Effect of a Novel Bioceramic Solvent on Apical Patency during Nonsurgical Endodontic Retreatment: An *Ex Vivo* Study

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ABSTRACT

Introduction: Calcium silicate–based sealers (CSC) are widely used due to their favorable biological and physical properties; however, their removal during nonsurgical root canal retreatment (NSReTx) remains challenging. This study evaluated the efficacy of a novel bioceramic solvent in re-establishing apical patency during NSReTx of canals obturated with CSC, comparing its performance to sodium hypochlorite (NaOCl), with and without adjunctive Er:YAG laser activation. **Methods:** Forty-eight extracted single-rooted teeth were instrumented and obturated 2 mm short of the working length using gutta-percha and CSC. After 14 days, the gutta-percha was removed, and BC Sealer Solvent (Brasseler USA, Savannah, GA) or NaOCl was used, with or without Er:YAG laser activation, to re-establish apical patency. The time to achieve patency using a size 10 C-file was recorded. Differences among the 4 groups were analyzed using the Kruskal–Wallis test. **Results:** Apical patency was achieved in all canals except one with transportation. The median overall time was 186 seconds, ranging from 57 seconds observed with solvent to 582 seconds with NaOCl. Significant differences were found among the groups ($P < .05$). Post hoc analysis showed a significant difference between the solvent and NaOCl with the Laser groups (adjusted $P < .05$). **Conclusions:** BC Sealer solvent demonstrated greater effectiveness and efficiency than NaOCl, with or without laser activation, in re-establishing apical patency. These findings suggest its potential to enhance the efficiency of this step during NSReTx involving CSC. *(J Endod 2026;52:1493–1498.)*

KEY WORDS

Apical patency; bioceramic sealer; calcium silicate–based sealer; Er:YAG laser; retreatment; solvent

SIGNIFICANCE

A novel bioceramic solvent significantly reduced the time required to re-establish apical patency during nonsurgical retreatment of straight canals obturated with calcium silicate-based sealers, improving retreatment efficiency.

Root canal treatment is a predictable procedure with high success when core biological principles are respected[1]. Post-treatment diseases are most commonly associated with inadequate disinfection and insufficient sealing of the root canal system, often necessitating retreatment[2,3]. In most cases, nonsurgical retreatment (NSReTx) should be considered the first treatment option whenever feasible as it is associated with favorable outcomes[4,5]. Endodontic retreatment aims to remove all obturation materials and debris from the root canal space to permit effective disinfection and healing[6]. Achieving this goal relies on re-establishing apical patency, which permits instruments, irrigants, and medicaments to reach the apical constriction and access the apical microbial reservoir[6,7]. When apical patency is not re-established, disinfection efficiency is compromised, and treatment outcomes become less predictable[4,7].

Calcium silicate-based sealers (CSC) are widely used in endodontics due to excellent sealing ability, antimicrobial activity, biocompatibility, bioactivity, and dimensional stability[8-10]. Effective removal of filling material, including sealer, is a crucial step in NSReTx. Current evidence indicates that complete CSC removal is difficult due to deep penetration into dentinal tubules[11,12]. Once set, they infiltrate the dentinal tubules and adhere to the dentinal walls[13], which can hinder file advancement and limit the re-establishment of patency[14]. While some studies suggest that CSC removal is comparable to epoxy-resin sealers, others highlight a significant increase in the time and difficulty required to reach the apical terminus[15-18].

