second session and intervisit calcium hydroxide disinfection were able to eliminate cultivable bacteria from significantly more teeth than a single session of treatment ($P < .05$). **Conclusions:** These *in vivo* results strengthen the case for a multi-visit approach to the treatment of apical periodontitis. *(J Endod 2010;36:1315–1318)*

Key Words

Bacteria, culture, EndoActivator, endodontic treatment, sonic irrigation

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0099-2399/$0 - see front matter

doi:10.1016/j.joen.2010.04.024

Apical periodontitis is the defense mechanism the human body has developed to keep microbial infection of the root canal system from spreading beyond the apical foramen. Studies have shown that periradicular inflammation will not occur without invasion of the root canal system by microorganisms (1, 2). The goal of endodontic treatment is, therefore, the elimination of viable bacteria from the root canal system (3).

The timing of when to complete nonsurgical root canal treatment of teeth with apical periodontitis is controversial (4, 5). In controlled, clinical settings, it has been shown that treatment in at least 2 visits with calcium hydroxide disinfection results in improved healing rates (6). On the other hand, meta-analysis suggests there is no statistical difference in the healing rates of single-visit and multi-visit treatments (7). Regardless of when treatment is completed, healing of apical periodontitis is more likely to occur if, before obturation, the root canal system has been disinfected to a level in which bacteria can no longer be cultured (8, 9).

The quest to completely eliminate bacteria from root canal systems has resulted in some novel treatment modalities (10, 11). The phenomenon of acoustic microstreaming and cavitation inside of irrigant-filled root canals has been investigated (12). When cavitation bubbles are produced by acoustic waves, they eventually collapse, and the energy released is transferred to the root canal wall, liberating any debris found thereon (13). Microstreaming then carries the debris coronally so that it can be removed from the canal (14). Acoustic cavitation has been shown to remove and destroy biofilm (15).

The EndoActivator (EA) (Dentsply/Tulsa Dental Specialties, Tulsa, OK) is a cordless, battery-powered handpiece with a sonic motor. It has been developed with the hope of "safer, better, and faster…debridement and disruption of the smear layer and biofilm" (16). This statement is based on the proposed ability of EA to produce cavitation and acoustic streaming inside of root canal systems. Clinical, peer-reviewed research is warranted to substantiate this claim.

The purposes of this study were (1) to evaluate whether the addition of EA to standard chemomechanical instrumentation results in a greater elimination of cultivable bacteria from root canals compared with standard irrigation (control group) and (2) to compare the ability of one-session treatment to eliminate cultivable bacteria with that of a second session with calcium hydroxide disinfection.

Materials and Methods

Approval for the project was obtained from the Institutional Review Board of the University of Connecticut Health Center. A power analysis (17) before beginning the study resulted in a sample size of 42 for each independent sample (sonic group or control group) for a total patient recruitment of 84. The 2 groups were randomized by using a computer program (www.randomizer.com), and patients were assigned according to the randomization sequence. Patients with any tooth with apical periodontitis, verified with a radiograph and negative cold test, were recruited for the study. Teeth with apical periodontitis previously treated were excluded. Patient consent was obtained before recruitment. All treatment was performed by 1 of 10 endodontic residents.

Each tooth was isolated with rubber dam and disinfected with 30% hydrogen peroxide and 5% iodine tincture to eliminate surface contaminants (18). All caries

and previous restoration were then removed, and the tooth was disinfected again as before. The tooth was then irrigated with 5% sodium thiosulfate to inactivate the iodine, and a bacteriologic sample was taken by using sterile paper cones and liquid thioglycolate broth enriched with vitamin K_1 and hemin in culture tubes. All samples were obtained by the same operator (S.K.H.) throughout the duration of the study to standardize the culture technique.

Following disinfection protocol, access was gained to the root canal system, and the canals were preflared slightly to allow space for paper cones to enter. The canals were then filled with sterile saline. The contents were absorbed into sterile paper cones placed at the most apical extent of the canal until the canal was dry; the saturated cones were deposited into a culture tube. This sample was taken to confirm the presence of bacteria in the system. In cases with multiple canals, each canal was sampled for viable bacteria.

Standard clinical instrumentation protocol followed the second bacterial culture. This involves obtaining working length (WL) approximately 1 mm short of the radiographic apex. This was established with an apex locator (Raypex 4, Johnson City, TN) and confirmed by radiograph. Root canals were then chemomechanically instrumented with hand (Kontrolflex K-file; Brasseler USA, Savannah, GA) and EndoSequence rotary instruments (Brasseler USA) to WL by using 0.5% sodium hypochlorite (NaOCl). The size of the master apical file (MAF) was determined by each of the 10 clinicians. Needle irrigation was performed with a 27-gauge side-vented monojet needle (Kendall, Mansfield MA). When chemomechanical instrumentation was complete, a treatment card with either "EndoActivator" or "Standard Irrigation" printed on it was brought to the resident performing treatment. Both the resident and the operator taking the bacteriologic sample were blinded as to which treatment group the tooth would be assigned before this point.

