Comparison of the Antimicrobial Efficacy of Irrigation Using the EndoVac to Endodontic Needle Delivery

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Abstract

Introduction: The purpose of this investigation was to compare the antimicrobial efficacy of root canal irrigation with the EndoVac (Discus Dental, Culver City, CA) to endodontic needle irrigation in the apical 5 mm of root canals infected with *Enterococcus faecalis.* **Methods:** Bilaterally matched, extracted human teeth were sterilized and inoculated with *E. faecalis*. Specimens in the EndoVac group were irrigated using the EndoVac system, whereas those in the needle group were irrigated with a 30-G side-vented needle. After chemomechanical preparation, the apical 5 mm of the roots were removed, frozen in liquid nitrogen, and pulverized to expose *E. faecalis* in dentinal tubules or other morphologic irregularities. The number of colony forming units (cfus) of *E. faecalis* per mg dentin was determined. **Results:** The EndoVac Group had a mean of 31.6 cfu/mg, whereas the needle group had a mean of 157 cfu/mg. This represents a bacterial reduction of 99.7% in group A and 98.8% in group B when compared with positive controls. **Conclusion:** Although there were fewer cfu/mg when using the EndoVac, there was not a statistically significant difference between the EndoVac and needle groups. *(J Endod 2010;36:509–511)*

Key Words

Disinfection, EndoVac, irrigation

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Normal root canal anatomy is complex and contains numerous ramifications and morphologic irregularities that provide an environment for microbes to colonize and cause disease (1). Microbes can infect not only morphologic ramifications and irregularities of the root canal system but also be present in dentinal tubules (2). These complexities make thorough disinfection of the root canal system a challenge in clinical endodontics. Concern has been expressed about the consequence of bacteria left in the root canal system and in the dentinal tubules (3–5). It has been shown that mechanical instrumentation and irrigation reduces but does not predictably eliminate bacteria in the canal and dentinal tubules (6–11). Ideally, endodontic irrigants are delivered to the apical regions of the canal system to flush out loose debris, dissolve organic tissues, kill microbes, remove microbial byproducts, and remove the smear layer (12, 13).

The EndoVac System (Discus Dental, Culver City, CA) is a device designed to safely deliver irrigants to the apical terminus of root canals. The device consists of a delivery/evacuation tip attached to a syringe of irrigant and the high volume suction of the dental chair. Using a combination of a macro- or microcannula attached to the suction device, irrigant introduced into the pulp chamber is pulled by negative pressure down the canal into the tip of the cannula and removed through the suction hose. Measuring 0.32 mm in diameter, the microcannula can be placed to the working length provided the canal is prepared to at least an International Standards Organization 35 or larger. The purpose of this investigation was to compare the antimicrobial efficacy of irrigation with the EndoVac to needle irrigation in the apical 5 mm of roots infected with *Enterococcus faecalis.*

Materials and Methods

Twenty-five bilaterally matched pairs of extracted human teeth with mature apices were obtained and stored in saline. Each tooth was radiographed to confirm the presence of a single canal. The infected dentin model used in this experiment was originally described by Haapasalo and Haapasalo and Orstavik (3), modified by Kho and Baumgartner (14), and adapted for this study.

The teeth were soaked in 5.25% NaOCl for 30 minutes to remove residual tissue and debris from the root surfaces. The incisal/occlusal surfaces were reduced as needed so that the length of each tooth within each matched pair was equal. An access preparation was made with a high-speed round bur, and patency was confirmed with a #10 K-file. The working length was determined as the point in which a #10 file was just visible with 20× magnification in the apical foramen. The canals were subsequently enlarged to a #20 K-file at the working length.

A customized model was assembled for each tooth for the subsequent instrumentation and irrigation procedures. Polyvinyl siloxane impression material was expressed into 2-mL scintillation vials. The teeth were embedded in impression material up to their cementoenamel junction. After the impression material set, the cementoenamel juncation of each tooth was sealed with cyanoacrylate (Super Glue Corporation, Rancho Cucamonga, CA). The vials were then placed into 10-mL scintillation vials, and the caps were loosely fitted to create individual chambers.

The teeth, customized models, and scintillation vials were assembled and steam autoclaved at 121°C for 30 minutes. Three positive control teeth and three negative control teeth were similarly treated. The three negative control teeth were cultured to establish the effectiveness of the sterilization procedures.