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The absence of an effective solvent capable of disrupting the bioceramic-dentin interface remains a major obstacle in NSReTx[19]. Consequently, adjunctive irrigant activation techniques have demonstrated potential in enhancing the retrievability of bioceramic sealers[18,20]. Laser-activated irrigation (LAI), specifically Erbium:Yttrium-Aluminum-Garnet (Er:YAG)-based photon-induced photoacoustic streaming and the advanced shock wave - enhanced emission photoacoustic streaming (SWEEPS), has emerged as a viable approach[21]. These modalities utilize cavitation and pressure waves to improve irrigant penetration and facilitate the mechanical disruption of filling materials, potentially aiding in the re-establishment of the root canal pathway[21-23]. *In vitro* evidence suggests that these laser-driven protocols achieve superior irrigant delivery and material removal efficacy compared to conventional activation techniques[20,24]. While the Er:YAG laser wavelength (2940 nm) is highly absorbed by water and hydroxy groups - components prevalent in both irrigants and the hydrated matrix of set bioceramics - limited evidence exists regarding its direct effect on the set CSC surface[25]. Moreover, there is a lack of comparative data on the efficacy of various chemical irrigants when used in conjunction with LAI for sealer removal. Understanding the interaction between CSC and SWEEPS could result in optimization of clinical protocols, particularly for the management of where traditional retreatment methods might fail, especially in cases with complex root canal morphologies.

Recently, a commercially available BC Sealer solvent (Brasseler USA, Savannah, GA) has been introduced to facilitate the chemical breakdown of CSC during NSReTx. Published information on its composition is limited, with citric acid ($\leq$20%) identified as the principal component. CSC materials are susceptible to acidic environments, and prior studies have shown that agents such as citric acid can promote their dissolution[26].However, evidence regarding the efficacy of commercially available formulations in re-establishing apical patency in canals obturated with CSC remains limited. To date, only one study has evaluated a comparable sealer solvent[27] and no data are available specifically for the BC Sealer solvent. Furthermore, the potential synergistic effect of combining this solvent with Er: YAG laser activation has not yet been investigated.

Given the rising clinical application of bioceramic materials and the inherent difficulty in their removal, developing optimized retreatment protocols is essential. Therefore, this *ex vivo* study aimed to evaluate the efficacy of BC Sealer solvent in re-establishing apical patency during nonsurgical root canal retreatment of canals obturated with CSC. The performance of the solvent was compared to conventional sodium hypochlorite (NaOCl), both with and without adjunctive Er:YAG laser activation.

MATERIALS AND METHODS

Teeth Selection

This study was reviewed and considered exempt by the Human Research Protection Program/Institutional Review Board, Virginia Commonwealth University. Forty-eight single-rooted teeth with single, straight, narrow canals were selected from a pool of de-identified human donors. Inclusion criteria were based on clinical and radiographic assessment in 2 projections. Teeth presenting with fractured apices, root curvatures, calcifications, wide canals, or extensive carious lesions were excluded from the study. All procedures were completed by a single experienced endodontist under a dental operating microscope (Zumax OMS2380, Enova Illumination, Minneapolis, MN, USA).

The coronal portions of the teeth were sectioned using a water-cooled diamond disc (Henry Schein Inc, New York, USA) to standardize the tooth length at 20 mm, leaving a 5 mm coronal reservoir space to accommodate irrigant containment and laser application.

The teeth were randomly assigned to 4 groups of 12 teeth. After access opening was performed, apical patency was verified by passing the K file ISO 10 (Dentsply Tulsa Dental, Tulsa OK, USA) through the apical foramen. Working length (WL) was set 0.5 mm short of the apical foramen. Root canals were instrumented to the WL using Vortex Blue nickel-titanium rotary instruments (Dentsply Tulsa Dental, Tulsa, OK, USA) to master apical file size 30/0.4. Irrigation was performed throughout instrumentation using 6% NaOCl (Henry Schein Inc, New York, USA). Final irrigation consisted of 2 mL of 17% EDTA (Henry Schein Inc, New York, USA) followed by 5 mL of NaOCl. The canals were dried with paper points, and master cones were fitted 2 mm short of WL. Radiographs were taken to confirm length. Obturation was performed with a single cone technique using EndoSequence BC sealer (Brasseler USA, Savannah, GA). Radiographs were taken to evaluate the obturation, and teeth were stored at 37°C at 100% humidity for 14 days (Fig. 1*A* and *B*).

Retreatment

Coronal gutta-percha was removed using a heat plugger (Dentsply Tulsa Dental, Tulsa, OK) at 200°C for 5 seconds. To reach 2 mm short of the working length (WL) without further enlarging the canal, a size 30/.04 Vortex Blue rotary file (Dentsply Tulsa Dental) was employed at 500 rpm. Teeth were randomly assigned into 4 treatment groups. In all groups, manual instrumentation was performed using a size 10 C-file (Dentsply Tulsa Dental) in a pecking motion until apical patency was established (Fig. 2).