If the card indicated "EndoActivator," the following protocol was followed. Each canal was filled with NaOCl, and then EA was inserted into the canal and activated for 30 seconds at 10,000 cpm. Time was kept with a timer. After 30 seconds, a fresh solution of NaOCl was introduced into the canals, and EA was again activated for 30 more seconds for a total of 1 minute. This is in accordance with manufacturer recommendation of 1-minute activation per solution per canal. After activation, canals were then flushed with sterile saline and dried with sterile paper cones. If the card indicated "Standard Irrigation," the same protocol was followed but without the use of EA in the canal.

Each canal was then flushed with 5% sodium thiosulfate, dried with paper cones, and then filled with sterile saline. A hand file equal in size to the MAF was then inserted into the canals and scraped against the canal walls to remove any debris and bacteria from the canal walls (18). The contents of the canal were then absorbed into paper cones and placed into the culture tubes as before. All samples were then incubated for 7 days and observed for growth daily by the study coordinator. No growth was assigned if turbidity was absent on the seventh day.

Following this third sample, each canal was filled with a slurry of calcium hydroxide (Henry Schein, Melville, NY) applied with a lentulo spiral or hand file, and the tooth was temporarily restored with a 4-mm layer of Cavit (3M ESPE, St Paul, MN) covered by Fuji IX (GC Company, Tokyo, Japan). The patient was then scheduled for a second appointment at least 2 weeks later.

At the second session, a surface disinfection sample was again taken before reaccessing the tooth. The teeth were then reaccessed, and the canals were irrigated copiously along with any additional instrumentation to remove calcium hydroxide and remaining debris. The EA was not used during the second visit in either of the treatment groups. Needle irrigation with NaOCl was the sole means of irrigation. A postmedication bacteriologic sample was then obtained, and the treatment was completed with root fillings placed.

Six teeth with no signs of radiographic periapical inflammation and vital pulps confirmed by the presence of vital tissue on entry into the pulp chamber were used for negative controls. Three teeth were assigned to the sonic group and 3 to the control group. The entire experimental protocol as described above was performed on these 6 teeth.

Data were analyzed (SPSS Statistical pack 17.0; SPSS Inc, Chicago, IL) by using independent and paired-sample *t* tests. Hypotheses were tested at the .05 level of significance.

Results

A negative culture was obtained for surface disinfection in 96.5% of the samples. All controls tested negative for growth at the end of the first and second visits.

Bacteria were initially present in the root canals of all 84 teeth treated. Ten patients refused to appear for the second session and were excluded from the data comparing one- and two-session treatment. The data comparing sonic group and control group at the first session are found in Table 1. After activation of NaOCl with EA, 25 teeth (60%) still harbored cultivable bacteria compared with 22 teeth (52%) for the control group. These differences were not significant ($P > .05$).

The data comparing one- and two-visit treatment are found in Table 2. At the end of the first session, 47 teeth (56%) still harbored cultivable bacteria. After calcium hydroxide disinfection and a second session of treatment, 20 teeth (27%) still harbored cultivable bacteria. This difference was significant ($P < .05$).

There was no significant difference found at the second visit between teeth assigned to sonic group or control group. At the end of the second session, 9 of 36 and 11 of 38 teeth still harbored bacteria in the sonic group and control group, respectively.

Discussion

When dealing with nonsurgical root canal treatment, clinicians are usually faced with 2 situations. The first is a tooth with a vital pulp in which the tissue found in the root canal is inflamed but not completely infected by microorganisms. When these types of cases present themselves, the treatment is relatively straightforward. In vital cases, all of the clinician's effort is spent removing the sterile tissue aseptically and not introducing microorganisms into the root canal. This type of

TABLE 1. Culture Results for EndoActivator (PSI) and Standard Irrigation (SI) Groups

			Culture result, 1st visit		
			Negative	Positive	Total
Protocol	PSI	Count	17	25	42
		% within protocol	40.5	59.5	100.0
	SI	Count	20	22	42
		% within protocol	47.6	52.4	100.0
Total		Count	37	47	84
		% within protocol	44.0	56.0	100.0

TABLE 2. Culture Results for One- and Two-visit Treatment Groups

			Culture result		
			Negative	Positive	Total
Treatment group	One-visit	Count	37	47	84
		% within visit result	44.0	56.0	100.0
	Two-visit	Count	54	20	74
		% within visit result	73.0	27.0	100.0
Total		Count	91	67	158
		% within visit result	57.6	42.4	100.0

treatment can usually be completed in 1 treatment session (19). The other situation is more complex. When a patient presents with a tooth that has been infected by bacteria causing periapical bone breakdown, the clinician must use all the means he/she has to kill and remove the invading bacteria and their inflammatory by-products from the canal system.

