Effect of Maintaining Apical Patency on Irrigant Penetration into the Apical Third of Root Canals When Using Passive Ultrasonic Irrigation: An *In Vivo* Study

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Abstract

Introduction: The complex anatomy of the root canal system has been shown to limit the penetration of irrigating solutions into the apical third; hence, the aim of this study was to determine whether the use of a patency file is related to the presence of a radiopaque irrigating solution in the apical third of human root canals after using passive ultrasonic activation *in vivo*. **Methods:** Forty human root canals were randomly divided into two groups. Apical patency was maintained in one group (n = 21) during shaping and cleaning procedures with a no. 10 K-file 1 mm beyond the working length (WL) but not in the other group (n = 19). In both groups, the canals were shaped with the Pro Taper system (Dentsply-Maillefer, Ballaigues, Switzerland). Irrigation was performed with 1 mL of a solution prepared with a radiopaque contrast medium and sodium hypochlorite 5.25%, and then passive ultrasonic irrigation (PUI) was applied after the shaping procedure. Digital images were taken, and a calibrated reader determined the presence or absence of the irrigating solution in the apical third. **Results:** There were significantly more canals with irrigant in the apical third after PUI when apical patency was maintained with a no. 10 file 1 mm beyond the WL than when apical patency was not maintained throughout the cleaning and shaping procedures (P = .02). **Conclusions:** Maintaining apical patency and then using PUI improves the delivery of irrigants into the apical third of human root canals. *(J Endod 2011;37:1276–1278)*

Key Words

Intracanal irrigants, passive ultrasonic irrigation, patency file, sodium hypochlorite

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Chemomechanical preparation of the root canal system is a crucial step when performing root canal therapy. Its main purpose is to eliminate organic tissue and reduce the microbial load (1–3). However, achieving complete debridement of all areas in the canal has proven to be a difficult task because of the anatomic complexity of the root canal system (4), especially in the apical third (5).

The most commonly used irrigating solution is sodium hypochlorite (NaOCl) (6–8). Its penetration into the apical third of root canals is influenced not only by internal anatomy but also by the mode of delivery (9), the volume of solution and its physical and chemical properties, and the presence of air bubbles (10).

Delivering NaOCl to the root canal terminus in sufficient quantity and concentration is extremely important because it is in that area of ramifications, deltas, and fins that microorganisms can survive by colonizing organic tissue and dentin or getting nutrients from the periradicular tissues and releasing byproducts associated with the development of apical periodontitis (5, 11). A recent classification of irrigating methods divides them into two categories: (1) passive, or static, delivery of the irrigant and (2) irrigant activation, or agitation, by instruments and devices (12). Some of the agitation techniques, such as passive ultrasonic irrigation (PUI), may help the irrigating solution reach the apical third by activating the NaOCl after the cleaning and shaping procedure, thus improving the cleaning efficiency of the irrigating solution by reaching irregularities in the root canal system (13–19).

In addition, the accumulation of soft-tissue remnants or dentinal debris in the apical region is a common event that can cause blockage of the root canal (20). It has been shown that this can be avoided by establishing patency of the apical foramen (21). Apical patency is achieved when the apical portion of the canal is maintained free of debris by a final reaming with a small file through the apical foramen (22, 23).

One of the alleged reasons for not striving for apical patency is the possible extrusion of debris through the apical foramen although Izu et al (24) have shown that contaminated patency files can be disinfected by 5.25% NaOCl present in the root canal after irrigation (24). No complications, such as increased postoperative pain or transportation of the major foramen, resulted (25, 26). We have not found any published *in vivo* research assessing whether maintaining apical patency throughout the cleaning and shaping procedure results in improved delivery of the irrigant into the apical third; furthermore, we believe that not maintaining apical patency could cause blockage of the canals even when using ultrasonic activation. The purpose of this study was to determine whether maintaining apical patency improves the delivery of irrigants, consisting of a contrast medium (Claritrast 300; Justesa Imagen, Mexico DF, Mexico) and NaOCl 5.25%, into the apical third of human root canals after using PUI *in vivo*.

Materials and Methods

This research was conducted with the approval of the institutional review board; informed consent of patients participating in the study was obtained. Exclusion criteria were patients allergic to any of the components of the formula, pregnancy, or failure to obtain patient's authorization.

