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Research Article

Retreatability of Endosequence® BCS™ Hiflow Utilizing Both Chloroform and An Aqueous Solution

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Abstract

Purpose: When RCT fails, retreatment of the case usually requires removal of the previous root canal fill (RCF). The aim of our research was to evaluate the retreatability of a root canal initially filled with gutta percha and EndoSequence® BCS™ HiFlow utilizing chloroform followed by 18% HCl, 18% HCl alone, chloroform alone or saline solution.

Methods: 40 extracted single canal teeth were decoronated and obturated utilizing a single cone gutta percha technique and Endosequence BCS, stored one week in an incubator, and then we attempted to remove the previous RCF. Teeth were divided in 4 different groups (n=10). Canals were then cleaned using heat, rotary instruments, hand files and specific solutions. Group A - cleaned by using only saline solution, Group B - cleaned by using only chloroform solution, Group C - cleaned by using only 18% HCl solution, and Group D - cleaned by using chloroform + 18% HCl. Image J software was used to evaluate and quantify the amount of obturation material left in the canal after cleaning of the canals.

Results: The pairwise comparison showed no significant difference between chloroform used alone and 18% HCl used alone (P = 0.82). However, chloroform + 18%HCl treatment showed a significant difference between chloroform alone (P = 0.026), 18% HCl alone (P = 0.021), and saline alone (0.003).

Conclusion: The result of this study indicates that chloroform followed by 18% HCl was superior in removing the previous RCF Compared to the individual solutions used alone in canals filled with gutta-percha and BCS. However, regardless of the solution used, patency could be achieved.

Keywords: *Nonsurgical Endodontic Treatment; Chloroform; Root Canal Fill (RCF)*

Introduction

Nonsurgical endodontic treatment is a predictable procedure with an excellent long-term prognosis and 97% tooth retention rate[1]. In most cases, failure of endodontic treatment is a result of microorganisms persisting in the apical portion of the root canal system, even in well- obturated teeth [2]. When root canal treatment is not successful, nonsurgical endodontic retreatment, apical surgery or extraction is indicated. The survival rate of teeth that received non-surgical endodontic retreatment was 85% after 72 months, 86.8% after 48 months and 90% after 24 months [3]. The success of endodontic retreatment depends upon removal of existing obturation material to allow disinfection of the root canal system to provide an environment satisfactory for periradicular healing [1]. During retreatment procedures, clinicians must remove filling materials from the previously filled root canal before working length (WL) determination. For this reason, it is advantageous to establish or reestablish apical patency [1].

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Bioceramic sealer (BCS) is a popular sealer worldwide. The sealer is used along with gutta percha to seal root canal systems and allow for a better hermetic seal of treated canals. BCS is often used in the obturation of root canals utilizing a single cone technique. Research shows similar success rates with a single cone technique and BCS compared to the more traditional obturation technique[5,7]. However, there is a concern about retreatability of calcium silicate–based sealers (CSS). BCS retreatments are difficult and time consuming, due to their hardness upon setting. Traditional retreatment solvents require the use of organic compounds like chloroform in order to soften and help remove the fill. Inconsistent results have been reported with BCS and GP retreatment thus far [10].

According to Chybowski conventional retreatment techniques are not able to fully remove BCS [6]. In his research, patency was not re-established in 20% of samples obturated with BCS/master cone to the working length or in 70% of samples with BCS/master cone short of the working length. This indicates that if the GP cone is short of the apex and only sealer is extruded in the apical portion of the canal, chloroform alone with files is not enough to remove it in most cases. Some studies reported that patency is possible when chloroform is used [9], others report that it was often impossible to gain apical patency on curved canals when fillings are short of the working length [8]. This suggests that BCS presence beyond the master cone may make endodontic retreatment even more challenging than usual.

In a recent survey, 44% of the dentists that responded, reported that the use of BCS did not influence their ability to re-establish apical patency during retreatment. The authors of this survey suggest that BCS retreatability may not be considered as a major clinical issue or that many practitioners are underestimating this problem [9]. We suggest that practitioners are underestimating the importance in adequately removing BCS. In other studies where dentists and endodontists reported that endodontic retreatment is more difficult in BCS cases; while many publications have investigated other procedures for BCS removal, to our knowledge, none have quantified the amount of sealer left after re-treatment with 18% HCl alone or following the use of chloroform.

The purpose of this study was to examine the efficacy of BCS removal using several solvents. Our study evaluated the retreatability of teeth initially filled with EndoSequence® BCS™ HiFlow (Brasseler USA, Savannah, GA, USA) using chloroform followed by 18% HCl and compared that to each solution alone and finally to saline solution.

