Delivery of Calcium Hydroxide: Comparison of Four Filling Techniques

Richard M. Simcock, DDS and M. Lamar Hicks, DDS, MS**

Abstract

This study compared the weight and radiographic appearance of $Ca(OH)_2$ delivered into standardized, minimally and fully prepared canals using (a) an injection system, (b) an endodontic Flex-O file rotated counterclockwise, (c) a lentulo spiral, and (d) a .04 rotary NiTi file rotated in reverse. Two extracted human second mandibular premolars with single canals were prepared to an MAF #25 or an MAF #40. A weight measurement and radiograph were made for each filling. Three independent examiners evaluated the radiographs. Regardless of technique, only about 45% of the optimal weight of $Ca(OH)_2$ was delivered into the minimally prepared canal. Radiographically the filling quality was only 1 to 2 (10 scale). In contrast, all delivery techniques delivered near optimal weight of $Ca(OH)_2$ in the completely prepared canal with a radiographic filling quality of 8.8 to 9.3. The results indicate that complete instrumentation is needed to obtain near optimal delivery of $Ca(OH)_2$. *(J Endod 2006;32:680–682)*

Key Words

$Ca(OH)_2$ delivery, complete instrumentation needed for near optimal delivery, testing of four techniques

From the *I. B. Bender Division of Endodontics, Albert Einstein Medical Center, Philadelphia, Pennsylvania. Current status of Dr. Simcock: Private Practice of Endodontics, 130 S. 15th Street, Suite 101, Mount Vernon, WA 98274.

Address requests for reprint to Dr. M. Lamar Hicks, Clinical Professor, Department of Endodontics, Operative Dentistry, and Prosthodontics, University of Maryland at Baltimore, 6601 West Baltimore Street, Baltimore, MD 21201. E-mail address: mhicks@umaryland.edu.

0099-2399/$0 - see front matter

doi:10.1016/j.joen.2006.01.009

Calcium hydroxide ($Ca(OH)_2$) is used extensively as an intracanal medication (1). It inhibits the growth of bacteria between appointments (2–5). Bystrom et al. (6) found that $Ca(OH)_2$ effectively eliminated all microorganisms in infected root canals when the dressing was maintained for 4 wk. Because the goal of cleaning the root canal system is to remove necrotic tissue and eliminate bacteria, $Ca(OH)_2$ has been recommended as an intracanal medication after cleaning and shaping the canal system (7).

To maximize the antibacterial properties of $Ca(OH)_2$, it is important to have a dense, homogenous filling to the root apex (8). Although several studies investigated the quality of $Ca(OH)_2$ placement in large immature canals (9–11), they typically described apexification procedures. However, when dealing with mature canals, questions remain as to the best placement technique to use.

Because of limited chair time, $Ca(OH)_2$ often is placed in minimally instrumented canals. Sigurdsson et al. (12) found that radiographically the lentulo spiral produced the highest quality filling when canals were instrumented to a master apical file (MAF) #25. However, in fully prepared canals (MAF #50), Staehle et al. (13) found that a syringe system gave the best results radiographically and in ground sections. Torres et al. (14) found the greatest radiodensity of $Ca(OH)_2$ in the apical 1 mm of a simulated canal (44 degree curvature) prepared to an MAF #40 when a lentulo was used. Therefore, it may be important to determine the degree of canal preparation needed to allow for optimal placement of $Ca(OH)_2$.

Delivering the largest amount of $Ca(OH)_2$ into the root canal should enhance the elimination of bacteria. No study has used a quantitative method to assess the amount of $Ca(OH)_2$ placed in a canal. Because a radiographic image is two-dimensional, clinically assessing the quality of a filling is difficult. It would be beneficial to assess the weight of material delivered for a given technique. This would allow for an objective and quantitative evaluation.

The aim of this study was to compare the weights of $Ca(OH)_2$ delivered by four different techniques into minimally and fully prepared canals in a standardized split-tooth model (15). In addition, the radiographic appearance was evaluated to determine if a correlation exists between the weight of $Ca(OH)_2$ delivered and the radiographic appearance.