Preparation of the Radiopaque Irrigating Solution

A sterile, intravascular contrast medium containing ioversol 678 mg/mL (Claritrast 300) was mixed with NaOCl by a chemist in the proportion of 45:55 in order to have an irrigating solution with a similar density (average, 1.0848 g/mL) and viscosity of pure 5.25% NaOCl. A total of 40 human root canals, consisting of the buccal roots of maxillary molars, mesial roots of mandibular molars, and both roots of maxillary first premolars, in which the working length (WL) would measure between 19 and 21 mm were randomly assigned to either of two experimental groups: the no patency group (NP) and the patency group (P).

Group NP (n = 19). Root canals were instrumented using the Pro Taper (Dentsply-Maillefer, Ballaigues, Switzerland) system in the following sequence: Sx, S1, and Gates Glidden drill no. 3 to flare the coronal third. The WL was determined with the use of the Elements Diagnostic Unit apex locator (Sybron Dental Specialties, Orange, CA) at the 0.0 reading of the device with a no.10 K-file and was confirmed radiographically. Hand files nos.10, 15, and 20 K were used until the WL was reached, and passive irrigation with 1 mL of the irrigating solution was used to the deepest penetration of a 27-G, side-vented needle (Endo-Eze Ultradent, South Jordan, UT). The first digital image was taken at this time using the Gendex Visualix digital image system (Des Plaines, IL) and then Pro Taper S2 and F1 instruments were used to the WL and passive irrigation was performed again with 1 mL of the solution to the deepest possible penetration of the needle. A 10 K-file was taken to length (no patency) using a push-pull motion, and then an F2 instrument was used to the WL followed by passive irrigation of 1 mL of the solution, placing the needle 2 mm from WL. A second digital image was taken at this time, and then an F3 Pro Taper instrument was taken to the WL, irrigation was performed to 2 mm from the WL, and a 10-K file was again taken to the same length; the third digital image was taken at this time. After the shaping procedure, PUI was done using an FF finger spreader (Sybron) attached to a file adapter (Sybron) at 3 mm from the WL connected to the Miniendo (Sybron) ultrasonic unit at power 5 for 20 seconds. A fourth digital image was taken at this time.

Group P (n = 21). The same procedure was performed for group P, but the 10 K-file was inserted 1 mm farther than the WL to maintain patency between each instrument and before each irrigation. Four teeth were used as positive controls, two *ex vivo* and two *in vivo*, in which the radiopaque solution was placed intracanally to determine whether it could be detected by an examiner. Four teeth were used as negative controls in patients receiveing root canal therapy wherein no intracanal radiopaque solution was used. Digital images were taken after the cleaning and shaping procedure.

A blinded calibrated reader determined the presence or absence of the irrigating solution in the apical 2 mm of the root canals, observing the digital images on a 6.56′ × 6.56× screen and recording no (the absence of irrigating solution) or yes (the presence of irrigating solution).

Statistical Analysis

The presence or absence of the irrigating solution (yes/ no) was compared between the two groups (P/NP). Results were analyzed with the chi-square test (SPSS 15 for Windows; SPSS Inc, Chicago, IL).

Results

Radiopaque irrigant was present apically in every positive control and absent in all negative controls. Of all the canals in group NP, irrigant was found in the apical third of three (15.8%) in the first digital image, one (5.3%) in the second, four (21.1%) in the third, and in the same four (21.1%) after PUI was used. In group P, there were no canals with irrigant in the apical third in the first and second digital images, but we found irrigant in six (28.6%) in the third digital image and in 12 (57.1%) in the last digital image.

We found no significant differences whether the patency file was used in the number of canals having irrigant in the apical third after coronal flaring (P = .06) or shaping to an F2 (P = .29) or an F3 (P = .58) instrument. We found significantly (P = .02) more canals with irrigant in the apical third after PUI when maintaining apical patency with a no. 10 file 1 mm beyond the WL than when apical patency was not maintained throughout the cleaning and shaping procedures (odds ratio = 4.9; 95% confidence interval, 1.2–20) (Fig. 1).