In recent years, it has been suggested that files attached to ultrasonic handpieces be used to aid in the irrigation and debridement of infected root canals (20, 21). Recently, the EA has been recommended to enhance the cleaning efficacy of irrigation of root canal systems. Its proposed ability to create sonic waves in irrigating solutions deposited inside of the root canal might aid in the killing of bacteria and debridement of necrotic tissue. In the current study it was not shown that EA improved the ability to eliminate cultivable bacteria from root canal systems. Our study found no significant difference between the number of negative cultures obtained by standard irrigation and the number obtained with use of EA. This is consistent with the results of a recent *in vitro* study evaluating bacterial removal in simulated canals by using both EA and needle irrigation (22).

One reason for this might be that EA produces only sonic waves. Ultrasonic instruments have been shown to enhance the cleaning efficiency of irrigation (23, 25). Stamos et al (24) compared the use of sonically and ultrasonically activated instruments and found that the ultrasonically activated instruments removed significantly more debris than those that were activated sonically. Node production along activated files is an important part of acoustic streaming (12), resulting in a strong current produced along the activated instrument (14). If the instrument touches the canal wall, the node in the immediate vicinity will be diminished (26). Because it is inevitable that the file will touch the canal wall, it is important to create several nodes along the instrument being activated. Ultrasonic energy has the ability to create several nodes along the length of the file (27). Sonic energy only has the power to produce 1 node along the length of the instrument, so any constraint of the instrument will significantly decrease, if not eliminate, the acoustic streaming necessary to dislodge and carry away necrotic debris (27).

EA might not be powerful enough to disrupt bacterial biofilms. Ahmad et al (28) showed that ultrasonically activated instruments could not disrupt bacteria but simply dispersed it to other areas of the canal. Even with ultrasonics, Mayer et al (25) found that only the coronal third of the canal was being cleaned. In that study there was no significant difference between syringe irrigation and ultrasonic irrigation in the apical third of the canal. This might be due to the activated file touching the canal wall in the apical third and not being able to produce the necessary nodes for acoustic streaming and cavitation (14). If ultrasonic instruments with their constant power supply and increased node production cannot effectively clean in the apical third, it is likely that EA with its battery power and sonic engine will have the same problem.

The ability of a second session of instrumentation and irrigation together with an interappointment medication of calcium hydroxide was compared with a single session of instrumentation and irrigation. Studies have shown that when treatment of necrotic pulps is performed in 2 sessions with calcium hydroxide disinfection, there is a reduction in intracanal bacteria and a greater likelihood of obtaining a negative culture (29). Calcium hydroxide raises the pH of the root canal system to a level at which many microorganisms cannot survive (30). It has also been found that when necrotic tissue has been in direct contact with calcium hydroxide, it becomes more soluble and susceptible to dissolution by NaOCl (31). In the present study it was shown that the addition of calcium hydroxide together with another round of instrumentation and irrigation was effective at eliminating cultivable bacteria from significantly more teeth.

In the current study, two-visit treatment with calcium hydroxide disinfection was able to eliminate cultivable bacteria from about 75% of teeth exhibiting apical periodontitis. This is comparable with some studies (29) and is a lower number than other studies (32). It is known that some bacteria are more resistant to the high pH of calcium hydroxide (33). Bacteria living in biofilms are also more resistant to NaOCl and the alkaline stress of calcium hydroxide, even when directly exposed *in vitro* (34).

A very important factor in the effectiveness of calcium hydroxide is the ability of the operator to place it effectively. It is essential that the calcium hydroxide be placed in the instrumented canal as a thick, moist paste that completely obturates the canal space (30, 35). The manner in which the calcium hydroxide was mixed and placed was not observed or standardized in this study, and this could be a confounder.

If a resistant species of bacteria is present, if bacteria have established themselves as a biofilm inside of the canal, or if the operator is not careful about his/her placement of calcium hydroxide, the effectiveness of the dressing will be compromised. One of the greatest benefits of multi-visit treatment might be the benefit of a second or third opportunity to disrupt biofilms and irrigate them out of the root canal (36). Calcium hydroxide is not the only benefit in a multi-session approach to apical periodontitis.

Our study supports the recommendation to render treatment of teeth exhibiting signs and symptoms of apical periodontitis in at least 2 sessions with the use of calcium hydroxide as an interappointment medicament. The EA did not enhance the ability of standard needle irrigation to eliminate cultivable bacteria from root canals in this study. Other *in vivo* studies comparing the ability of sonic and ultrasonic instruments to eliminate bacteria from root canals are warranted.

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