Materials and Methods

This study used two extracted human second mandibular premolars with single canals. After cleaning, the teeth were accessed with a high speed, water-cooled #4 round bur. The working length was determined by visualizing a #15 K-file through the apical foramen and subtracting 1 mm. The teeth were prepared with a crown-down technique using .04 rotary nickel-titanium (NiTi) files (Tulsa Dental Products, Tulsa, OK). The canals were irrigated between files with 2 ml of 17% REDTA (Roth International, Chicago, IL) followed by a 5-ml flush of 5.25% sodium hypochlorite. A #15 K-file maintained canal patency throughout instrumentation. One tooth was prepared to a master apical file (MAF) #25 (minimally prepared canal) to simulate an emergency appointment and the other to an MAF #40 (fully prepared) to simulate a completed preparation. After final irrigation, the canals were dried.

Two custom boxes were fabricated to provide a matrix for orthodontic resin (Caulk/Dentsply, Milford, DE), which was mixed according to the manufacturer's directions. After pouring the resin into each box, the teeth were inserted root end first into the center of the resin to the buccal CEJ. After the resin polymerized, two alignment holes were drilled in the resin on the mesial side of the root taking care not to penetrate the root.

Each resin block was then longitudinally sectioned through the center of the root canal using an Isomet Buehler low-speed saw (Buehler LTD., Evanston, IL). After sectioning, the two halves of the block were reassembled and secured with threaded bolts placed in the alignment holes

The reassembled blocks were individually weighed to the nearest .0001 g on a Mettler H20 scale (Mettler-Toledo, Inc., Columbus, OH). To establish a target weight for maximum capacity, both blocks were disassembled and $Ca(OH)_2$ firmly condensed into each half using a cement spatula. After condensation, the spatula leveled the $Ca(OH)_2$ to the cut root surface. The blocks were then placed together, secured with the bolts, and weighed independently three times to obtain the maximum (optimal) average weight.

Ultracal (Ultradent, South Jordan, UT) was used for each delivery technique tested: (a) an injection system (Ultracal), (b) an endodontic Flex-O file (Maillefer, Ballaigues, Switzerland) rotated counter-clockwise, (c) a lentulo spiral (Maillefer, Ballaigues, Switzerland), and (d) a .04 rotary NiTi file (Tulsa Dental Products) rotated counterclockwise at a constant 150 rpm. Each technique was repeated 10 times and an average weight determined.

Ultracal Syringe System

The working length measurement for each tooth was marked on the long flexible plastic tip using a sharp endodontic explorer. The paste was applied slowly and continuously from the apical to the most coronal part of the root canal using a slight up-and-down movement. This was continued until the paste was seen at the canal orifice.

Counterclockwise Flex-O File

The paste was applied to the entire length of a #25 or #40 Flex-O file and introduced to the working length using a counterclockwise rotation. This was repeated until the material was visible at the canal orifice.

Lentulo Spiral

A #1 or #4 lentulo spiral was passively placed to the working length before the $Ca(OH)_2$ was applied. The lentulo was then coated with the paste, the instrument introduced into the root canal, and the paste slowly rotated into the canal. The procedure was repeated until the paste was seen at the canal orifice.

Reverse Rotary NiTi File

Using .04 rotary NiTi files corresponding to the MAF #25 and MAF #40 preparations, paste was applied to the entire file length and placed passively to working length before running the files in reverse at 150 rpm. The procedure continued until the paste was visible at the canal orifice.

After each $Ca(OH)_2$ placement, one radiograph was taken from a buccal-lingual direction to simulate the clinical condition. Then, the blocks were weighed three times and the average weight calculated.

Radiographic Evaluation

Three blinded independent examiners radiographically evaluated the completeness of filling. Radiographs were mounted in 35-mm slide format and examined by screen projection. A scale from 1 (empty canal) to 10 (full canal) was used to assign a grade of filling quality.