1. **Group 1 (NaOCl):** Canals were filled with the 6% NaOCl during instrumentation
2. **Group 2 (Solvent):** BC Sealer Solvent (Brasseler USA, Savannah, GA) was introduced for 30 seconds prior to instrumentation following manufacturer's instructions.
3. **Group 3 (Solvent/Laser):** Canals were filled with solvent, followed by alternating 30-second cycles of manual instrumentation and Er:YAG laser activation (LightWalker, Fotona, Ljubljana, Slovenia). Laser parameters were: SWEEPS 400/14 flat tip, auto-SWEEPS mode, 20 mJ, 15 Hz, and 0.6 W according to manufacturer's instructions.
4. **Group 4 (NaOCl/Laser):** Canals were filled with 6% NaOCl, followed by alternating 30-second cycles of manual instrumentation and Er:YAG laser activation using the aforementioned settings.

Apical patency time was recorded while maintaining constant solution levels through regular replenishment during instrumentation and laser activation. Patency was radiographically confirmed to ensure clinical accuracy (Fig. 1*C* and *D*).

Statistical Analysis

A sample size of 12 in each of the 4 groups was calculated to have 80% power to detect an effect size of 0.25 at the 5% level, which would be indicative of clinically significant differences. Time to remove the sealer was converted to seconds for analysis. Both the total time to remove the sealer and the active time to remove the sealer after subtracting the laser time (in increments of 30 seconds) were assessed. Nonparametric Kruskal–Wallis tests were used to test for differences in the time across the 4 groups. Figures are provided to display

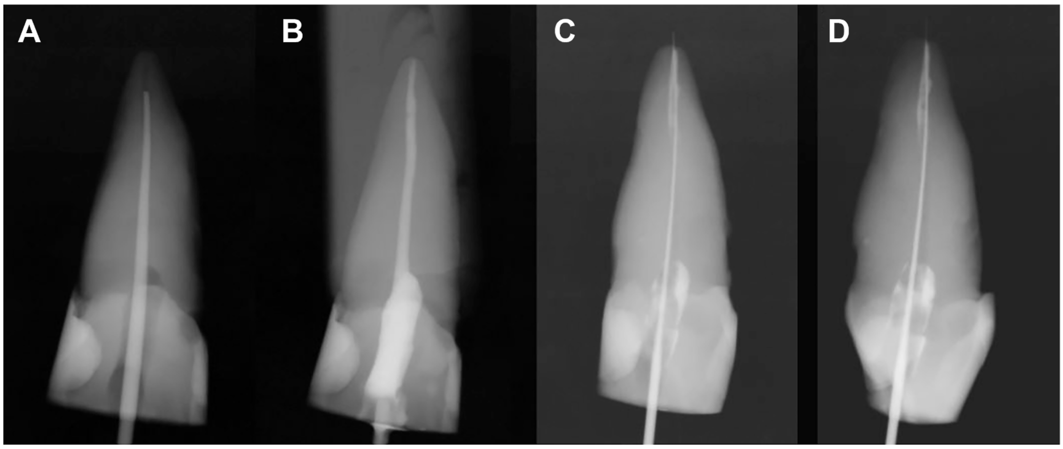

FIGURE 1 – Radiographic evaluation of endodontic treatment stages and apical patency. Initial cone-fit radiographic demonstrating the master gutta-percha cone positioned 2 mm short of the working length (*A*). Postoperative radiograph showing completed root canal obturation (*B*). Radiographic evidence of the retreatment process and confirmation of apical patency achievement, in both buccolingual (B-L) and mesiodistal (M-D) orientations (*C* and *D*).

the distribution of completion times across the 4 groups. In these figures, the error bars extend from the minimum to the maximum observed time. The circle represents the mean time, and the horizontal line indicates the median time. The shaded region denotes the 25th to 75th percentile. Significance level was set at 0.05. SAS EG v.8.2 (SAS Institute Inc, Cary, NC) was used for all analyses.