A 24-hour pure culture suspension of *E. faecalis* (ATCC 19434) was cultivated in brain-heart infusion (BHI) broth (Becton Dickinson and Company, Sparks, MD). The

25 experimental pairs of teeth and three positive control teeth were each inoculated with *E. faecalis* by placing the suspension in the access of each tooth with a micropipette. Fresh inoculum was added every 48 hours and cultured for 6 weeks under aerobic conditions at 37°C. The three negative control pairs of teeth were inoculated with sterile BHI.

At the end of the 6-week incubation period, the teeth in each experimental pair were randomly assigned to one of two groups. The teeth in each matched pair were instrumented to the same master apical file size, and each tooth received irrigation for the same amount of time. The instrumentation sequence for the experimental teeth was as follows: coronal flaring was accomplished with size 2 to 4 Gates-Glidden drills. The canals were prepared to the working length using ProFile .06 (Dentsply Tulsa Dental, Johnson City, TN) taper rotary instruments in a crown-down, continuous taper technique. To ensure patency, recapitulation to the working length was accomplished after each rotary instrument series with a #10 K-file. The canals were instrumented to a minimum size of 35/06 and a maximum size of 50/06 at the working length. Each file was evaluated immediately after its use in the canal, and master apical file was determined by the first file sized 35 or larger to reach the working length that showed the presence of dentin debris in the flutes of the apical 5 mm of the file.

EndoVac Group

Use of the EndoVac system followed manufacturer's recommendations and began during the use of Gates Glidden drills. While the Gates Glidden drills were being used, the EndoVac delivery/evacuation tip was placed above the access opening to constantly deliver and evacuate 5.25% NaOCl, keeping the canal and pulp chamber full of irrigant at all times. One milliliter of NaOCl was used to replenish the irrigant in the pulp chamber after each rotary nickel-titanium instrument. After reaching the working length with the master apical file, macroirrigation of each canal with NaOCl was accomplished over a 30-second period. This was performed by using the EndoVac delivery/evacuation tip while the macrocannula was constantly moved up and down in the canal from a point where it started to bind to a point just below the orifice. The canal space was then left undisturbed and full of irrigant for 60 seconds. Three cycles of microirrigation followed, during which the pulp chamber was kept full of irrigant while the microcannula was placed at the working length for 6 seconds. The microcannula was then positioned 2 mm from the working length for 6 seconds and then moved back to the working length for 6 seconds. This up-down motion continued until 30 seconds had elapsed, ensuring 18 seconds of active irrigation directly at the working length. After 30 seconds of irrigation, the microcannula was withdrawn from the canal in the presence of sufficient irrigant in the pulp chamber to ensure that the canal remained totally filled with irrigant and that no air was drawn into the canal space. The canal filled with irrigant was left undisturbed for 60 seconds. This completed one microirrigation cycle. The first cycle used 5.25% NaOCl as the irrigant, the second cycle 15% tetra-sodium EDTA, and the third cycle 5.25% NaOCl. At the end of the third microirrigation cycle, the microcannula was left at the working length without replenishment to remove excess fluid. Complete drying of the canals was accomplished using sterile paper points.

Needle Group

The other tooth in each pair was irrigated by using a 30-G ProRinse needle and syringe (Dentsply Tulsa Dental, Johnson City, TN). A 1-mL flush of 5.25% NaOCl, short of the binding point, was used after each instrument, leaving the canal filled with irrigant between instruments. A small, 1- to 2-mm, constant apical-coronal movement of the needle was maintained during expression of the irrigant. After instrumentation to the master apical file size, irrigation with NaOCl for 30 seconds was accomplished. The irrigant was then left undisturbed in the canal for 60 seconds. Further irrigation with the needle was performed moving the needle from 2 mm from the working length to 4 mm from the working length in constant motion for 30 seconds. NaOCl was used and left in the canal for 60 seconds. This was followed by EDTA for 30 seconds or irrigation and left undisturbed for 60 seconds. NaOCl was then used as the last irrigant, using the same method for the same amount of time. The irrigant was then aspirated from the canal by using the irrigation needle at 2 mm from the working length. Complete drying of the canals was accomplished using sterile paper points.