The quantitative (objective) data (weights) were analyzed using analysis of variance and post hoc Scheffe F-test. The qualitative (subjective) evaluations of radiographic appearance were analyzed using Kruskal-Wallis and Pearson's χ^2 tests. Statistical significance was set at $p < 0.05$.

TABLE 1. Mean Weights (gms) of $Ca(OH)_2$ Delivered Into Minimally (MAF #25) and Fully Prepared Canals (MAF #40)

Delivery Method	Mean Weights			
	MAF #25		MAF #40	
	x	SD	x	SD
Injection system	0.3110	±0.0008	0.6340	±0.0004
Flex-O file	0.3084	±0.0011	0.6015	±0.0007
Lentulo spiral	0.3115	±0.0007	0.6290	±0.0005
NiTi reverse rotary	0.3022	±0.0010	0.5912	±0.0010
Optimal	0.5340*	±0.0005	0.6425	±0.0003

Differences among the MAF #25 or MAF #40 experimental groups were not significant ($p > 0.05$). Differences between the experimental weights and the optimal weight at MAF #40 were not significant ($p > 0.05$).

*Significant difference between the optimal weight delivered and all MAF #25 experimental groups ($p = 0.003$).

Results

For the minimally prepared canal, there were no statistical differences among the four experimental groups in the mean weights of $Ca(OH)_2$ delivered ($p = 0.15$) (Table 1). However, when the mean weight of $Ca(OH)_2$ for each experimental group was compared with the optimal weight delivered into the same canal, the differences were highly significant ($p = 0.003$) (Table 1). Regardless of the technique, only about 45% of the optimal weight of $Ca(OH)_2$ was delivered into minimally prepared canals.

In the completely prepared canal, all four experimental techniques delivered close to the optimal weight of $Ca(OH)_2$ (Table 1). Although the injection system and the lentulo spiral technique delivered modestly more weight than the other two experimental groups, the differences were not significant ($p > 0.05$) (Table 1). The differences between the experimental groups and the optimal weight were not significant ($p > 0.05$).

The interobserver reliability for all radiographic evaluations exceeded 85%. Radiographically the minimally prepared canal consistently contained multiple voids and had an overall filling quality of 1 to 2 on the 10 scale (Fig. 1*A*). In contrast, the completely prepared canal contained few voids and had an overall filling quality of 8 to 9 on the 10 scale (Fig. 1*B*). For each experimental technique, both radiographic evaluation and weight determination showed near optimal placement of $Ca(OH)_2$. Thus, a strong correlation was found between the radiographic appearance and the weight.

Discussion

The results of this study indicate that to achieve optimal or near optimal placement of $Ca(OH)_2$, a complete preparation is needed. Regardless of the technique used, delivery of $Ca(OH)_2$ into the minimally prepared canal was ineffective.

No previous study used a quantitative (objective) method for assessing the weight of $Ca(OH)_2$ fillings in mature permanent teeth. The split-tooth model enabled a comparison of the four delivery techniques in a standardized manner. In addition, two different canal conditions, minimal and complete preparation, were tested to determine the canal size needed to achieve optimal or near optimal delivery of $Ca(OH)_2$. Direct comparisons could then be made for filling quality.

The results of our study agree with Staehle (13) who found that an injection system was more effective than a K-file in delivering $Ca(OH)_2$ into fully prepared canals. Although Sigurdsson et al. (12) reported that a lentulo spiral achieved "adequate" fills in minimally prepared canals,