Discussion

In our study, maintaining apical patency with a no.10 file 1 mm beyond the WL resulted in more canals having irrigant in the apical third after agitating the irrigant with PUI. It may be that a patency file facilitates removal of the air bubble or vapor lock effect (10) although the influence of the patency file and PUI on the penetration of irrigating solution had not been studied *in vivo* before. Of all canals in group NP, irrigant was found in the apical third in three (15.8%) in the first digital image and one (5.3%) in the second; this finding may be because of gas or air bubbles moving inside the root canal as instruments rotate in it. This dynamic movement of air bubbles has been observed in closed systems (10).

This study is in agreement with previous studies that have shown PUI to facilitate the penetration of irrigants into confined areas of the root canal system (18). De Gregorio et al (18) showed *in vitro* that ultrasonic activation resulted in a better irrigation of lateral canals at 4.5 and 2 mm from the WL compared with traditional needle irrigation when patency was obtained using a 10 K-file.

One of the main problems when analyzing irrigant penetration inside the canal with a radiographic technique is the need to add radiopaque material to the irrigant solution without altering any of the properties of the NaOCl. As opposed to previous studies that used radiopaque solutions to determine irrigant penetration *in vivo* (27, 28), we enlisted a chemist to carefully mix this solution with NaOCl to a density and viscosity very similar to 5.25% NaOCl.

Another important factor in the penetration of irrigants into the root canal is the diameter of the last instrument used at the WL. Salzgeber and Brilliant (27), Chow (29), and Senia et al (30) showed that very little if any solution reaches the apical third before the root canal system is flared to accommodate a size 30 file. In contrast, other studies, mostly *ex vivo*, have shown that the low surface tension of NaOCl allows it to penetrate into the apical third and lateral canals even when the main canal has been flared to sizes smaller than a no. 30 (31–33). These results could be influenced by the fact that detecting radiopaque solution *in vivo* may be more difficult than *ex vivo* due at least in part to anatomic interferences. The type of

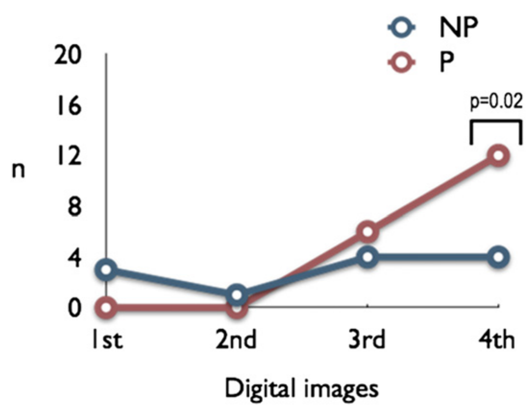

Figure 1. The delivery of irrigants, consisting of a contrast medium (Claritrast 300) and NaOCl 5.25%, into the apical third of human root canals.

teeth we used in this study allowed us to have a sample of canals shaped to an F3 instrument, but in some canals the radiopaque solution was observed in the apical third after they had been flared to an F2 instrument (size 25 at the tip) and before PUI.

Another important consideration is the diameter of the patency file. Cailleteau and Mullaney (34) reported that 42% of dental schools in the United States teach their students to use a no. 10 file to maintain patency, 33% use a no. 15 file, and 25% use a no. 20 file, whereas we used a no. 10 file. Using larger instruments for this purpose can cause injury to the periapical tissues and extrusion of significant amounts of infected debris. Goldberg and Masson (35) observed that if a no. 20 file is used for patency, the chance of transporting the apical foramen reached 56.6%.

From our data, it can be concluded that maintaining apical patency with a no. 10 K-file improves the delivery of irrigants into the apical third of human root canals when using PUI to agitate the irrigant inside the canal, but the mere presence of NaOCl in the apical third does not guarantee that it has been properly cleaned and disinfected (7, 14). Once there, NaOCl needs enough time, concentration, and contact to dissolve organic tissue and affect the microorganisms protected by biofilm (1, 5); however, every effort should be made to use an irrigating technique that predictably delivers the solution early in the cleaning and shaping procedure. In conclusion and within the limitations of this study, maintaining apical patency and then using PUI improved the delivery of irrigants into the apical third of human root canals.

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The authors deny any conflicts of interest related to this study.

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