To test for bacterial survival in the apical 5 mm of the root canal system and dentinal tubules, sterile multipurpose burs in a rear exhaust surgical handpiece (Impact Air 45; Palisades Dental, Fort Lee, NJ) were used to remove the apical 5 mm of all experimental and control teeth. The samples were pulverized for 30 seconds in liquid nitrogen using a sterile mortar and pestle. The pulverized samples were collected and weighed on sterile aluminum foil. The samples were then suspended in 1 mL of sterile BHI. Ten-fold dilutions were prepared, and 0.1-mL aliquots of the suspensions were spread on BHI agar media. They were incubated at 37°C for 48 hours and the colony forming units (cfus) enumerated. Using the weight of the pulverized root end, the number of cfu/mg was determined. Specimens from the control teeth were sampled and cultured using the same techniques. The purity of the positive cultures was confirmed, and the sterility of the negative controls was confirmed.

A paired *t* test was used to determine if there was a significant difference in cfu/mg between the experimental and control groups. Independent *t* tests were used to compare the EndoVac Group with the positive controls and the needle group with the positive controls.

Results

All teeth in the negative control group showed no bacterial growth. The teeth representing the positive control group showed substantial bacterial growth with a mean of 1.40×10^4 cfu/mg. Both experimental groups showed very high efficacy with regards to reduction of viable bacteria. There were no significant differences between the experimental groups. The EndoVac Group had a mean of 31.6 cfu/mg, whereas the needle group had a mean of 157 cfu/mg.

Discussion

A pilot study showed that incubating the teeth for 6 weeks with *E. fae*calis under the experimental conditions provided adequate cfus for the investigation. Pulverizing of teeth for bacterial quantification has been used previously by other researchers (3, 14). Baker et al (15) used liquid nitrogen to freeze bovine teeth and then pulverized them for evaluation of the antibacterial action of medicaments. Kho and Baumgartner (14) showed that by pulverizing teeth with a mortar and pestle, it is possible to determine the cfus in dentinal tubules and other morphologic recesses in addition to the main root canal system. Bacteriologic sampling with paper points may underestimate the true levels of infection because only microorganisms collected on the paper points can be cultivated and quantified. By freezing and pulverizing the root ends, it is possible to quantify the cfus in the apical regions of the root canal system, including those in dentinal tubules and other morphologic irregularities, giving a better indication of the remaining bacteria after chemomechanical instrumentation than using paper points to collect samples.

Recent studies have shown increased canal cleanliness using the EndoVac. Nielsen and Baumgartner (16) found that at 1 mm from the working length, the main canal lumen of teeth irrigated with the

EndoVac contained significantly less debris than matched teeth irrigated using a 30-G needle. No difference was seen, however, at 3 mm from the working length in that study.

An *in vitro* study by Hockett et al (17) compared the incidence of canals positive for the growth of *E. faecalis* after the use of either the EndoVac system or needle irrigation by collecting fluid and dentin shavings from the inside of the canals after chemomechanical debridement. They concluded that apical negative pressure delivery of irrigants with the EndoVac had the potential to achieve better microbial control than positive pressure needle irrigation. Townsend and Maki (18) also evaluated the use of the EndoVac system recently. That study found that ultrasonic irrigation was significantly more effective in removing intracanal bacteria than both needle irrigation and the use of the EndoVac.

It has been shown that although an irrigant can penetrate into the dentinal tubules, it does not mean that the concentration is sufficient to kill all types of bacteria present (19). It has been previously shown that bacteria may remain viable in tubules at great distances from the pulp (20, 21). This study showed that although our current techniques clearly reduce the bioburden within the canal space *in vitro*, we still cannot effectively disinfect the canal system. This study and previous investigations have shown that disinfection of root dentin is not achieved by chemomechanical preparation alone (8-11, 22-24). Bacteria deep in dentinal tubules and other morphologic irregularities are apparently protected from instrumentation and irrigation making their removal or eradication difficult. It has been suggested that microorganisms may be eliminated or rendered harmless by entombing by obturation of the canal space after chemomechanical root canal preparation (25). Although the consequences of microbes remaining in the dentinal tubules after root canal treatment is not clear (5), the main goal of root canal treatment is still the elimination of microorganisms. Future research must also be concerned with the efficacy of root canal disinfection of microbial aggregates and biofilms (26, 27).

It is worth noting that although the present study shows no statistically significant benefit to using the EndoVac System, other potential benefits to using the EndoVac may exist. A recent study by Desai and Himel (28) found that the EndoVac was able to be used to the working length very safely, without extrusion of irrigating solution beyond the apical constriction of the canal.

Although there was a trend toward better antimicrobial efficacy with the negative pressure group, the results of this study showed no statistically significant difference in antimicrobial efficacy between negative pressure and positive pressure irrigation with 5.25% NaOCl and 15% EDTA in the apical 5 mm of roots infected with *E. faecalis*.

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