RESULTS

Forty-eight teeth were tested. One tooth from Group 2 was excluded due to canal transportation during sealer removal; Final group sizes were: Solvent (n = 11), NaOCl (n = 12), Solvent/Laser (n = 12), and NaOCl/Laser (n = 12). Patency was achieved in all canals, except for the tooth with canal transportation. The median overall time to achieve apical patency was 186 seconds or 3 minutes and 6 seconds. The time ranged from 57 seconds, which was achieved in Group 2 (Solvent), to 582 seconds or 9 minutes and 42 seconds in Group 1 (NaOCl). The time required to achieve apical patency during sealer removal was evaluated by analyzing both the total elapsed time and the active working time, excluding the laser cycle time. Summary of the working times is provided in Table 1.

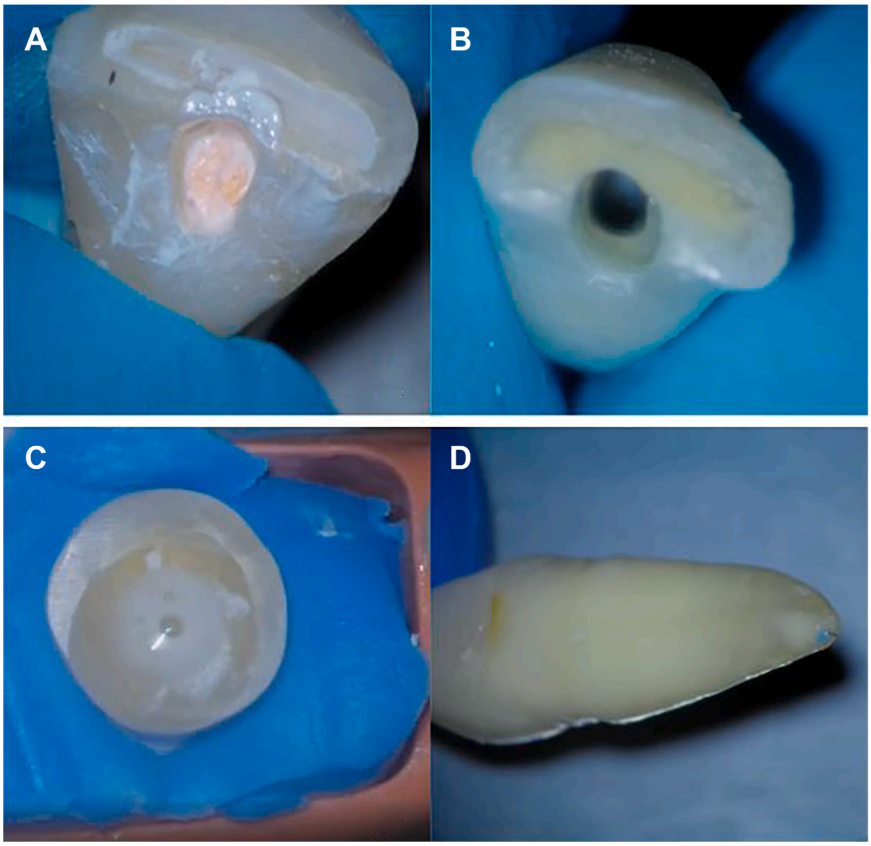

FIGURE 2 – Sample tooth initial root canal treatment (*A*); sample tooth retreatment (*B*); visible chemical reaction when solvent is used (*C*); re-establishment of apical patency (*D*).

Total completion time differed significantly among the 4 groups (P-value $<.05$). Post hoc pairwise comparisons revealed a statistically significant difference between solvent and NaOCl with Laser (adjusted P-value $<.05$). None of the other comparisons demonstrated significantly different completion times. Figure 3*A* displays the distribution of times among the 4 groups. Notably, the Solvent-only group displayed the lowest mean and median times, as well as the narrowest distribution range.