Materials and Methods

Experimental Groups

Forty extracted human teeth, single canal maxillary central incisors and canines with straight roots were used as study models. Crowns were removed for each tooth near the CEJ level, and each tooth length was adjusted to be approximately 16mm with a flat coronal surface. Teeth were randomly assigned to one of 4 test groups of 10 teeth each according to the treatment:

Group A (negative control): Teeth were retreated with up to 2mL of saline for 10 minutes.

Group B (positive control): Teeth were retreated with 200uL of chloroform. Additional 200uL were added as needed until most GP was removed or 10 minutes of retreatment time was reached.

Group C (experiment group with acid only): Teeth were re-treated with 200uL of 18% HCl. Additional acid drops were added as needed until all the obturation material was removed or 10 minutes of retreatment time was reached.

Group D (experiment group: with Chloroform and acid): Teeth were re-treated with 200uL of chloroform. After initial GP removal with file, 200uL 18% HCl were added and additional instrumentation was performed, only 18% HCL was added after initial chloroform until all material was removed or 10 minutes of retreatment time was reached.

All experimental roots were stored in saline solution for the duration of the experiment.

Teeth Instrumentation

Each tooth was initially entered with #10 K-file that was placed into canal until visible at the apical foramen and 1mm was subtracted from that measurement to set as the WL for the GP filling with an intention to fill the last apical 1mm with BCS. Each root canal was instrumented to a final size of 35/.04 (Vortex Blue rotary file system). Canals were irrigated with 2mL of 6% NaOCl initially, using a 30-G side-venting needle. In addition, 1 mL of 6% NaOCl was used after each introduction of a new rotary file. For the final irrigation rinse 1 mL of 17% EDTA was used followed by 2mL of 6% NaOCl. The canals were dried using sterile, absorbent paper points matching the diameter of the master apical file (35/.04).

Teeth Obturation

Each tooth was obturated via the single GP cone technique utilizing EndoSequence® BCS™ HiFlow. The matching GP cone size 35.04 was coated with sealer 2/3 of the length (from the apex extending coronally) of the master cone.

After sealer and GP cone placement, each master GP cone was placed to WL- 1mm short of the apical foramen to ensure the apical 1 mm is filled with BCS only. The excess coronal gutta-percha was removed using a size 55/.06 heat-activated plugger (Alpha II; B&L Biotech, Fairfax, VA) for 5 seconds at 200°C. Then the GP cone was gently condensed using a cold condenser to make it flush with orifice of the canal. Lastly the coronal part of the canal was covered with clear nail polish.

After obturation, the teeth were placed in an incubator for 7 days at 37°C and 100% humidity.

The retreatment of teeth

The teeth were accessed after 7 days. Nail polish was easily removed with spatula, and the coronal few mm of GP cone was removed using a size 55/.06 heat-activated plugger for 5 seconds at 200°C. All engine-driven rotary files were operated using cordless endo motor Elements™ Connect (Kerr, Brea, CA) at a speed of 500 rpm and a torque of 3.0 Ncm. EdgeTaper Retreat files, D1: 30.09, and #10 K-files (Dentsply; Tulsa Dental Specialties) were used in that order, utilizing a back-and-forth motion to remove the GP cone. After the test solution was introduced into the canal, a file set at MAF length was used to remove most of the GP, then the canal was flushed out with the test solution. A #10.02 K-file was used to recapitulate the canal; a fresh test solution was introduced into the canal and the removal of debris was resumed with D1 retreatment file until the canal was completely clean or the 10-minute time limit was reached. After the instrumentation with D1, each canal was irrigated with 200uL of the test solution as described above for each experimental group.

A #10 K-file was used after D1 retreat file followed by 200uL drops of appropriate test solution, then instrumentation resumed, followed by more test solution to remove debris until apical patency was obtained or the procedure time reached 10 minutes. A timer was started once the heated plugger touched GP.

Teeth were radiographed in a mesio- distal dimension using a radiographic mounting jig specially fabricated to ensure consistent tooth orientation throughout the procedure. Teeth were radiographed after being instrumented, obturated, and finally after root canal filling removal was completed. For all radiographs, a 35.04 file was radiographed adjacent to each tooth to ensure consistency in radiographic contrast. Additionally, an aluminum step-wedge was radiographed at the beginning and end of each experimental group to ensure that the gray scale did not shift over the course of the experiment. Candeiro et al., 2014,[11] reported the ISO-standard radiopacity of EndoSequence BCS to be equivalent to 3.83 mm of aluminum. Images included are instrumented root canals, obturated root canals, and re-treated root canals (Figure 1).