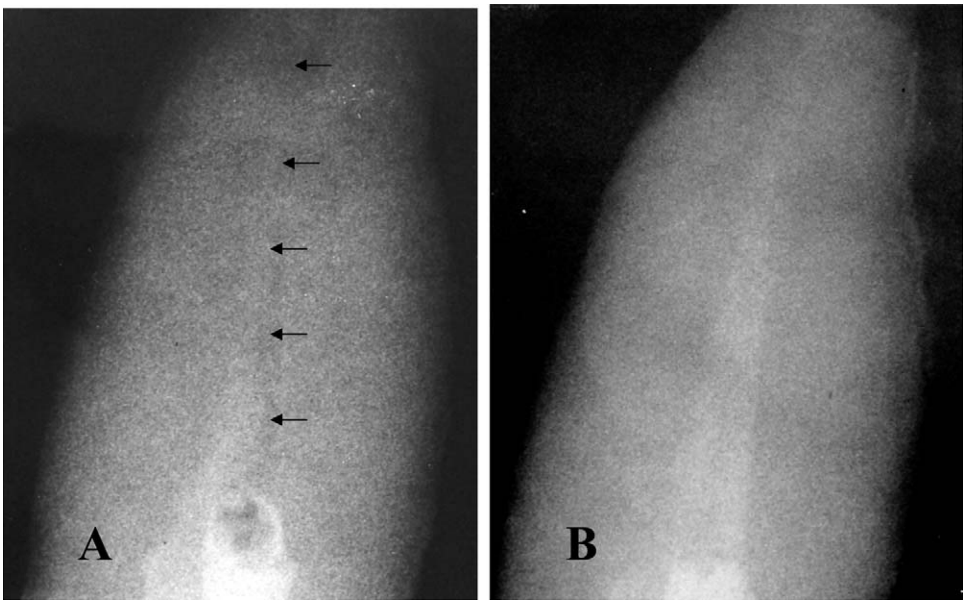

Figure 1. Radiographic examples of minimally (*A*) and completely prepared (*B*) canals filled with $Ca(OH)_2$. Note large areas of unfilled canal (arrows) in the minimally prepared canal.

our study does not support those findings. An explanation for this disparity could be in the differences in experimental technique. In their study, each experimental procedure was repeated three times before a radiographic assessment was made. In our study, each experimental procedure was discontinued as soon as $Ca(OH)_2$ was visualized at the canal orifice, which more closely approximates the clinical condition. Another explanation could be the dissimilar mixtures of $Ca(OH)_2$ used in the two experiments. Sigurdsson used an aqueous mixture of $Ca(OH)_2$, which has higher flow properties than the more viscous Ultracal mixture. The aqueous mixture could flow into a minimally prepared canal more easily. Thus, it could give a better overall radiographic appearance than what we observed in our minimally prepared canal.

Our study found a strong correlation between the radiographic appearance and the weight of $Ca(OH)_2$ delivered. In the minimally prepared canal, only 45% of the optimal amount of $Ca(OH)_2$ was delivered. This correlated well with the overall radiographic appearance, which rated 1 to 2 on a scale of 10. Regardless of technique used in the minimally prepared canal, the radiographic appearance correlated with the amount of $Ca(OH)_2$ placed. In the completely prepared canal, the near optimal weight of $Ca(OH)_2$ delivered and the overall radiographic quality also strongly correlated.

If the clinician uses $Ca(OH)_2$ as an interappointment medication, a technique should be selected that will deliver the maximum amount of material for a given preparation. If time is limited, which is common in an emergency appointment, instrumentation procedures must be chosen that will permit an adequate amount of $Ca(OH)_2$ to be placed in the canal. According to our study, a complete preparation is needed to deliver close to optimal amounts of $Ca(OH)_2$ with the physical properties of Ultracal using any of the four delivery techniques.

In conclusion, a complete preparation is needed to deliver a near optimal amount of $Ca(OH)_2$ into the root canal system. The four techniques tested can all achieve that desirable degree of filling. The clinician can be confident in radiographically evaluating the quality of placement because of the strong correlation between the weight of $Ca(OH)_2$ delivered and the radiographic appearance.

Acknowledgments

The authors would like to thank Drs. Stephen Niemczyk, Peter Brothman, Chris Ward, and Ellen Teverovsky for their assistance in this research, and Leonard Braitman, PhD, for statistical analysis of the data. This study was supported, in part, by the I. B. Bender Research Fund.

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