After excluding the laser time, there was insufficient evidence of any significant differences among the 4 groups (P-value $>.05$). Figure 3*B* displays the distribution of completion times across the 4 groups. In comparison to Figure 3*A*, in Figure 3*B*, Groups 3 and 4 include only the use of manual instrumentation labor and thus demonstrate lower completion time since laser time was removed. No significant differences were observed among the groups. Despite the reductions in time for the laser groups, the

TABLE 1 - Time to Achieve Patency by Group

	Time to remove sealer(s)	
	Total time	**Excluding laser cycles**
Group 1		
GP-NaOCl	239.1 (145.7, 252.9)	
Group 2		
GP-solvent	130.0 (77.5, 156.0)	
Group 3		
GP-solvent-laser	217.7 (129.9, 285.6)	157.7 (99.9, 210.6)
Group 4		
GP-NaO Cl + laser	199.2 (185.6, 280.1)	130.1 (122.1, 190.1)

NaOCl, sodium hypochlorite.
Values indicate median (interquartile range), measured in seconds.

solvent-only group continues to demonstrate the lowest, and the NaOCl-only group the highest mean and median time of completion.

DISCUSSION

To our knowledge, this is among the first investigations to evaluate the efficacy of a commercially available bioceramic sealer solvent, specifically focusing on its capacity to facilitate the re-establishment of apical patency, a crucial step during NSReTx.

In this study, an obturation model featuring CSC placed on the apical 2 mm of the root canal was utilized to simulate clinically relevant challenges, consistent with established methodologies[17,28].

Overall, apical patency was successfully re-established in 47 out of 48 specimens, confirming that removal is technically feasible under the tested conditions. However, the wide variability in time (ranging from 57 to 582 seconds) underscores the ongoing challenges of managing teeth treated with CSC, consistent with previous reports[11,12,14]. NaOCl was used as the reference irrigant given its established role in endodontic therapy[29] and its inability to disrupt the set matrix of CSC was evidenced by a median patency time of nearly 4 minutes. The solvent-only group demonstrated a significantly reduced time to achieve apical patency compared to all other groups, with a median time of 130 seconds. The application of the tested solvent resulted in a visible chemical reaction upon contact with the sealer. While this observation may indicate an interaction between the solvent and the material[11-13], the underlying mechanisms were not directly evaluated in this study and cannot be confirmed. CSC materials are known to be susceptible to acidic environments, and citric acid–based formulations may contribute to material softening. In addition, previous studies suggest that such agents can interact with dentin without significant erosion compared with stronger acids[27], however, their specific role in sealer removal remains limited and warrants further investigation.

Although LAI) has been proposed to enhance irrigant penetration and material disruption through photoacoustic effects[20,24], the present findings do not demonstrate an improvement in overall efficiency with the use of Er:YAG SWEEPS in this setting. The addition of laser cycles increased the total procedure time in both the solvent and NaOCl groups. However, when adjusting for the time required for laser application, the "active" working time for the NaOCl/Laser group was reduced to a median of 130.1 seconds, compared to 239.1 seconds for NaOCl alone. These findings indicate that any potential mechanical effects of LAI are offset by the additional procedural steps required. Furthermore, the limited irrigant volume in the apical 2 mm may restrict effective energy transmission, reducing the clinical impact of LAI in this region[21-23]. Therefore, any assumption that LAI predictably improves the retreatability of CSC should be approached with caution.

The softening of the sealer may have been enhanced by the absorption of laser energy and its photoacoustic effect. The tested sealer contains water, calcium silicates, and hydroxyl-rich components that serve as primary chromophores for this wavelength[30,31]. Despite their high chemical stability, they may be susceptible to the Er:YAG laser's optical effects, facilitating the ablation by absorbing the Er:YAG laser energy[25]. This interaction between laser energy and sealer components was not directly evaluated in this study. Therefore, any assumptions regarding laser-induced material alteration or enhanced ablation remain speculative and require further investigation.