Image J analysis

Image J software was used to analyze images in grayscale where radiopaque pixels (white = 0) ranged to radiolucent (black = 256). In obturated teeth, the gray scale for intact dentin and empty root canals were quantified. The area of lighter pixels (defined as more radiopaque than either the empty root canal or dentin)) was quantified within each root canal and compared between the treatments. The area of radiopaque material within the root canal of obturated teeth was defined as 100% of the area of the canal. Following retreatment and removal of the gutta percha and sealer, the area of remaining radiopaque material was measured and defined as a percentage of the original area of the canal for each tooth. For each treatment condition, 10 teeth were obturated and cleaned, and the percentage of remnant GP and sealer were averaged. Data is represented as the mean and standard deviation of 10 samples. Significance was determined using Student's T-test with a $P < 0.05$.

Results

A small pilot study was performed using 20µL (1 measuring unit on a syringe of EndoSequence® BCS™ HiFlow sealer) expressed on a glass slide and incubated for 7 days at 37°C and 100% humidity. Dissolution of BCS was tested by adding 200µL of each of the following solvents: saline solution, 5% acetic acid, 37% H3PO4, 18% HCl and chloroform. Only 18% HCl resulted in a detectable dissolution of the BSC (data not shown) and was therefore chosen to be used in subsequent experiments.

Chloroform is commonly used to remove the GP from the center of the obturated canal [11]. By removing GP from the canal, we expect that BCS was exposed so that 18% HCl can react with and dissolve BCS, facilitating easier removal. We therefore expected that the use of chloroform followed by 18% HCl will remove BCS and GP cones significantly better than either one of them alone. Our results confirm this prediction.

Efficiency of sealant removal was determined radiographically based on the amount of radiopaque sealer/GP remaining in the canal compared to instrumented canal prior to obturation (Figure 1A, D, G, and J). Obturated canal images were used to demonstrate the total area of each canal (Figure 1B, E, H and K). Saline was used as a negative control for a retreatment solvent, revealing significant quantities of remnant gutta percha and sealer (Figure 1A-C, and Figure 2). Chloroform was used as a positive control group as this solvent is known to remove GP. In these retreating canals, significantly less GP and BCS remained within the canal (Figure 1D-F, and Figure 2).

Similarly, the use of 18% HCl removed a significantly greater amount of GP/Sealer than saline (Figure 1G-I, and Figure 2). Finally, the use of chloroform followed by 18% HCl significantly reduced the remnant GP and sealer compared to either solvent alone (Figure 1J-L and Figure 2).

A pairwise comparison of the groups (Figure2) demonstrated no significant difference between chloroform and 18% HCl alone (P = 0.82). However, chloroform and acid treatment showed a significant difference between chloroform alone (P = 0.026) and 18% HCl alone (P = 0.021).

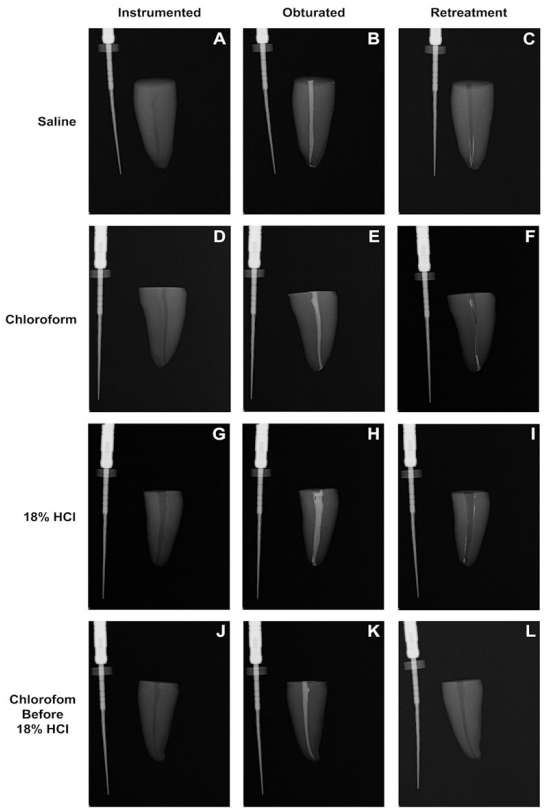

Figure 1. Removal of Sealer using various solvents: *Remnant Sealer was observed in radiographs of obturated roots of single rooted teeth using various solvents. Instrumented canals prior to obturation (A, D, G, and J), obturated canals (B, E, H and K), and cleaned canals (C, F, I, L) were examined. Solvents tested were saline (A-C), chloroform (D-F), 18% HCl (G-I) and chloroform followed by 18% HCl (J-L).*

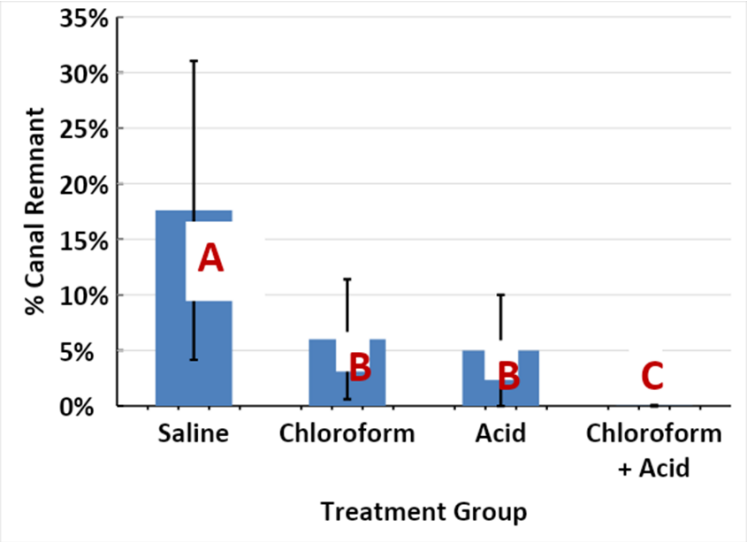

Figure 2 . Quantification of Remnant Sealer: *Remnant Sealer was quantified from radiographs of obturated roots of single rooted teeth cleaned with various solvents using ImageJ software. Each bar represents the mean and standard deviation of 10 samples. Significant differences are denoted by different letters (P < 0.05).*

Discussion

Previous studies have documented a challenge of achieving patency in teeth previously obturated with the BCS [11]. The major components of BCS (di-calcium and tri-calcium silicate) are soluble in acid but not chloroform [14]. Several acids have been used previously to try to gain patency during the RCT retreatment [1, 7, 14]. However, none of these previous studies have quantified the amount of sealer left behind at the completion of the procedure.

One study has evaluated retreatability using heat, chloroform, rotary instruments, and hand files [8]. They evaluated the ability to regain patency and time required to remove obturation material. They found that working length was not achieved in 70% of samples obturated with BSC/ GP cone short of WL, and they were not able to achieve patency in 20% of samples obturated with BSC/GP to WL as well. Similarly, others evaluated the time and ability to achieve patency [13]. They used 3 different solvents, 10% formic acid, 37% HCl and chloroform. However, this study did not quantify the amount of sealer remaining on the walls. Based upon SEM visualization the group that was irrigated with 37% HCl appeared to have the greatest amount of demineralization. Likewise, 37% hydrochloric acid lowered the microhardness and push-out strength of MTA (which is similar in composition to BCS) [12]. In our study, we used 18% HCl in order to minimize dentin demineralization.

Carrillo et al [4] compared the retrievability of 3 different calcium silicate sealers using 1 of 3 different solutions (6% sodium hypochlorite, 5% acetic acid, and carbonated water) or no solution at all. Their research found that compared with no solution, the retrievability of calcium silicate-based sealers decreased when solutions were used. However, these researchers only examined canal patency and chose to examine particularly weak acids that may not react and dissolve di-calcium and tricalcium silicate needed to make retreatment more efficient and complete.

When treated with chloroform, more BCS was removed than without chloroform [8]. Therefore, we used chloroform followed by acid to enhance the removal of BCS. The reasoning behind the concept is that by using chloroform we will remove the GP core from the center of the fill and then add acid to react with the BCS in order to remove it more effectively from the walls and apical one third of the canal.

The biggest difference between our study and the previous studies is that we quantified the amount of BSC left in the canals by using radiographic images and ImageJ software. Our study did not time how long it took to gain patency, but all the samples were retreated well within 10 minutes of the bench time, similar to Carrillo's study, and we gained patency in all samples.

Recently, an examination of the efficacy of 10% formic acid, 20% HCl, and chloroform for the retreatment of teeth obturated with GP cone and BCS was conducted [13]. Using SEM, they evaluated the effect of the solvents on root canal wall dentin and compared the level of erosion caused by these solvents qualitatively. They concluded that 20% HCl was superior to 10% formic acid and chloroform in achieving patency in teeth obturated with BCS. Regardless of the solvent used, they achieved patency for most of the cases obturated with gutta-percha and BCS.

Conclusion

In conclusion, the result of this study indicates that chloroform followed by 18% HCl was superior to any individual solution used alone in BCS retreatment of single canal endodontically treated teeth. However, regardless of the solution used, patency can be achieved. The only difference is that sealer is sometimes not removed from the coronal and middle 1/3 of the root canal. Future studies are needed to evaluate the effects of these acids on dentin and the outcome of endodontic treatment.

Conflicts of Interest

The authors deny any conflicts of interest.

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