Removal times in the present study were generally higher than those reported in the literature. Hanson et al[27] reported lower median times for comparable groups, while Agrafioti et al[32] found similar values for the GP-NaOCl group. Rezaei et al, evaluating a smaller

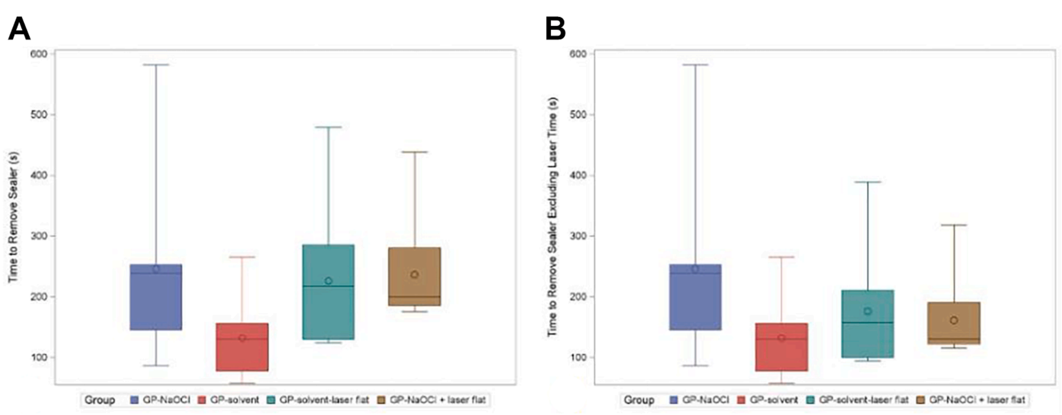

FIGURE 3 – Distribution of completion time across the 4 treatment groups with LAI time included (*A*) LAI time excluded (*B*). The most efficient time to achieve apical patency was achieved with the novel solvent without the use of LAI (*red bar*). Increased efficiency of manual instrumentation for NaOCl groups was observed after adjusting for the time required for LAI (*brown bar* shift from *A* to *B* in relation to *blue bar*). LAI, laser-activated irrigation; NaOCl, sodium hypochlorite.

apical segment with different solutions, also reported shorter times. Additional studies[17,33-35] have evaluated retreatment of CSC sealers; however, direct comparison is limited due to differences in methodology, including obturation techniques, apical patency models, and evaluation criteria. Importantly, CSC sealers vary in composition, particularly in cement content, which may influence their resistance to removal and represents a limitation of the present study.

Several limitations must be acknowledged. This *ex vivo* study utilized single-rooted teeth with straight canals, which do not fully replicate the clinical complexity of curved canals with isthmuses, deltas, and lateral canals[2,3]. In addition, the full chemical composition of the tested solvent remains undisclosed, and its long-term effects on dentin integrity, interaction with irrigants, and potential biological toxicity remain unknown. The absence of comparison with established or previously investigated agents (eg, EDTA, formic acid, citric acid, chloroform) also limits interpretation of its relative efficacy[27]. Finally, the standardized laser protocols used in this study do not allow for comprehensive assessment of sealer removal or dentinal surface alterations.

In conclusion, these findings provide preliminary evidence that the BC Sealer solvent can significantly enhance the efficiency of re-establishing apical patency during NSReTx of CSC. While LAI showed potential in reducing active instrumentation time for NaOCl-based protocols, it did not provide an additional benefit when combined with the solvent. Future micro-computed tomography and curved-canal studies are needed to assess wall cleanliness and optimize protocols for complex retreatment cases.

CONCLUSION

The novel bioceramic solvent significantly shortened the time required to regain apical patency during NSReTx of CSC. While LAI may have enhanced traditional protocols, it does not provide a synergistic benefit to the solvent-only technique, which remained the most efficient protocol tested.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Duska Stopar: Conceptualization, Methodology, Investigation, Writing - Original Draft, Writing - Review & Editing, **Janina Golob Deeb:** Conceptualization, Methodology, Supervision, Writing - Original Draft, Writing - Review & Editing **Caroline K. Carrico:** Formal analysis, Visualization, Writing - Original Draft, Writing - Review & Editing. **Ana Cristina Andrada:** Conceptualization, Methodology, Investigation, Writing - Original Draft, Writing - Review & Editing, Supervision, Project administration

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

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